INFORMATION PROCESSING ABILITIES AND PARENT-INFANT INTERACTION: PREDICTION OF IMITATIVE ABILITY IN THE FIRST YEAR

by

Shana L. Nichols

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

at

Dalhousie University
Halifax, Nova Scotia
January, 2005

© Copyright by Shana L. Nichols, 2005
NOTICE:
The author has granted a non-exclusive license allowing Library and Archives Canada to reproduce, publish, archive, preserve, conserve, communicate to the public by telecommunication or on the Internet, loan, distribute and sell theses worldwide, for commercial or non-commercial purposes, in microform, paper, electronic and/or any other formats.

The author retains copyright ownership and moral rights in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author’s permission.

In compliance with the Canadian Privacy Act some supporting forms may have been removed from this thesis.

While these forms may be included in the document page count, their removal does not represent any loss of content from the thesis.

AVIS:
L’auteur a accordé une licence non exclusive permettant à la Bibliothèque et Archives Canada de reproduire, publier, archiver, sauvegarder, conserver, transmettre au public par télécommunication ou par l’Internet, prêter, distribuer et vendre des thèses partout dans le monde, à des fins commerciales ou autres, sur support microforme, papier, électronique et/ou autres formats.

L’auteur conserve la propriété du droit d’auteur et des droits moraux qui protègent cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

Conformément à la loi canadienne sur la protection de la vie privée, quelques formulaires secondaires ont été enlevés de cette thèse.

Bien que ces formulaires aient inclus dans la pagination, il n’y aura aucun contenu manquant.
DALHOUSIE UNIVERSITY

To comply with the Canadian Privacy Act the National Library of Canada has requested that the following pages be removed from this copy of the thesis:

Preliminary Pages
  Examiners Signature Page (pii)
  Dalhousie Library Copyright Agreement (piii)

Appendices
  Copyright Releases (if applicable)
Dedicated to the memory of my Poppa, Stanley McLaughlin.

I shall be telling this with a sigh
Somewhere ages and ages hence:
Two roads diverged in the woods, and I—
I took the one less traveled by,
And that has made all the difference.

– Robert Frost (1920).
# TABLE OF CONTENTS

LIST OF TABLES................................................................................................................. xiv
LIST OF FIGURES .............................................................................................................. xvii
ABSTRACT .......................................................................................................................... xix
LIST OF ABBREVIATIONS AND SYMBOLS USED .............................................................. xx
ACKNOWLEDGEMENTS .......................................................................................................xxi

1. INTRODUCTION ........................................................................................................... 1
   Defining Imitation.............................................................................................................. 2
       Developmental Emergence of Forms of Social Learning ................................................. 4
   The Developmental Importance of Imitation ..................................................................... 6
   The Study of Imitation as a Developmental Phenomenon ................................................. 7
       Neonatal Imitation ....................................................................................................... 8
   Moving Beyond the Neonatal Period: Matching Behaviour from 2 to 6 Months ............. 10
   Imitation in the Second Half of the First Year ................................................................. 11
       Developmental timeline: What infants are able to imitate in the second half of the first year ......................................................................................................................... 13
       Developmental progresses in the accuracy of infants’ imitative responses .................. 17
       Capacity versus performance: Beyond the cognitive-developmental theory of imitation ................................................................................................................................. 19
   Summary ........................................................................................................................... 21
   Sensitivity to interpersonal contingencies and being imitated by others ......................... 21
   Sensitivity to social contingencies ..................................................................................... 22
   Imitation detection .......................................................................................................... 23
   Theories of Imitation Development in Infancy ................................................................. 26
   Classical theories of imitation ......................................................................................... 27
Modern theories of imitation ................................................................. 30
Summary .................................................................................................. 35
The Need for Longitudinal Studies of Predictors of Imitation .................. 36
Reciprocal Approaches: Understanding Imitation via the Study of
Psychopathology .................................................................................. 37
Prediction of Imitative Ability and Concurrent Relationships in Typically
Developing Infants .................................................................................. 37
Visual-spatial attention .............................................................................. 38
Intermodal perception ................................................................................ 40
Mother-infant play .................................................................................... 43
Temperament and self-regulation ............................................................. 46
Correlates of Imitative Ability at the End of the First Year ...................... 49
The Present Study .................................................................................... 52
Overall Aim of the Current Study: Informing Developmental Theory and the
Study of Psychopathology ....................................................................... 57
2. METHOD ................................................................................................. 58
Participants ............................................................................................. 58
Screening (4 and 9 months) ..................................................................... 59
Measures (4, 9, and 12 months) ............................................................... 60
Questionnaires ........................................................................................ 60
Demographics (4 and 9 months) .............................................................. 60
Infant Behaviour Questionnaire-Revised (IBQ-R; Rothbart & Garstein,
2000) (4 and 9 months) ......................................................................... 61
Kent Inventory of Developmental Skills (KIDS; Reuter & Gruber, 2000)
(9 months) .............................................................................................. 61
MacArthur Communicative Development Inventory: words and gestures
(Fenson et al., 1993) (9 months) .............................................................. 62
Imitation questionnaires (9 and 12 months) ............................................. 63
Tasks .................................................................................................................. 65
Computerized visual-spatial attention task (VSAT) (4 and 9 months) .................. 65
VSAT coding ........................................................................................................... 68
Visual-auditory inter-modal processing task (VAIP) (4 and 9 months) .......... 68
VAIP coding and reliability ................................................................................... 71
Visual-proprioceptive inter-modal processing tasks (VPIPs) (4 months and 9 months) ................................................................. 71
4-month task – VPIP kicking ............................................................................... 72
9-month version – VPIP faces ............................................................................ 74
VPIP coding and reliability ................................................................................... 76
Mother-infant dyadic play (4 and 9 months) and imitation (4 months) .......... 77
4-month version ..................................................................................................... 77
9-month version ..................................................................................................... 79
Coding and reliability .......................................................................................... 79
Object exploration task (4 and 9 months) ........................................................... 80
9 months ................................................................................................................ 80
Coding and reliability .......................................................................................... 82
Imitation task (9 months) .................................................................................... 82
Coding and reliability .......................................................................................... 85
Gaze following task (9 months) .......................................................................... 88
Coding and reliability .......................................................................................... 90
Procedure (4 months) ......................................................................................... 90
Procedure (9 months) ........................................................................................ 93
Procedure (12 months) ....................................................................................... 95
3. RESULTS ........................................................................................................... 96
Overview of Analyses ......................................................................................... 96
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imitation Abilities and Sensitivity to Being Imitated</td>
<td>97</td>
</tr>
<tr>
<td>Imitation Measures</td>
<td>97</td>
</tr>
<tr>
<td>Imitation Questionnaire at 9 and 12 months</td>
<td>97</td>
</tr>
<tr>
<td>Parent Report of Infant Imitation – Quantitative Ratings at 9 and 12 Months</td>
<td>98</td>
</tr>
<tr>
<td>Parent Report of Infant Imitation – Qualitative Information at 9 and 12 Months</td>
<td>103</td>
</tr>
<tr>
<td>9 month imitation questionnaire</td>
<td>104</td>
</tr>
<tr>
<td>12-month imitation questionnaire</td>
<td>106</td>
</tr>
<tr>
<td>Imitation Task at 9 Months</td>
<td>109</td>
</tr>
<tr>
<td>Completion of imitation trials</td>
<td>110</td>
</tr>
<tr>
<td>Imitation Task Performance – Approaches to Scoring</td>
<td>112</td>
</tr>
<tr>
<td>Full imitation (0-9 score) results for trials one through three and for best performance</td>
<td>113</td>
</tr>
<tr>
<td>Approximations to imitation (0-27 score) results for trials 1 to 3 and for best performance</td>
<td>116</td>
</tr>
<tr>
<td>Imitation task performance across trials</td>
<td>119</td>
</tr>
<tr>
<td>Patterns of imitation performance</td>
<td>122</td>
</tr>
<tr>
<td>Delayed imitation</td>
<td>124</td>
</tr>
<tr>
<td>An imitative state</td>
<td>125</td>
</tr>
<tr>
<td>Relationships between Performance on the Imitation Task and Questionnaire Ratings</td>
<td>126</td>
</tr>
<tr>
<td>Secondary Imitation Measures</td>
<td>128</td>
</tr>
<tr>
<td>Maternal and infant imitation during free play at 9 months</td>
<td>130</td>
</tr>
<tr>
<td>Patterns of Performance Across All Imitiation Measures</td>
<td>137</td>
</tr>
<tr>
<td>Performance on Predictor and Concurrent Relationships Tasks</td>
<td>140</td>
</tr>
<tr>
<td>Infant Behaviour Questionnaire - Revised (IBQ-R) 4 and 9 months</td>
<td>140</td>
</tr>
<tr>
<td>Visual-Spatial Attention Task (VSAT)</td>
<td>141</td>
</tr>
</tbody>
</table>
Visual Proprioceptive Inter-modal Processing Task (VIP) ......................... 143
4-month VIP: Attention to the displays, discrimination and preference ....... 143
4-month VIP: Behavioural findings .................................................. 145
9-month VIP: Attention to the displays, discrimination and preference ....... 147
9-month VIP: Behavioural findings .................................................. 148
Visual Auditory Inter-modal Perception Task (VAIP) ............................. 151
Play session – 4 Months ................................................................... 151
Maternal imitation ............................................................................ 152
Maternal imitation and infant behaviour ........................................... 153
Play session – 9 Months ................................................................... 159
Relationships among maternal play behaviours ................................. 160
Relationships between infant and maternal play behaviours and ratings ...... 162
Gaze Following Task (9 months) .......................................................... 165
Object Exploration Task – Initiating Joint Attention Behaviours ............ 170
Relationships Between Initiating and Responding to Joint Attention ........ 171
Prediction of Imitation Abilities at 9 and 12 Months From 4-Month Measures ...... 171
Imitation and Temperament at 4 Months .............................................. 172
Prediction of imitation task performance ....................................... 172
Prediction of infant engagement during the imitation task .................... 176
Prediction of spontaneous imitation during free play .......................... 176
Prediction of parent report of infants starting to copy (at 9 and 12 months) .... 177
Prediction of parent report of sensitivity to being imitated (at 9 and 12 months) ................................................................. 178
Imitation and Mother-Infant Play at 4 Months ...................................... 181
Prediction of imitation task performance ....................................... 182
Prediction of spontaneous imitation during free play .......................... 183
Prediction of parent report of infants starting to copy (at 9 and 12 months)...... 183
Prediction of parent report of sensitivity to being imitated (at 9 and 12 months) ................................................................. 184
Imitation and Visual-Spatial Attention at 4 Months .................................... 186
Prediction of imitation performance at 9 and 12 months ....................... 186
Prediction of parent report of sensitivity to being imitated at 9 and 12 months ................................................................. 187
Imitation and VPIP 4 months ................................................................. 187
Prediction of imitation performance at 9 and 12 months ....................... 187
Prediction of parent report of sensitivity to being imitated (at 9 and 12 months) ................................................................. 189
Concurrent Relationships with Imitation Ability at 9 and 12 Months ........ 189
Imitation and Temperament at 9 Months .............................................. 189
Prediction of imitation task performance ........................................... 189
Prediction of infant engagement during the imitation task ..................... 191
Prediction of spontaneous imitation during free play ............................ 192
Prediction of parent report of infants starting to copy (at 9 and 12 months) ..... 192
Prediction of parent report of sensitivity to being imitated (at 9 and 12 months) ................................................................. 193
Imitation and Play at 9 Months ............................................................. 196
Prediction of imitation performance at 9 and 12 months ....................... 196
Prediction of parent report of sensitivity to being imitated (at 9 and 12 months) ................................................................. 198
Imitation and Visual-Spatial Attention at 9 Months ............................. 200
Prediction of imitation performance at 9 and 12 months ....................... 200
Prediction of parent report of sensitivity to being imitated at 9 and 12 months ................................................................. 201
Imitation and Joint Attention at 9 Months............................................. 202
Prediction of imitation performance at 9 and 12 months................................. 202
Prediction of parent report of sensitivity to being imitated at 9 and 12 months................................. 203
Imitation and VPIP at 9 Months .............................................................. 203
Prediction of imitation performance at 9 and 12 months................................. 204
Prediction of parent report of sensitivity to being imitated at 9 and 12 months................................. 205
Summary of Prediction and Concurrent Relationships Findings............................. 207

4. DISCUSSION .......................................................................................... 209

Methodological Considerations and Limitations .................................................. 210
Choice of Constructs and Tasks ........................................................................... 210
Sample Size ........................................................................................................ 212
Interpretation of Null Findings ............................................................................. 212
The Descriptive Nature of the Current Study ......................................................... 213
Imitation at the End of the First Year .................................................................... 214
The “Picture” of Imitation at the End of the First Year ........................................... 214
Elicited imitation ................................................................................................... 215
Approximations to imitation ................................................................................. 216
Spontaneous imitation ........................................................................................... 218
Parent report of imitation: Performance and perception ....................................... 219
Relationships between the imitation measures ....................................................... 222
Associations between performance and perception .............................................. 222
Imitative skill in different contexts ....................................................................... 224
Longitudinal Relationships .................................................................................... 225
Variability in Imitative Skill at 9 Months ............................................................... 225
Measurement Issues in the Study of Infant Imitation ............................................ 227
Validation of 4 and 9 Month Measures ................................................................. 228
Temperament: IBQ-R (4 and 9 months) ................................................................. 228
Visual-Spatial Attention Task (4 and 9 months) .................................................. 229
Visual-Proprioceptive Intermodal Perception (4 and 9 months) ....................... 229
  4-month VPIP findings .................................................................................. 229
  9-month VPIP findings .................................................................................. 231
Mother-Infant Play (4 and 9 months) ................................................................. 232
  4-month play session findings ...................................................................... 232
  9-month play session findings ...................................................................... 235
Initiating and Responding to Joint Attention (9 months) ................................... 236
Prediction of Imitation and Correlates at 9 Months ............................................ 238
  Visual-Proprioceptive Intermodal Processing .............................................. 238
  Visual-Auditory intermodal processing ....................................................... 242
  Visual-Spatial Attention ............................................................................. 242
Temperament .................................................................................................... 247
  9-month temperament relationships ......................................................... 253
Summary .......................................................................................................... 256
Mother-Infant Play ............................................................................................ 256
  4-month findings ......................................................................................... 256
  9-month findings ......................................................................................... 259
Summary (4 and 9 months) ............................................................................... 264
Joint Attention .................................................................................................. 264
Conclusions ...................................................................................................... 271
Implications for the Study of Imitation and Autism .......................................... 275
REFERENCES ................................................................................................... 278
APPENDIX A. Screening Phone Call and Interest Check ........................................... 299
APPENDIX B. 4 Month Demographics Form ............................................................. 300
APPENDIX C. Infant Behavior Questionnaire - Revised ........................................... 304
APPENDIX D. Imitation Questionnaires 9 and 12 Months ........................................ 313
   Imitation Questionnaire – 9 Months ............................................................... 313
   12-month Imitation Questionnaire ................................................................. 315
APPENDIX E. Description of Measures Coded During the 9 Month Play Session ...... 319
APPENDIX F. Informed Consent Documents at 4 and 9 Months ............................... 321
   Consent Form – 4-Month Visit ........................................................................ 321
   Consent Form – 9-Month Visit ........................................................................ 326
APPENDIX G. Questions on the KIDS and the MacArthur That Comprise the 
   Secondary Imitation Scores ............................................................................. 328
APPENDIX H. Detailed Findings from the IBQ-R .................................................... 329
   Age and sex differences .................................................................................. 329
APPENDIX I. Expected Chance Value for Proportion of Time Spent Looking at 
   Preferred Screen .............................................................................................. 340
APPENDIX J. VAIP Task Findings at 4 and 9 Months .......................................... 342
   4-Month VAIP Findings ...................................................................................... 342
   9-Month VAIP Findings ...................................................................................... 342

xiii
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Questionnaires and Tasks Administered at the 4- and 9-Month Visits</td>
<td>62</td>
</tr>
<tr>
<td>Table 2</td>
<td>Infant Behaviour Questionnaire-Revised (IBQ-R) Scale Descriptions</td>
<td>64</td>
</tr>
<tr>
<td>Table 3</td>
<td>Actions Demonstrated for the Infants During the Imitation Task</td>
<td>84</td>
</tr>
<tr>
<td>Table 4</td>
<td>Descriptive Data for the Imitation Questionnaire at 9 and 12 months</td>
<td>99</td>
</tr>
<tr>
<td>Table 5</td>
<td>Within Age Differences Between Parent Report Ratings of Imitation at 9 (N = 72) and 12 Months (N = 48)</td>
<td>100</td>
</tr>
<tr>
<td>Table 6</td>
<td>Age-Related Changes in Parent Report Imitation Performance From 9 to 12 months (n=44)</td>
<td>101</td>
</tr>
<tr>
<td>Table 7</td>
<td>Interrelationships Among Parent Report Imitation Scores at 9 and 12 months of age</td>
<td>102</td>
</tr>
<tr>
<td>Table 8</td>
<td>Number of Infants Who Can Perform and Imitate the Actions Demonstrated During the Imitation Task</td>
<td>111</td>
</tr>
<tr>
<td>Table 9</td>
<td>Percentage of Infants Who Fully Imitated the 9 Actions Across Trials 1-3 and Their Best Score</td>
<td>114</td>
</tr>
<tr>
<td>Table 10</td>
<td>Percentage of Infants Who Fully Imitated the 9 Actions Across Trials 1-3 and Their Best Performance for Category of Imitation (0-3 score)</td>
<td>115</td>
</tr>
<tr>
<td>Table 11</td>
<td>Number of Infants Engaging in Approximations to Imitation on Each of the 3 Trials</td>
<td>117</td>
</tr>
<tr>
<td>Table 12</td>
<td>Percentage of Infants Receiving Approximation to Imitation Scores For the 9 Actions Across Trials 1-3 and Their Best Score</td>
<td>118</td>
</tr>
<tr>
<td>Table 13</td>
<td>Relationships Between Ratings of Infant Engagement During the Imitation Task and Imitation Performance (Task and Parent Questionnaire) (N = 71)</td>
<td>126</td>
</tr>
<tr>
<td>Table 14</td>
<td>Relationships Between Parent Report of Infant Imitation Ability and Performance on the Laboratory Imitation Task</td>
<td>127</td>
</tr>
<tr>
<td>Table 15</td>
<td>Relationships Between Parent Report of Infant Imitation Ability on the KIDS and the MacArthur Questionnaires and Our Parent Report Imitation Questionnaire</td>
<td>129</td>
</tr>
<tr>
<td>Table 16</td>
<td>Relationships Between Spontaneous Infant Imitation During Free Play, Parent Report of Imitation Ability, and Performance on the Imitation Task</td>
<td>131</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Table 17</td>
<td>Performance by Free Play Imitators and Non-Imitators on the Imitation Task and on Parent Report of Imitation</td>
<td>132</td>
</tr>
<tr>
<td>Table 18</td>
<td>Percentage of dyads within each categorical classification of free play imitation</td>
<td>133</td>
</tr>
<tr>
<td>Table 19</td>
<td>Relationships between maternal imitative behaviours during 9-month free play and parent report of infant imitation at 9 and 12 months</td>
<td>135</td>
</tr>
<tr>
<td>Table 20</td>
<td>Relationships between maternal imitative behaviours during 9-month free play and infant imitation on the imitation task</td>
<td>136</td>
</tr>
<tr>
<td>Table 21</td>
<td>Accuracy of maternal imitation and testing behaviour in infants</td>
<td>157</td>
</tr>
<tr>
<td>Table 22</td>
<td>Relationships amongst maternal behaviours during play at 9 months (N = 69)</td>
<td>161</td>
</tr>
<tr>
<td>Table 23</td>
<td>Relationships among parent and infant behaviours and ratings during play at 9 months (N = 69)</td>
<td>164</td>
</tr>
<tr>
<td>Table 24</td>
<td>Number of infants engaging in confirmatory behaviours on each of the four trials</td>
<td>170</td>
</tr>
<tr>
<td>Table 25</td>
<td>Summary of Regression Analyses for 4-Month Temperament Variables Predicting Performance on the Imitation Task</td>
<td>174</td>
</tr>
<tr>
<td>Table 26</td>
<td>Summary of Regression Analyses for 4-Month Temperament Variables Predicting Parent Report of Infants Starting to Copy at 9 and 12 Months</td>
<td>177</td>
</tr>
<tr>
<td>Table 27</td>
<td>Summary of Regression Analyses for 4-Month Temperament Variables Predicting Parent Report of Sensitivity to Imitation at 9 and 12 months</td>
<td>179</td>
</tr>
<tr>
<td>Table 28</td>
<td>4-Month Play Session Measures Included in the Prediction of Imitation at 9 and 12 Months</td>
<td>182</td>
</tr>
<tr>
<td>Table 29</td>
<td>Summary of Regression Analyses for 4-Month Play Session Variables Predicting Parent Report of Infants Starting to Copy at 9 and 12 Months</td>
<td>184</td>
</tr>
<tr>
<td>Table 30</td>
<td>Summary of Regression Analyses for 4-Month Play Session Variables Predicting Parent Report of Sensitivity to Imitation at 9 and 12 months</td>
<td>185</td>
</tr>
<tr>
<td>Table 31</td>
<td>Summary of Regression Analyses for 4-Month VPIT Variables Predicting Imitation Production at 9 and 12 months</td>
<td>188</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>32</td>
<td>Summary of Regression Analyses for 9-Month Temperament Variables Predicting Performance on the Imitation Task</td>
<td>190</td>
</tr>
<tr>
<td>33</td>
<td>Summary of Regression Analyses for 9-Month Temperament Variables Predicting Parent Report of Infants Starting to Copy at 9 and 12 Months</td>
<td>192</td>
</tr>
<tr>
<td>34</td>
<td>Summary of Regression Analyses for 9-Month Temperament Variables Predicting Parent Report of Sensitivity to Being Imitated at 9 and 12 months</td>
<td>194</td>
</tr>
<tr>
<td>35</td>
<td>Summary of Regression Analyses for 9-Month Play Measures Predicting Imitation Performance at 9 and 12 months</td>
<td>197</td>
</tr>
<tr>
<td>36</td>
<td>Summary of Regression Analyses for 9-Month Play Scores Predicting Sensitivity to Being Imitated at 9 and 12 months</td>
<td>199</td>
</tr>
<tr>
<td>37</td>
<td>Summary of Regression Analyses for 9-Month VSAT Latency Scores Predicting Sensitivity to Being Imitated at 9 and 12 months</td>
<td>201</td>
</tr>
<tr>
<td>38</td>
<td>Summary of Regression Analyses for 9-Month VPIP Variables Predicting Imitation Performance at 9 and 12 months</td>
<td>204</td>
</tr>
<tr>
<td>39</td>
<td>Summary of Regression Analyses for 9-Month VPIP Variables Predicting Sensitivity to Being Imitated at 9 and 12 months</td>
<td>206</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Figure 1</td>
<td>Visual-spatial attention task setup</td>
<td>67</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Central stimulus for the visual-spatial attention task</td>
<td>67</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Stimulus display for the visual-auditory inter-modal processing task</td>
<td>70</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Task set-up and stimulus displays for the visual-proprioceptive inter-modal processing task at 4 months.</td>
<td>73</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Stimuli for the 9 month visual-proprioceptive inter-modal processing task</td>
<td>75</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Free play session at (a) 4 months and (b) 9 months</td>
<td>78</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Object exploration task at 9 months</td>
<td>81</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Imitation task at 9 months</td>
<td>83</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Breakdown of scores for full imitation and approximation to imitation</td>
<td>86</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Gaze following task at 9 months</td>
<td>89</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Infant behaviour when imitated by parent (questionnaire) at 9 months (N = 72)</td>
<td>105</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Relationship between 0-9 and 0-27 imitation scores (N=72)</td>
<td>120</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Performance across trials for (a) 0-9 full imitation and (b) 0-27 approximations to imitation scores. Error bars represent 95% confidence intervals.</td>
<td>121</td>
</tr>
<tr>
<td>Figure 14</td>
<td>4-group solution from the cluster analysis of approximations to imitation scores. Error bars represent standard deviations.</td>
<td>123</td>
</tr>
<tr>
<td>Figure 15</td>
<td>3-group solution from the cluster analysis of imitation performance measure. Error bars represent standard deviations.</td>
<td>139</td>
</tr>
<tr>
<td>Figure 16</td>
<td>Mean reaction times for shift and disengage trials at 4 and 9 months. Error bars represent 95% confidence intervals.</td>
<td>142</td>
</tr>
<tr>
<td>Figure 17</td>
<td>Comparison of mean proportions of time spent performing four observed behaviours while looking at the contingent and non-contingent displays at 9 months. Error bars represent 95% confidence intervals.</td>
<td>150</td>
</tr>
</tbody>
</table>
Figure 18  Mean difference scores in action watching and engagement ratings for infants of LMI and HMI mothers. Error bars represent 95% confidence intervals. ................................................................. 156

Figure 19  Differences in maternal behavior during the free play segment of the play session for HMI and LMI mothers. Error bars represent 95% confidence intervals. ................................................................. 158

Figure 20  (a) Gaze following score out of 4. (b) Number of infants receiving total gaze following scores (-4 to +4) when using a difference score. ........ 167

Figure 21  Percentage of infants demonstrating gaze following and target location (N = 60). ................................................................. 168

Figure 22  Number of infants achieving scores (out of 4) for target location ........... 169

Figure 23  Summary of 4-month predictors and concurrent relationships with 9-month imitation ability measures. ........................................ 208

Figure 24  Relationships among imitation, gaze following, and other joint behaviours ................................................................. 270
ABSTRACT

In this dissertation I provide a comprehensive description of imitation in a large sample of 9-month-olds, and I examine the prediction of imitation abilities at 9 months from performance on both social and non-social tasks at 4 months. Participants were 90 typically-developing infants and their parents who were seen at 4 and 9 months (77 families returned at the 9-month visit). Infants' imitation abilities were assessed within three contexts: (1) an elicited imitation task (vocal, gesture, object imitation with experimenter and parent), (2) spontaneous imitation during free play with their parents, and (3) parent report (ratings of infants' starting to copy and their sensitivity to being imitated). Predictor variables at 4 months included visual-spatial attention, visual-proprioceptive intermodal processing, maternal and infant play behaviours, and temperament. Concurrent relationships with imitation were also examined at 9 months; measures of joint attention were added to the other predictor variables. Consistent with previous research, infants as a group imitated actions on objects more frequently than gestures or vocalizations. However, considerable individual differences in imitative behaviour were noted. The current findings provide the first rich description of partial imitative behaviour at 9 months, and demonstrate that there is marked regularity in the behaviours that precede accurate action-copying. Relationships between imitative skill and sensitivity to being imitated indicate that these aspects of imitative behaviour during infancy share underlying mechanisms. An unexpected finding was that temperament emerged as the strongest predictor of imitative skill, whereas relationships with other predictor measures were not as strong as expected. Some of these associations might become more apparent in the second year, revealing differences between mechanisms that underlie higher levels of imitative behaviour, versus the early form of imitation examined in this study. The present results suggest avenues for future research, including implications for the study of developmental psychopathology.
### ABBREVIATIONS AND SYMBOLS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>Chi squared</td>
</tr>
<tr>
<td><em>ANOVA</em></td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td><em>IBQ-R</em></td>
<td>Infant Behavior Questionnaire – Revised</td>
</tr>
<tr>
<td><em>KIDS</em></td>
<td>Kent Inventory of Developmental Skills</td>
</tr>
<tr>
<td><em>M</em></td>
<td>Mean</td>
</tr>
<tr>
<td><em>MacArthur</em></td>
<td>MacArthur Communicative Development Inventories</td>
</tr>
<tr>
<td><em>RA</em></td>
<td>Research Assistant</td>
</tr>
<tr>
<td><em>SD</em></td>
<td>Standard Deviation</td>
</tr>
<tr>
<td><em>VAIP</em></td>
<td>Visual-Auditory Inter-Modal Processing Task</td>
</tr>
<tr>
<td><em>VPIP</em></td>
<td>Visual-Proprioceptive Inter-Modal Processing Task</td>
</tr>
<tr>
<td><em>VSAT</em></td>
<td>Visual-Spatial Attention Task</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

I first want to thank Isabel Smith, my supervisor, mentor, and friend. Without her
guidance and support, taking the road less traveled would have had much fewer pleasant
stops along the way. Balance, professional and personal identity, and asking meaningful
questions. Thank you for everything I have learned.

In so many ways, I have been privileged to have an excellent committee. I thank Ray
Klein, John Barresi, and my co-supervisor Chris Moore not only for their numerous
intellectual contributions, but also for meeting each of the tight deadlines that were set.

I want to thank all of the families and their infants who participated in this research. Their
interest and commitment to understanding their child's development made it easier to
keep pushing ahead.

Thank you to Brad Frankland for his much appreciated statistical advice, and to Teri
Phillips and the army of coders who helped code and organize an enormous amount of
data. I couldn't have done it without you.

This has been a long road from day one, and I am so grateful to my Halifax friends
Randy, Nadine, Ivan, and Nicole for all their encouragement and support. Without our
dinners, movies, and glasses of wine, this dissertation may not have come to completion.
Balancing internship and writing was a challenge. My network of friends and supervisors
in Denver, Mimi, Marina, Kayt, Meena, Judy, Susan, and Hal made it possible to not only
accomplish both, but to still enjoy life in Colorado.

Thanks to Joss Whedon whose brilliantly creative vision has helped to keep me sane over
the years.

Without fully understanding the mysterious process of a PhD dissertation, my family
took it all in stride, saying "we know you can do it, we're here for you". Seven years
later, it has come together, thanks in great part to their encouragement.

To my husband, J.P. Grossman, PhD. What do I say? Unwavering support and patience, technical magic, culinary genius, and knowing just how to make me laugh when I needed it most. You did everything, and all was possible because of you. This is our year…
INTRODUCTION

Infants are “veritable copying machines”. So said James Mark Baldwin in 1897 when he referred to infants’ propensity to copy the actions of others. Despite much research describing this complex developmental phenomenon, there remains a paucity of data addressing the precursor skills, experience, and concomitant abilities that contribute to imitative ability. What makes an infant a skilled imitator? What processes are important in the development of the capacity to imitate? Numerous theories propose putative mechanisms yet there exist no direct tests of these. By drawing on the typical developmental literature and on research on developmental psychopathological imitation impairments, the current study seeks to assess empirically the predictive relationship between information-processing skills at 4 months and the early capacity to imitate at 9 months. Concurrent relationships between these skills and imitation ability at 9 months are also examined.

A review of the developmental literature on imitation follows and first addresses how imitation has been defined by investigators, including where imitation fits within the context of a social learning framework. Next, the developmental importance of imitation is outlined, followed by a review of studies examining both imitation and sensitivity to being imitated within the first year. Theories of imitation, both classical and modern, are then discussed, followed by a summary of possible mechanisms underlying imitation. Included is a brief discussion of impairments seen in autism and theoretical links between these impairments and the difficulties individuals with autism have in imitating others. Lastly, the present study is described.
Defining Imitation

Interest in imitation has a rich history across a wide-ranging body of disciplines including art, theology, anthropology, philosophy, primatology, cognitive neuroscience and artificial intelligence, and within various fields of psychology such as comparative, social, evolutionary, cognitive and developmental. Due to the diversity of approaches, since its earliest study imitation has been conceptualized in a number of ways. Many labels have been used to describe the broad phenomena of imitation and related social learning behaviour, including: stimulus enhancement (Spence, 1937), matched dependent behaviour (Miller & Dollard, 1941), mimesis (Armstrong, 1951), true imitation (Thorpe, 1956), social facilitation (Zajonc, 1965), observational conditioning (Mineka et al., 1984), emulation (Tomasello, 1990), and contagion (Levy & Nail, 1993; Whiten & Ham, 1992).

While some researchers have used the term imitation in its broadest sense to indicate general copying behaviour (e.g., Meltzoff and Moore, 1989), others have argued for a more restrictive characterization of imitative behaviour (focusing on similarity to the model, Galef, 1988, or novelty of responding, Thorpe, 1956; Zentall, 1996), and for strict requisites for “true” imitation. Researchers have proposed lists of criteria for a behavioural act to constitute imitation, resulting in considerable narrowing of the scope of its definition. Byrne (2002) has argued that strictly defining which actions can be classified as imitative permits a better understanding of the range of mechanisms (imitative or not) that enable “learning to do an act from seeing it done” (p. 124). According to Byrne, a set of necessary conditions for a behaviour to be considered imitative include: (1) an act that is sufficiently complex that its origin can be traced (e.g.,
the imitator makes errors during production of the act; (2) copying that is dependent on observing a model's action; (3) a lack of environmental constraints that could otherwise shape or reinforce the behaviour; and (4) the behaviour that is acquired / produced by the imitator is novel. With the refinement of definitions over the years many instances of what were previously considered imitative responses have come to be regarded as other forms of observational learning (e.g., stimulus enhancement, Spence, 1937).

Recently, a number of attempts to differentiate the various types of social learning have been put forth. Want and Harris (2002) presented a conceptual framework within which five forms of social learning, including imitation, are distinguished and organized hierarchically. Local enhancement (Thorpe, 1956/1963) works by increasing interest in the location where an individual has seen another perform a particular action. Stimulus enhancement occurs in a similar manner with the exception that enhanced interest is directed towards the object and not the location. Emulation (Tomasello, 1990) refers to acquired understanding about the causal relationships between objects. Attention is not paid to the model's actions or goals, but rather to the results of the action. Replication of the results occurs, but not necessarily by the same means as the model. A separate but related definition of emulation has also been presented by Whiten and Ham (1992): individuals engage in goal emulation when they learn by observation that a particular goal can be achieved and choose a means to reach that goal. In contrast to emulation, mimicry and imitation involve paying attention to and learning about a model's actions. Tomasello, Kruger, and Ratner (1993) defined mimicry as replication of a model's actions without insight into the effectiveness or goal of the action, whereas imitation also requires recognition of the model's goal. Imitation is further broken down into two forms:
blind imitation, which occurs when the action and its effect are copied without understanding of the link between the action undertaken and the goal, and insightful imitation, whereby individuals learn about the relation between the action and the effect (Want & Harris, 2002). Want and Harris (2002) proposed that such a taxonomy of social learning provides important insight into what process is involved in a given observational learning situation. When researchers have knowledge of what information an observer brings to the experience, controlled study designs can potentially enable the distinction between various forms of social learning (e.g., mimicry and imitation).

Developmental Emergence of Forms of Social Learning

To address the question as to whether social learning mechanisms emerge in an age-related manner, Want and Harris (2002) proposed that over time, infants' observational learning transitions from replication of actions only (mimicry) to the ability to represent the demonstrator's goals. In their model, Tomasello and Carpenter (2004) present a similar developmental progression, suggesting that intention reading in imitation arises in typically developing infants at around 14-15 months. Prior to 14 months, infants are capable only of mimicry or emulation (0-9 months), or imitative learning (learning to perform a novel action by imitating a model, 12-14 months). As they get older, infants are argued to focus on the intentions of the model and respond accordingly, with “intention-reading” becoming the primary method driving the re-enactment of others’ behaviour.

While a developmental framework is clearly useful for many reasons, there is a danger of considering infant behaviour as moving along a strictly linear path towards demonstrating increasingly sophisticated understanding. Other authors have argued that
while forms of social learning likely emerge in an age-related progression, eventual use of different processes (e.g., emulation versus mimicry versus imitation) is not necessarily hierarchical. In a commentary on Want and Harris (2002), Barr (2002) argued that implementation of a particular social learning mechanism will be strongly influenced by a number of factors including age, task complexity, the model, the number of exposures to the modeled action, and mode of presentation (see also Barr & Hayne, 1999). Bauer and Kleinknecht (2002) also presented evidence that task difficulty and the demand a task places on infants’ attentional abilities influences whether they resort to simply “aping” a model or emulating. In their study, twenty-month-old infants used emulation, imitation, or both strategies across two trials of replicating a 2- and 3-step causally-related sequence (Bauer, 1992). More research is needed regarding the developmental progression of social learning, particularly from the midway through the first year into the second year when critical changes are occurring with respect to infants’ copying skill and their growing representational abilities.

The present study examines “imitation” as is manifest at the end of the first year. We use a broad definition of imitation as the production of a behaviour (motoric or verbal) that is topographically similar to a behaviour previously observed. This behavioural definition of imitation is consistent with what most authors present as encompassing imitative phenomenon (Mitchell, 2002). Within Want and Harris’ (2002) framework, the behaviour of infants in the present study would be described as mimicry or emulation. As the purpose of the current study is to examine precursors and concurrent relationships with “copying behaviour” demonstrated by infants at 9 months, we argue
that use of a broad (yet not all-encompassing) and behavioural definition of imitation is warranted.

_The Developmental Importance of Imitation_

Imitation is a critical and powerful developmental phenomenon, serving a host of functions in infancy and childhood (Nadel, Guerini, Peze, & Rivet, 1999; Nadel, 2002; Uzgiris, 1981). Perhaps the earliest function of imitation is social-communicative. Imitation aids in the establishment of interconnectedness between infant and parent, affect sharing and sharing of mutuality (Meltzoff & Moore, 1983; 1999; Uzgiris, 1981). For pre-verbal children, imitation also serves a communicative purpose with social partners (Meltzoff & Gopnik, 1993; Trevarthen, Kokkinaki, & Fiamenghi, 1999).

As a potent learning mechanism, imitation also facilitates cognitive development and acquisition of specific skills. It is a strategy that enables rapid learning and mastery of new behaviours, often sidestepping lengthy trial-and-error approaches (Meltzoff & Moore, 1983; Yando, Seitz, & Zigler, 1978). The cognitive function of imitation provides a window for understanding events in the physical world (Piaget, 1954/1962; Uzgiris, 1981), and through reproduction of parents’ vocalizations and behaviours, infants’ communicative and adaptive learning develops. Piaget (1945/1962) described imitation as a precursor to symbolic functioning, and research has demonstrated an association between language development and imitation (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bloom, Hood, & Lightbown, 1974; Meltzoff & Gopnik, 1989; Snow, 1981; 1989). Within early imitation also lie the roots of later-emerging cognitive and social-cognitive abilities. Meltzoff and Gopnik (1993) have considered imitation to be fundamental to later development of an understanding of others’ beliefs and intentions. In
a more detailed argument, Barresi and Moore (1996) proposed that through imitation children first learn correspondences between self and others and become aware of intentionality in actions. Meltzoff and colleagues have also suggested that infants use imitation to learn about the identities of people (Meltzoff & Moore, 1992; 1994; 1995) and that via imitation, infants develop a “like me” stance in their interpretation of others’ actions, leading to the development of empathy and role-taking.

Imitation as an interpersonal phenomenon has perhaps overshadowed the role imitation plays in intrapersonal development. A third function of imitation in infancy is to facilitate ego development. Rochat (2002) considers imitation as a mechanism by which infants come to see themselves as objects of reflection. Very early on, infants begin to engage in self-imitation, the reproduction of one’s own actions. By approximately 2 months, infants begin to move their limbs in periods of apparent visual exploration (Piaget, 1952). These repeated, self-exploratory movements enable the infant to establish an intermodal awareness of their own body, thus facilitating a sense of self as separate from objects in the environment (Rochat, 1995; 2002). According to Rochat, they are also the first signs that the infant is also developing a sense of self-agency, taking a “contemplative stance”. Thus, in addition to the social-communicative and cognitive functions served by imitation of others, repetition of one’s own actions arguably plays a critical role in ego development.

*The Study of Imitation as a Developmental Phenomenon*

The study of imitation has a long history within developmental psychology, beginning with the classic theories of James Mark Baldwin (1894, 1903), Paul Guillaume (1926/1971), Jean Piaget (1945, 1962), and Lev Vygotsky (1978). However, despite the
attention paid to imitation by early influential theorists, the period until the 1970s saw a
dearth of developmental research on this critical skill. Yando, Seitz and Zigler (1978)
suggest that one of the primary reasons was the predominance of learning theory
approaches, which are essentially non-developmental. Additionally, some of the early
definitions of imitation were quite restrictive, reserving the term “imitation” for
behaviour demonstrated by infants older than 18 months of age (e.g., Wallon, 1942, as
cited in Nadel & Butterworth, 2002). As a result, only in the last 30 years has attention
again been paid to imitative behaviour within the first year. From the 1970s, the study of
imitation has ebbed and flowed, with consideration of imitative skill at different ages
(e.g., at birth, in the first year, in the second year) garnering primary focus at different
times. Currently, the study of intentional understanding and imitative behaviour between
14 and 24 months has come to the forefront. However, it was the study of neonatal
imitation that began the rediscovery of imitation as a phenomenon of scientific interest.

*Neonatal Imitation*

From the late 1970’s, Meltzoff and Moore have suggested that human infants
imitate a range of facial expressions at birth, including mouth opening, tongue protrusion,
and lip protrusion (1977; 1997). Their interpretation of their findings sparked a
controversy regarding the nature of apparent imitation in early infancy, and a flurry of
empirical studies aimed at confirming or refuting the early results. While a number of
laboratories replicated Meltzoff and Moore’s findings, Anisfeld and colleagues (1979;
1991; 1996; 2001; 2002) have long argued that the conclusions drawn in support of
neonatal imitation are overreaching. In a re-analysis of the entire body of findings on
early imitation, Anisfeld (2001) concluded that observing tongue protrusion increases the
subsequent rate of tongue protrusion in neonates but that this finding does not generalize to any other gesture. A careful examination of the methodology used in these studies indicates that the designs were sensitive enough to detect differences if present. Given that only one facial gesture is matched by infants during the first few months, Anisfeld concluded, more parsimoniously, that tongue protrusion in response to a model can be attributed to an arousal response on behalf of the infant, possibly via an innate releasing mechanism (Turkewitz, Gardner, & Lewkowicz, 1984). Meltzoff and Moore (1977; 1997) have argued in response that infants are capable of facial imitation by way of an innate “supramodal” representation of the observed gesture. Their “active intermodal mapping” (AIM) hypothesis posits that an “equivalence detector” enables the infant to detect correspondences between their own and the model’s behaviour. A proprioceptive feedback loop then permits active comparison following the imitative response. Anisfeld and others (e.g., Heyes, 2001) suggest that this theory attributes mental capacities to newborn infants far beyond what can be justified on the basis of the evidence.

Use of the term imitation and invoking a visual-proprioceptive mechanism functioning at birth implicitly suggests that earlier forms of action copying are related to later forms, though Meltzoff and Moore (1977, 1997) make no explicit connections between neonatal and later imitation in their model. To date, few data are available to support or refute this supposition given the paucity of longitudinal studies of imitation during the first year. One might argue, based on work by Anisfeld and others that the mechanisms underlying neonatal copying are different than those that are responsible for later forms of imitation. Goldman-Rakic (1985) and Vintner (1986) have suggested that subcortical processes are likely responsible for neonatal matching behaviour, whereas
cortical processes mediate later-developing imitation. Heimann and Ullstadius (1999) reported one of the few longitudinal studies of imitation in year one. Elicited imitation tasks were conducted with infants at 3 weeks, 3 months, and 12 months. Individual differences in imitation ability at 12 months were related to those at 3 months, but not at 3 weeks, thus providing preliminary evidence that refutes the supposition that later forms of imitation develop continuously from early forms. Replication of these findings is necessary, as is more longitudinal work that examines relationships between forms of imitative behaviour at different ages.

Despite contradictory evidence, many researchers continue to accept Meltzoff and Moore's assertion that neonates are capable of facial imitation via an innate inter-modal matching system. The acceptance of this claim has had a significant impact on the direction of developmental research in imitation and has shaped both developmental theory and views of psychopathology (e.g., imitation deficits in autism).

*Moving Beyond the Neonatal Period: Matching Behaviour from 2 to 6 Months*

While considerable research has focused on the imitative abilities of neonates, much less work has addressed the ontogeny of imitation during infancy. A few studies have examined copying behaviour longitudinally during the first months of development (Gattis & Perra, 2004; Heimann & Ullstadius, 1999; Kugiumutzakis, 1999; Maratos, 1973, 1982; Vinter, 1985). Findings from these studies suggest that early matching behaviour does not increase steadily during the first few months. Rather, declines in response to modeled actions (e.g., tongue protrusion and mouth opening) have been observed. A number of hypotheses have been proposed to account for this decrease (e.g., a decline in reflexes; Jacobson, 1979), but these have not been tested. In fact, little is
known about relationships between early matching behaviour and imitation in the second half of the first year, and whether similar processes and developmental functions are involved.

Lewis and Sullivan (1985) examined exact matches and partial imitations of manual and facial movements in a cross-sectional study with groups of 2-week, 3-month, and 6-month-old infants. Results indicated that 6-month-olds made fewer exact matches and more partial imitations than did the younger infants. The authors suggested that exact matches early in infancy are distinct from later-developing approximations to the model and that partial imitations occurring at 6 months are indicative of the emergence of a different imitative behaviour. Consistent with the findings of Heimann and Ullstadius (1999), these data support a hypothesis of discontinuity between early and later forms of imitation. Imitation in infants from birth to approximately 3 months may be characterized by certain features (e.g., more direct featural matching). Between 3 and 6 months, different processes may be involved in infants’ emerging imitative capabilities.

*Imitation in the Second Half of the First Year*

Studies conducted primarily during the 1970s and 80s provided descriptive accounts of the types of actions infants are able to imitate at various ages (e.g., actions with or without objects and visible and non-visible gestures), and discuss the developmental functions (e.g., cognitive, social) that imitation serves. Interest in imitation has recently shifted to the role of imitation in informing our understanding of infants’ developing intentional awareness, and has focused on the period from 14 to 24 months. Thus, there exist gaps in the imitation literature, with relatively few studies conducted between the neonatal period and toddlerhood, and little investigation of the
links between earlier forms of matching behaviour and more mature forms of imitation. Additionally, little research has empirically addressed what earlier or concomitant abilities contribute to the development of this important skill. What follows therefore is a comprehensive review addressing the development of imitation and related abilities within the first year.

The end of the first year is a crucial period in the growth of symbolic representational capacities, transitions in language development, and triadic interactions. Infants begin to demonstrate gaze following, protodeclarative pointing, showing, and social referencing (Corkum & Moore, 1998; Rochat & Striano, 1999) and to acquire conventional communicative gestures (Masur, 1983). Parallel transitions are seen in imitation skills towards the end of the first year. From approximately 6 to 12 months, the undisputed ability to copy another’s actions emerges and undergoes significant changes. Piaget’s (1964) developmental timetable for infants’ emerging imitation skills suggests a gradual progression whereby sporadic matching of vocalizations and gestures first appears after the first month (1-4 months: before that, infants are incapable of imitation) and is highly influenced by external rewards and training (“imitation by training”). Imitation of vocalizations and familiar actions that the infant can see herself reproducing begins to occur between 6 and 8 months, while imitation of non-visible facial models and unfamiliar actions is not evident until approximately 12 months. Through growth in representational abilities, deferred imitation (copying in the absence of a model) also arises at the end of the first year.

Few longitudinal studies exist that can address Piaget’s proposed general progression of imitation skills during infancy. With a few notable exceptions (e.g.,
Abravanel, Levan-Goldschmidt, & Stevenson, 1976), cross-sectional studies currently provide the most information about the developmental course of imitation from 6 to 18 months of age. For the present purpose, we will restrict our discussion of the literature to age-related changes in imitation from 6 to 12 months of age. Data from experimental and observational studies provide a fairly consistent picture of the developmental course of imitation during this period, demonstrating age-related changes in both what can be imitated, and in the accuracy of infants' imitation (McCall, Parke, & Kavanaugh, 1977).

**Developmental timeline: What infants are able to imitate in the second half of the first year**

Findings from imitation studies with infants less than a year old indicate that cognitive and motor maturation set the upper limits for what an infant is capable of imitating (Piaget, 1964; Rochat, 2002; Uzgiris, 1999). These abilities interact with the nature of what is to be imitated (e.g., a vocalization, an object-directed action) in determining whether an infant at a particular age will be able to produce a similar response to a modeled action. Few studies have examined imitation of many types of actions in the same design (Uzgiris, 1999). However, those that have addressed differential rates of imitation across actions suggest somewhat separate time courses within the first year for copying gestures, vocalizations, and actions on objects (Masur, 1993).

Abravanel, Levan-Goldschmidt, and Stevenson (1976) examined the pattern of action imitation development in infants from 6 to 18 months of age. A small sample of 14 infants was seen longitudinally from 6 to 18 months at 3-month intervals, in addition to a cross-sectional sample (n = 44) of 9, 12, and 15-month-olds. Twenty-two actions, including gestures and object-directed actions, were demonstrated. By 6 months, many of
the infants had begun to imitate familiar, practiced actions on objects such as shaking, placing, and patting surfaces. These instances of imitation were the earliest noted in the sample and continued as part of a sharp developmental trajectory for imitation of actions on objects between 6 and 15 months. In contrast, little imitation of non-visible body gestures (e.g., shake head, open and close mouth, smack lips) was observed in the younger infants and the developmental progression was considerably flatter.

The findings of Abravanel and colleagues (1976) are consistent with other observations. Imitation of actions on objects typically emerges between 6 and 9 months of age as infants’ motoric abilities mature and interest in objects increases (Piaget, 1962; Meltzoff, 1988a). Both Uzgiris (1973) and Rodgon and Kurdek (1977) noted that during this period actions with objects tended to elicit more imitation than other behaviours. McCall, Parke, and Kavanaugh (1977) found that even at 12 months, imitation of object-directed actions was greatest compared to gestural or vocal imitation. Killen and Uzgiris (1981) reported age-related increases in object-directed imitation from 7½ to 22 months, with the youngest infants imitating simple, familiar actions (e.g., banging or shaking a block). By 10 months, infants were beginning to imitate functional actions on objects such as pushing a car and walking a toy dog.

The developmental course for imitation of gestures without objects is less straightforward. Kaye and Marcus (1978, 1981) found that with multiple, repeated exposures to the modeled action as directed by the infant, infants could demonstrate visible imitation at approximately 6 months, but that spontaneous, imitation of non-visible gestures begins to occur towards the end of the first year. These data suggest that learning can make a difference in the emergence of imitative abilities which Piaget
(1964) claimed required representational capacities that do not develop until 9 months. The relative roles of learning and cognitive transformations in determining imitative capacity are important to understand (Heyes, 2000).

Rogdon and Kurdek (1977) noted high levels of object-directed imitation by infants at 8, 14, and 20 months of age, but far fewer instances of vocal and gestural imitation across all ages. A difficulty in mapping the developmental trajectory of gestural imitation in the first year has been the lack of distinction among actions that vary across a number of parameters (e.g., visible and non-visible, communicative and non-communicative, familiar and unfamiliar: Abravanel et al., 1976; Masur & Ritz, 1984) that vary in level of difficulty. Imitation of non-visible and non-meaningful actions have been found to be more difficult for infants than are actions they can watch themselves perform and that are socially meaningful (e.g., clapping, waving: Masur & Ritz, 1984; Parton, 1976; Uzgiris & Hunt, 1975); however the developmental priority of visibility versus meaningfulness has not been addressed, nor whether different mechanisms contribute to imitation related to these two variables.

Temporal parallels have been observed between the emergence of vocal imitation and language development at the end of the first year, and a theoretical connection between the two abilities has been posited (e.g., Meltzoff & Gopnik, 1989). However, in contrast to the study of language development, surprisingly little empirical research has examined the development of vocal imitation within the first two years (Masur, 1993). The youngest infants in the few studies that have addressed age-related changes in vocal and verbal imitation were typically 10 to 12 months of age, with 8-month-olds assessed in one study (e.g., Masur & Ritz, 1984; Masur, 1993; McCall et al., 1977; Rodgon &
Kurdek, 1977). These infants tended to demonstrate some imitation of sounds (e.g., “eeeee”), but not words; imitation of vocalizations gradually increased over time. Masur (1993) found that imitation of words lagged behind copying of all other models at 10 months, but that by 17 and 21 months of age, infants were imitating words significantly more than other actions.

In summary, infants begin to be able to reproduce simple and familiar object-directed actions approximately mid-way through the first year. Imitation of visible gestures follows, with infants copying familiar, socially meaningful gestures (e.g., waving) more than arbitrary gestures (although imitation of these is susceptible to training). Towards the end of the first year, imitation of non-visible gestures emerges, as does imitation of vocalizations, which can be considered a paradigm case of non-visible gestures. At this time, infants are also capable of imitating actions that are moderately discrepant from familiar schemas. Reproduction of completely novel behaviours (e.g., put ring on teddy bear’s arm, push a button on a box) and imitation of words, appear towards the beginning of the second year (McCall, Parke, & Kavanaugh, 1977; Meltzoff, 1988a, 1988b, Parton, 1976; Uzgiris & Hunt, 1975). In general, imitation proceeds from the simple and familiar to the complex and novel; studies report steady age-related increases in average scores on imitation batteries (e.g., Masur, 1993; Masur & Ritz, 1984).

Given the critical role imitation is presumed to play in later-developing social-cognitive abilities, language and learning, one would expect that the development of imitation within the second half of the first year would warrant careful analysis. However, the literature is sparse and it is particularly striking that longitudinal studies are lacking. There is a paucity of recent developmental studies that build on the work
conducted in the 1970s and 80s. Authors of those studies argued for the need to examine developmental relationships among various forms of imitation, and for a detailed approach to delineating transitional periods in imitative capacity such as the shift from imitation of familiar to novel actions, and from imitation of visible to non-visible actions. There are no studies investigating predictors of imitative proficiency at the end of the first year, and few studies have examined concurrent relationships with other abilities. Earlier work has laid a descriptive foundation, and identified some critical gaps, yet these have not been addressed. Carpenter, Nagell, and Tomasello (1998) conducted a longitudinal investigation, starting at 9 months, of mature forms of imitative learning and other social-cognitive abilities. Knowledge of whether similar or different relationships are evident among constructs will be important in addressing the question of developmental continuity of forms of imitation. Currently, the mechanisms underlying imitation in infancy and its early development continue to be poorly understood.

*Developmental progressions in the accuracy of infants' imitative responses*

In addition to age-related changes in the kinds of actions infants imitate, their reproductions of a model's demonstrations become more accurate over time. Though Piaget (1962) described instances of early attempts to imitate that involved homologous responses with different body parts (e.g., J's opening and closing hands in response to a model's eye blinks at 11 months) and partial copying (between 8 and 9 months), little regard has been paid to approximations to imitation in the experimental literature (but see Kaye & Marcus, 1978, 1981, and Meltzoff & Moore, 1997). Infants are often assessed on a single trial and are scored as imitating or not, with partial imitations scored as failures. Pioneers in the field of infant imitation have argued that it is critical to not think of imitation as an all-or-none phenomenon (Kaye & Marcus, 1978, 1981; Uzgiris, 1972).
Infants have been observed to gradually match a model over successive trials during a single assessment period and, between 6 and 12 months, come to imitate both actions and vocalizations more precisely. The study of approximations can provide important insights into the nature of imitation and how infants begin to imitate.

Based on findings from a longitudinal study of the imitation of vocalizations and gestures, Uzgiris (1972) proposed a four-phase sequence of the development of imitation from (1) partial imitation to (2) responding to the model but not necessarily with a matching response to (3) attempts to approximate the action of the model, and finally to (4) reasonably accurate imitation (fully emerging between 19-23 months). Kaye and Marcus (1978) went beyond the traditional elicited imitation paradigm (a single demonstration of an action followed by a brief observation of the infant’s behaviour). They made demonstrations contingent on infant attention, in effect allowing 2-to-26 week old infants to control the presentation of the action. When the infant made eye contact with the experimenter, the model (e.g., opening and closing mouth 5 times) was presented. This sequence of eye contact followed by modeling of the action continued for as long as the infant was interested. The authors found that after a series of trials, 6-month-old infants made “bursts” of one or two mouth openings. These occurred following a progression of approximations beginning with orienting attention to the model, moving the mouth, matching single features of the model (e.g., opening the mouth), and finally opening and closing the mouth. Infants did not necessarily maintain or improve upon their performance on each subsequent trial, but rather gradually approximated opening and closing in a non-linear fashion. Kaye and Marcus (1978) noted that the general sequence of accommodation that they observed replicated the
Piagetian stages of imitation within the first year. They suggested an approach to understanding infant imitation that considers the development of speed and efficiency in infants’ responses.

In 1981, Kaye and Marcus extended their earlier work by conducting a small sample (N = 6) longitudinal study with infants from 6 to 12 months of age. Six actions were presented to the infants and, as before, the infants themselves dictated how many trials would occur based on their attention and interest level. Consistent with previous findings, infants matched the model’s actions by gradual approximations over trials and months. Kaye and Marcus noted the considerable variability in performance across infants and from month to month; the highest levels achieved by infants in one month were not necessarily maintained during the following month. These findings suggest that individual differences in imitation during the first year are important to investigate, and that a comprehensive understanding of infant imitation requires going beyond the question of capacity.

In summary, detailed examination of infants’ responses is essential to delineating the course of imitative learning and may provide insight into the processes involved. Partial imitations may demarcate transitional periods in infants’ changing imitative capacity, and the mechanisms underlying approximate responding may be different than those that contribute to the ability to make a perfect match.

*Capacity versus performance: Beyond the cognitive-developmental theory of imitation*

Piaget emphasized a cognitive-developmental approach to understanding growth in imitation within the sensory-motor period. Other authors have argued that factors such as environments, social contexts, experience, behavioural goals, motivation (both
external reinforcement and intrinsic motivation) and individual differences are also strong influences on development (Yando & Zigler, 1978) and may affect how likely it is that the infant will demonstrate skills within her repertoire. A number of studies have examined the role of variables other than characteristics of the modeled action and infants’ age and cognitive capacity. The influence of the social context of imitation has been studied (e.g., Bandura, 1977), as have differences across models (e.g., mother versus experimenter: McCabe & Uzgiris, 1983), motivation (McCall, Parke, & Kavanaugh, 1977), and goals (Uzgiris, 1999).

Individual differences have received considerably less attention. Though significant variability has been reported in the tendency of infants at a similar developmental level to copy adult actions, few studies have attempted to understand the sources of these individual differences in imitative expression or capacity. Of interest to the current study is the role that temperament might play in influencing infant imitation. Associations have been proposed between neonatal matching tendencies and temperament (Field, 1982; Heimann, 2002), but not with later imitation. Heimann, Nelson, and Schaller (1989) demonstrated positive relationships between activity level and attentiveness and matching behaviour at 3 weeks and at 3 months. In a later study (Swerlander, 2001, cited in Heimann, 2002), relationships between imitation and temperament were not found at 9 months, with the exception of a single significant correlation between “attentiveness” and deferred imitation. More work is needed to determine how temperamental attributes affect infants’ tendency to show imitative behaviour. Are infants who are more expressive, socially engaging, and attentive to other’s behaviour more demonstrative in an imitative context? Do infants who are more
attentive and enjoy particular kinds of social experiences (e.g., high activity level versus calm and easily soothed) learn to imitate more readily? Many questions remain about the impact early personality and temperament characteristics have on infants’ tendency to imitate, and the ability to do so accurately, in the second half of the first year.

Summary

Overall, experimental and observational studies indicate that age-related changes in imitation occur predictably along a number of dimensions and are generally consistent with Piaget’s developmental timetable. Younger infants begin by copying simple and familiar actions and progress towards being able to imitate a greater range of behaviours (e.g., more novel and complex actions; Masur & Ritz, 1984; McCabe & Uzgiris, 1983) and coordinated series of actions near the end of the second year (McCall, Parke, & Kavanaugh, 1977). Older infants are also more accurate in their imitation and tend to exhibit more imitation overall (Killen & Uzgiris, 1981; Masur, 1993; Pawlby, 1977). Analyses that examine partial imitations indicate that infants work up to higher levels of accuracy both over trials and as they get older. A hierarchical approach to coding infant imitative behaviour may contribute to a fuller understanding of individual differences, developmental prerequisites, and correlates. Finally, while the cognitive-developmental perspective is essential to understanding imitation during infancy, a more comprehensive picture is provided by also considering other factors that influence infant behaviour and development (e.g., early social experiences, motivation, goals).

Sensitivity to interpersonal contingencies and being imitated by others

Infants’ responses when they are being imitated by social partner (imitation perception versus performance) may share some of the same underlying mechanisms with imitation. We suggest that infants who are better able to recognize when they
themselves are being imitated might become better (or earlier) imitators. To date, no study has examined these two facets of imitation ability together.

Understanding of representations of perceived and produced actions has been a focus of interest within the adult cognitive literature for a number of years (Decety, 2002, 1996; Jeannerod & Decety, 1995). The recent discovery of “mirror neurons” in monkey premotor cortex (neurons that have been observed to fire in a like manner when monkeys are observing a modeled action as when they are performing that action themselves; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996; Rizzolatti, Fadiga, Fogassi, & Gallese, 2002) has led to speculation about the neural underpinnings of imitation and the psychological processes involved. Though there is currently no direct evidence of mirror neurons in human infants, interest in the implications of their existence for the study of imitation has grown (Decety, 2002; Prinz, 2002). From a developmental perspective, the link between perception and production of actions and the ontogeny of this connection during infancy is particularly significant. Insight into the neural basis of imitation will contribute to the understanding of its development, however much still remains to be understood at a process level about relationships between perception and action. Research is needed that identifies the associations during development between sensitivity to being imitated and imitative skill, and that describes the nature of observed relationships.

*Sensitivity to social contingencies*

Like imitation, recognition that one is being copied also follows a developmental course, starting with awareness of interpersonal contingencies in social interactions. Evidence of sensitivity to temporally-contingent responding on behalf of a social partner has been noted in infants as young as 6 weeks. If social responsiveness is violated within
the context of a “still-face” paradigm (mother maintains a still, neutral face during an interaction with her infant), infants become upset (Murray & Trevarthen, 1985; Muir & Nadel, 1998).

Behaviour during parent-infant dyadic interactions has been extensively studied. Stern (1985) wrote that parents primarily imitate the actions of their young infants, and empirical investigations show that parents match their infant’s affect and the intensity and tempo of their actions, but imperfectly (that is, parental behaviour is not random, but also is not a perfectly contingent match to their infant’s behaviour; Gergely & Watson, 1996; 1999). Uzgiris, Vase, and Benson (1984) found maternal imitation during 20% of free play segments between mothers and their 3-month-old infants. Through these early social experiences with parents, infants become sensitive to imperfect social contingencies and during the second quarter of their first year demonstrate, via preferential looking and conditioning paradigms, the ability to discriminate between contingent and non-contingent adult behaviour (Bigelow, 1996; Bloom & Esposito, 1975; Field, 1977). Social contingency detection has been suggested to contribute to infants’ developing self-knowledge, their ability to distinguish self from other, and sensitivity to contingencies in the non-social environment (e.g., Watson, 1979). If imitation performance and awareness of being imitated rely on similar mechanisms, early detection of social contingencies during the second quarter of the first year may be related to emerging imitation skills in the second half of the first year.

*Imitation detection*

Beyond awareness of social contingencies, imitation detection necessarily involves perceiving that not only is a social partner responding contingently to one’s own
behaviour, but that the form of the response resembles that of the action performed. A few studies have examined early awareness of having been imitated.

In 1977, McCall and colleagues conducted a study in which 15-, 18-, and 24-month-old infants were given two toys and seated across from an experimenter who had an identical set of toys. When the infant performed pre-determined target behaviours with a toy, the experimenter either imitated the infant’s behaviour or displayed an alternative target behaviour with the other toy. Although the experimenter responded contingently in both conditions, infants “acted-paused-looked” more frequently following imitation than during the alternative condition. “Action-pause-look” behaviour increased from 15 to 18 months, then decreased sharply in 24-month-olds. The authors argued that being imitated was more likely to lead to a reciprocal social behaviour at 18 months as infants are becoming aware of their own social influence on others. By two years, infants’ cognitive abilities have developed such that being imitated no longer drives this awareness.

Meltzoff (1990) examined behavioural responses to being imitated in a group of 14-month-olds. Infants looked longer at and smiled more towards an experimenter who was imitating them than at the experimenter who was merely responding in a contingent manner. Infants also engaged in “testing” behaviours that were directed more towards the imitating experimenter. Testing was noted when an infant suddenly changed her behaviour and looked towards the experimenter (e.g., sliding a toy slowly then changing to quick movements while looking at the adult’s face). Meltzoff interpreted this behaviour as the infant checking to see if the adult was intentionally copying her. Meltzoff and Moore (1999) have since suggested that infants this young are implicitly aware of when others copy them, but that they do not yet demonstrate this awareness by
responding differentially in an imitative context. Instead, they consider the adult’s imitation as directly connected to their own actions. Older infants, however, make the connection at a higher level, person-to-person. According to Meltzoff and Moore, not only are the adult’s actions seen to match hers, the older infant sees the interaction as a game whereby “you copy me”, regardless of what actions are performed. The ability of young infants to detect imitation is suggested to facilitate their growing sense of self and other as they move beyond the neonatal period.

Nadel (2002) has discussed imitation detection, suggesting that awareness of imitation, like imitation performance, may manifest at different levels, and that indicators of imitation recognition at these various levels are needed. Nadel, Field, and Potier (2000) coded 6 hierarchical responses to being imitated: no reaction; looks at experimenter; looks at experimenter and gives a social signal (e.g., smile); alternates looks to the experimenter’s object and their own object; tests the experimenter (e.g., changes action); tests the game “you intend to imitate what I want you to”.

Most recently, Agnetta and Rochat (2004) examined 9-, 14-, and 18-month-old infants’ responses to being imitated by an experimenter. Infants at all ages engaged in more testing behaviour directed towards the imitating as opposed to the contingent experimenter. In contrast to the older infants however, nine-month-olds did not more frequently gaze or smile at the imitating experimenter.

The developmental course of the transition from being aware of social contingencies (at about 9 months) to having an explicit awareness of intentional, reciprocal imitation (by 14 months) is not known. Nadel’s (2002) recommendation that
imitation recognition be conceptualized as on a variety of levels provides a starting point for empirical study, for which longitudinal designs will be especially helpful.

With the discovery of mirror neurons and renewed interest in the idea of common representational codes for perception and action, it is surprising that no studies have yet examined the relationship between imitation perception and performance in infancy. Numerous studies have documented that by the second quarter of the first year, infants are highly sensitive to temporal contingencies in dyadic social interactions. Actual imitative skill, however, begins to emerge from the middle of the first year (for theorists who interpret neonatal imitation as reflexive behaviour only), which perhaps indicates that a developing sensitivity to interpersonal contingencies is a prerequisite for imitation. Many questions remain about the relationships between early social contingency awareness and later imitative skill, and between the developmental emergence of imitation detection and imitation performance during the second half of the first year. As will be discussed in more detail, addressing these questions is an aim of the current study.

Theories of Imitation Development in Infancy

Though the study of imitation has a rich history, an understanding of the psychological mechanisms involved and how infants come to be able to copy another’s actions is still elusive and poses a puzzling problem to those who investigate imitation in humans and animals. Imitation is ubiquitous, and appears effortless; however investigators remain unable to explain it. Imitation is necessarily comprised of a variety of psychological mechanisms. Motor imitation requires vision and the perception of others’ actions, attention, intermodal coordination of visual and proprioceptive information, memory and representation of actions, translation of perceived actions into
self-produced movements, motor control, and motor planning. Of the processes involved, imitation uniquely requires the translation of perceptual input into a matched motor output (Heyes, 2001). A theory of imitation and of its development must be able to account for the imitation of actions that are “perceptually opaque” (Heyes, 2001).

Theories of how imitation develops in infancy vary in emphasis. Some, such as Piagetian theory, emphasize cognitive-developmental maturation during the sensorimotor period. Others stress the importance of early social experiences and infants’ growing awareness of contingencies in dyadic interactions (Stern, 1985). Still others (Meltzoff & Moore, 1997) invoke innate mechanisms, claiming that the requisite psychological processes are present at birth. In the following section, classical theories of imitation will be discussed, as will more modern accounts of imitative abilities.

Classical theories of imitation

In Baldwin’s (1894, 1903) theory of mental development, imitation provides the roots of internal representations of self and other. From birth, infants engage in imitative behaviour that develops and changes substantially throughout infancy. “Self-imitative” responses occur initially as circular reactions (reflexive, repetitive behaviours), while imitation of a model becomes more intentional towards the end of the first year. At this time, infants actively compare the action of a model with their own behavioural response, resulting in persistent imitations that more closely approximate an accurate response. Through imitation, Baldwin argues that infants learn about the world of both self and other. By imitating, the infant experiences subjectively that which the other experiences and thus expands her understanding of herself and of her social partner.

In contrast to Baldwin’s work that, as a philosophy of imitation, focused primarily on developmental consequences and social outcomes of imitative proficiency, Guillaume
(1926/1971) wrote mainly about the psychological mechanisms of imitation with the goal of elucidating the origin of matching behavior and the processes involved. Beginning with the psychological mechanisms of movement and kinaesthetic sensations, Guillaume argued that imitation in infancy does not depend on innate mechanisms but rather that infants learn to imitate. According to his theory, vocal imitation emerges around at 5 months, but true imitation of actions is not seen before 6 or 7 months and requires at least a simple level of representation. As with Baldwin, Guillaume’s theory is premised on the suggestion that imitation of others develops from the child’s inclination towards self-imitation; sensory-motor mechanisms stemming from circular reactions play a critical role in the transition from self-imitation to the repetition of a movement produced by another. A type of conditioned learning process is the second mechanism responsible for the emergence of imitation during the early months of infancy. With self-awareness and the correspondence between self and other emerging at the end of the first year, infants move from demonstrating conditioned imitation to flexible and novel imitation (Guillaume, 1926/1971).

Piaget (1945, 1962) argued that the development of imitation is one of the major milestones of the sensory-motor period of development and serves to promote the capacity for representation. His six stages of imitation parallel those of the sensory-motor period itself, and as with Baldwin and Guillaume’s theories, highlight the role of circular reactions in imitation development. Early stages of imitation, according to Piaget, are “preparatory forms” of later-arising representational imitation and are characterized by continuing accommodation with already-formed circular reactions. By the third stage, an infant is able to imitate movements she has already made and those that she can see.
herself performing. From stage four to six (between 9 and 12 months), an infant begins to imitate actions that are not visible to her (e.g., facial movements: stage four), and that are novel (stage five). Stage six imitation marks an advance in representational capacity, as evidenced by infants engaging in imitation following a delay (deferred imitation). Piaget argued that this ability is a crucial foundation for the development of symbolic thought, as demonstrated by the concurrent emergence of spoken language and symbolic play between 18 and 24 months of age. In contrast to Guillaume’s theory, Piaget conceptualizes the development of imitation as a more continuous process, and argues that, in order to replicate a model’s actions, the young infant must assimilate the “copy” to his own gestures.

Imitation is also a central concept in Lev Vygotsky’s (1978) theory of cognitive development. Though others like Piaget accepted that social interactions play a role in developing constructs, Vygotsky placed interpersonal experience at the center of his theory, arguing that cognition originates through interaction in social groups and that cognition cannot be isolated from social life. Imitation is of particular importance within his concept of the “zone of proximal development”. This zone falls between what the child “knows” and can do independently and what they can “know” or do with the assistance of others (parents, teachers, or peers). Though Vygotsky did not characterize what he meant by imitation, a child can presumably imitate what is in the zone of proximal development. Such imitation results in the advancement of the child’s skills, and aids in the development of pretend play:

"While imitating their elders in culturally patterned activities, children generate opportunities for intellectual development. Initially, their games are recollections and re-enactments of real situations; but through the dynamics of their imagination and recognition of implicit rules governing the activities they have reproduced in their games,
children achieve an elementary mastery of abstract thought." (Vygotsky 1978)

According to Vygotsky, imitation is necessary for children to learn, demonstrate knowledge, and generate new solutions. Imitation is a prerequisite for deeper understanding, with the emphasis placed on the role adult-child interactions play in the child’s acquisition of meaning.

*Modern theories of imitation*

Heyes (2002) surveyed theories concerning the mechanisms of imitation, classifying each as falling into one of two categories: “transformational” or “associative” (Heyes & Ray, 2000). Associative theories suggest that the information necessary for imitation is acquired through cumulative experiences of observing and performing a particular action. In contrast, transformational theories account for imitation via an internal cognitive process that transforms perceptual information derived from watching the demonstrator into a representation that can facilitate a behavioural match by the observer. Each of these theories has implications for the development of imitation during infancy, and the relative importance of the underlying processes and experiences involved.

Meltzoff and Moore’s (1977; 1997) Active Intermodal Mapping (AIM) hypothesis is perhaps the best-known of the purely transformational theories of imitation. AIM is a model of facial gesture imitation in early infancy that has been extended to account for imitation generally. The hypothesis suggests that infants are able to encode the perceived actions of others and self-produced actions within a common “supramodal” framework. The result of this supramodal encoding is that infants are able to detect the equivalence between movements of self and other. The authors propose that the AIM mechanism does not arise from early experiences of matched behaviours between self
and other, but rather is an innate intermodal representation system. While the theory posits a supramodal framework, it does not specify how representations are formed, or coded. The ambiguous nature of the AIM hypothesis, and the lack of specificity regarding the representational codes, gives little insight into the nature of imitation and how it develops.

Heyes (2002) has argued that other transformational theories share a similar problem of underspecification. For example, Bandura’s (1986) social-cognitive theory of imitation involves attention to the model and a conceptual representation against which sensory information is compared. A motoric response is generated following this comparison, while the mental representation provides the specifications for response correction. As with the AIM hypothesis, a representational system is argued to be responsible for imitation, however both theories lack descriptions of how the system works, and what functions are involved. The critical piece, how perceptions of others’ actions are translated into motor output, is missing in both theories.

Associative theories fall into two groups, those that consider reinforcement necessary following a stimulus and response sequence in order for associations to be made (reinforcement theory), and those that do not (contiguity theory; Heyes, 2002; Parton, 1976). Behavioral associative models preclude observational learning, suggesting rather that imitation relies solely on the process of conditioning (Holt, 1931). Imitation only arises from stimulus-response conditioning, and for reinforcement theories, only when those associations have been rewarded in the past. A model’s behaviour acts as a discriminative stimulus for the observer as a result of contiguous occurrences with the observer’s matching behaviour, which have been rewarded (Miller & Dollard, 1941).
Purely associative theories thus do not credit imitation to a cognitive mechanism. While both Piaget and Guillaume recognized the necessity of early pairings of observations and responses in the development of imitation, they differed from contiguity theorists in that cognitive processes were considered to mediate imitation. The limitations of associative theories include difficulty explaining how invisible imitation is more difficult than imitation of actions an infant can see herself performing. Parton (1976) concluded in his review that imitative learning theories fall short of explaining how associations are formed between disparate sources of information (representations of self-produced actions and of others’ actions), and how an infant recognizes levels of similarity between her own action and her representation of a model’s action.

In contrast to behavioural associative accounts of imitation, Heyes and Ray (2000) proposed an associative model that grants a place for observational learning. Associative Sequence Learning (ASL) theory suggests that for imitation of novel sequences of action units to occur, two sets of processes are necessary, both of which are associative and contiguity-based. Horizontal processes encode the action sequence and do not require an observer to act. The result of these processes is that through observation, the individual has learned what a sequence “looks like”. Though insufficient to facilitate matching behaviour independently, horizontal processes set the stage. For imitation to occur, associations need to have formed between sensory and motor representations via vertical processes. Accuracy of imitation is directly related to prior experience with particular action units that make up a sequence (e.g., curling fingers towards palm and lifting thumb as units of a “thumbs up”); the more components of a sequence that have been executed prior to observation of the complete sequence, the more accurate the
matching behavioural response. Associative connections become established through experiences of self-observation (e.g., circular reactions), play with mirrors, and synchronous action (e.g., when a parent imitates her child, when a parent and child are simultaneous responding to a shared stimulus such as a toy). Thus, in the ASL theory, both cognitive and experiential processes are necessary for imitative learning to occur.

Thus, theories of imitation range from purely behavioural approaches that rely solely on reinforcement histories to those that consider matching behaviour to occur as a result of complex cognitive processes. While a transformational theory, the AIM hypothesis (Meltzoff & Moore, 1977, 1997) stands alone in that the sole behaviour it explicitly accounts for is imitation of non-visible actions. Additionally, a central characteristic of AIM that distinguishes this approach to imitation from others is that the capacity to form supramodal representations of a modeled action is considered to be innate. A strength of ASL theory is that it allows for conjoint influence of cognitive and associative mechanisms. The relative contributions of mechanisms involved in imitative learning will likely vary as a function of past experience and development. ASL theory can accommodate the concept of mirror neurons, currently considered by many to be the neural substrate of imitation, as well as evidence for neonatal “imitation” via an innate inter-modal mapping system. Heyes and Ray (2000) suggest that “canonical neurons” (neurons that act only when an animal is executing a particular action) become “mirror neurons” (activated by observation and action) through simultaneous and repeated experiences of observation and action. Given that there is no evidence supporting (or refuting) the existence of mirror neurons in human infants, it is possible that mirror neurons themselves develop as a result of observation-action pairing during early life.
Early theories of the development of imitation are based on transformations of cognitive schemas (Baldwin, 1903; Guillaume, 1971; Piaget, 1962). Coordination of perception and action early in infancy leads to repetitions of self-induced movements (circular reactions) that eventually accommodate to a wide variety of sensory stimuli. Infants come to represent their own activities and the activities of others within a single conceptual system. This integration of information enables imitation of actions that are unseen when produced. From a cognitive perspective, many theories of imitation and its development highlight the role of perception-action coupling: how first person and third person information are coordinated within a single conceptual framework. Research that examines intermodal matching in infancy has demonstrated that early in the first year, infants develop the ability to perceive intermodal correspondences between inputs from different sensory systems (e.g., visual-auditory; Spelke, 1979; and visual-proprioceptive; Bahrick & Watson, 1985). Visual-proprioceptive integration is arguably most important in the imitation of gestures, particularly those that the infant is unable to see herself performing (e.g., eye blinks, mouth opening). Mitchell (2002) wrote of the importance of visual-kinesthetic matching for understanding imitation, stating that this ability may initially develop from experiencing invariants between positions and movements of one’s body and the visual perception of it (e.g., through early experience with mirrors). For the development of imitation, the infant goes beyond integrating information from visual and proprioceptive feedback from her own body, and must extend those connections to recognizing equivalences between another person’s actions and her own. During the first year, adult social partners tend to imitate infants’ expressions, vocalizations, and actions (Moran, Krupka, Tutton, & Symons, 1987; Uzgiris, 1981). These interactions likely
provide infants with experiences of high degrees of contingency between the actions of self and other, facilitating recognition of equivalences between observed and felt movements.

Other researchers have also speculated that more basic information-processing abilities underlie imitation and are critical to its development. Mataric’s (2002) model proposed sensory-motor “primitives” as a substrate for imitation. In one of the only theories to explicitly consider visual attention as a primary mechanism of imitation (but see Bandura, 1986), Mataric implicates visual tracking of movements that lead to a “selective attentional mechanism” by which focal attention is directed towards the effector of an action (e.g., hands). Selected features of the action then become the basis for classifying movement into primitives (basic motor programs that, when combined, underlie an individual’s movement repertoire). Mataric’s model is premised on the idea that features are translated in primitives via direct mapping of perceptions onto actions.

Based on Allport’s (1987) functional view of attention as a process that maps perception onto the control of action, Smith and Bryson (1994) have also suggested that flexible allocation of attention may be critical to the development of representations of events and actions, and to the cross-modal integration of experiences necessary for imitation.

Summary

Putative mechanisms underlying imitation include early experiences with contingent dyadic interactions, reinforcement histories, visual-proprioceptive inter-modal processing, and to a lesser extent, visual-spatial attention. The importance of experience with contingent interactions via maternal imitation has been emphasized. The contribution of visual-spatial attention to imitation has only recently been suggested.
within the context of a model and is deserving of future consideration. Finally, intrapersonal variables have also been overlooked in theories of imitation development. Variables such as temperament may not only affect the likelihood of an infant imitating an adult given that she has the capacity to do so, but may also directly influence the development of imitative abilities. Aspects of temperament that reflect how an infant interacts with others and processes information from the environment (e.g., activity level, duration of orienting) may affect the developmental course of imitation.

*The Need for Longitudinal Studies of Predictors of Imitation*

Though imitation has been the focus of much study within the last century, little research has addressed what earlier or concomitant abilities contribute to the development of this important skill. The field of infancy research is in need of studies that will elucidate mechanisms involved in imitation during infancy. At the end of the first year there is considerable growth and change in cognitive and social abilities, of which imitation is a key emerging skill (Barresi & Moore, 1996). Relationships among the processes that span social and cognitive development within the first year have been subjected to limited exploration (Carpenter, Nagell, & Tomasello, 1999). Longitudinal studies provide an important line of research that can test hypotheses regarding the development of imitation and reveal what mechanisms are involved. While research in typical development naturally leads to further understanding of changes in imitative capacity, the study of impairments in imitation can contribute complementary knowledge of the psychological processes involved.
Reciprocal Approaches: Understanding Imitation via the Study of Psychopathology

Work within the area of developmental psychopathology has emphasized the importance of reciprocal approaches to the appreciation of social, emotional, and cognitive development in childhood (Cicchetti, 1989). The study of atypical developmental pathways can inform our appreciation of typical developmental patterns, while a clear understanding of normal development provides insight into alternate paths. Autism is the only form of developmental psychopathology in which a specific deficit in imitation has been identified (Rogers, 1999; Rogers & Pennington, 1991; Smith & Bryson, 1994, Williams, Whiten, & Singh, 2004). Autism is a neurodevelopmental disorder that is characterized by profound impairments in a triad of domains including communication, social interaction, and behavior/cognition. Psychological processes thought to be important for imitation are also impaired in individuals with autism and may contribute to difficulties with imitation. Disruptions in imitation and associated impairments in autism permit an examination of what abilities may be integral to the development of early imitation skills in typically developing infants.

In the following section that discusses psychological mechanisms thought to underlie imitation, evidence from the autism literature demonstrating impairments in these processes will be reviewed briefly.

Prediction of Imitative Ability and Concurrent Relationships in Typically Developing Infants

Theories of the emergence of imitation in typically developing infants and of the imitation impairment in children with autism vary in the emphasis they place on underlying social and non-social processes. Potential mechanisms identified in both literatures directed the focus of the current study with respect to the selection of variables
of interest in the prediction of imitation. In this section, we review precursors of imitative skill and constructs that are expected to be related to imitation at 9 months.

*Visual-spatial attention*

During the first 6 months, the visual attention system undergoes significant maturation. Posner (1995) and Johnson (1990) have put forward theoretical accounts of the development of visual attention during infancy. It is generally accepted that visual attention within the first months of life is largely overt (associated with observable eye movements) and under the control of exogenous stimuli (i.e., within the environment; Johnson, Posner, & Rothbart, 1991; Klein, 1994). At approximately 4 months of age, infants begin to demonstrate more flexibility and control over the operations that are essential for orienting to objects and events in the world (Atkinson, 1984; Johnson, 1990). These processes include *disengaging* attention from a current target of interest, *shifting* attention to a new object of focus, and *re-engaging* attention (Posner & Peterson, 1990), and together are referred to as “visual orienting” (Rothbart, Posner, & Rosicky, 1994). Covert shifts of attention and increasing responsiveness of the endogenous system are also seen in infants at 4 months of age as cortical structures mature (Hood, 1993; Hood, Atkinson, & Braddick, 1998). Periods of “obligatory looking”, during which infants fixate for prolonged intervals and often appear distressed, disappear; this is attributed to infants’ increased ability to disengage attention (Johnson, 1990; Posner & Rothbart, 1980).

Studies of the development of visual orienting typically involve paradigms in which infants are presented with colourful and dynamic stimuli appearing in central and peripheral space. Saccadic latencies to orient to peripheral stimuli permit an examination of infants’ ability to shift and disengage attention at various ages. Though most studies to
date have used cross-sectional designs (e.g., Hood & Atkinson, 1993; Johnson, Posner, & Rothbart, 1991), McConnell and Bryson (2004) employed a longitudinal approach to examining the development of visual attention from 2 to 6 months of age. Latencies to shift attention were observed to decrease significantly with age. At 2 months, there was a large difference between the ability to shift and disengage attention, with infants being able to shift attention much more rapidly than to disengage. By 4 months, this difference was only marginally significant, supporting previous research demonstrating a major developmental change in the disengage operation within the first 4 months (Atkinson, 1984; Hood, 1993; Hood, Atkinson, & Braddick, 1998; Johnson, 1990).

A flexible attentional system in infancy is critical for development. During the first year, infants are able to orient to novel and interesting events and objects, develop sustained attention for exploration and learning, and become increasingly able to flexibly shift attention between targets (Ruff & Rothbart, 1996).

Though it has been suggested that a child’s ability to imitate depends upon attention to the actions of their social partner, research has not yet demonstrated whether the development of attention and individual differences in attentional capacities within the first year affects infant imitation. At the most obvious level, infants must attend to the actions of others. However, other relationships among attention, perception, and action may be critical. Allport (1987) conceptualized attention as a process that acts to map perceptions onto control of action, and as such, attentional capacities may underlie how infants come to represent events and actions that they then access in their attempts to imitate others. The ability to attend selectively to relevant aspects of experiences and disengage and shift focus between stimuli is also likely to be critical to integration of
sensory experiences. Given that visual-proprioceptive cross-modal abilities must be essential to imitation, attention may also indirectly affect imitation through its contributions to intermodal processing in infancy (Smith & Bryson, 1994).

Smith and Bryson’s (1994) account of the difficulties individuals with autism have in imitating the actions of others emphasizes lower level, non-social information processing deficits as preceding the imitation impairment. Attentional functioning is disordered in autism; marked difficulty in disengaging attention has been observed clinically and demonstrated in various experimental paradigms (e.g., Bryson, Wainwright-Sharp, & Smith, 1990; Courschesne, 1989; Courschesne et al., 1993; Landry & Bryson, 2004). Smith and Bryson (1994) suggested that attentional deficits could underlie problems in the representation of events and goal-directed behaviour, and be related to difficulties in reproducing others’ movements. Early difficulties with attentional processing may affect imitation through various mechanisms at the level of perception, translation, or action (e.g., encoding information about others’ movements, recognizing similarities between movements of self and other, understanding the meaning of others’ actions, translating others’ movements in movements of the self, executing imitative responses). Lower-level processing deficits may contribute to executive function impairments (e.g., difficulties with inhibition, planning, set shifting, generativity, action monitoring) that have been documented in autism (see Hill, 2004, for a review).

*Intermodal perception*

Visual-proprioceptive intermodal processing figures prominently in all theories of imitation (Heyes, 2002; Meltzoff & Gopnik, 1977, 1997). From early in the first year, infants develop capacities for detecting relationships across perceptual modalities (for a
review, see Lewkowicz & Lickliter, 1994). Theories of intermodal perception offer
different accounts of what capacities infants possess at birth, and vary according to the
emphasis placed on sensation (e.g., Helmholtz, 1885/1962), perception (e.g., Gibson,
1969) or action (e.g., Piaget, 1952) as the primary basis of intermodal perception (Spelke,
1987). Research has consistently demonstrated age-related changes within the first year
for intermodal perception of visual-auditory events with objects and faces, and for visual-
haptic exploration (e.g., Bahrick, 1983; Spelke, 1979; Walker-Andrews, 1986). With
respect to imitation, infants’ ability to integrate visual and proprioceptive information is
of particular interest given that imitation requires the ability to translate actions seen in
others into actions felt within the self. Bahrick and Watson (1985) were the first to
examine infants’ ability to detect relationships between observed and felt movements.
When vision of their own legs was occluded, 5- but not 3-month-old infants
discriminated between a perfectly contingent live video display of their own legs and a
matched noncontingent display (of another infant’s legs). Five-month-olds preferred to
view the non-contingent display, which was interpreted by the authors as evidence that
between 3 and 5 months, infants develop a preference for imperfect contingencies that
specify other (a social orientation). Bahrick and Watson argued that detection of visual-
proprioceptive invariants was important in the development of self-perception; it may
also be fundamental to perceiving similarities between self and others’ actions and
ultimately for translating observed movements into matching self-produced actions.

Follow-up studies using Bahrick and Watson’s (1985) video paradigm have
examined parameters of visual-proprioceptive intermodal perception in infants from 3 to
7 months of age. In summary, this research suggests that by 3 to 5 months, infants

41
discriminate differences in visual-proprioceptive temporal contingencies (Bahrick & Watson, 1985), spatial calibration of visual and proprioceptive feedback (Rochat & Morgan, 1995; Schmuckler, 1996), and the presence or absence of eye contact (Papousek & Papousek, 1974). By 7 months, infants are able to discriminate the temporal contingencies contained in off-joint, ego-centered views using point-light displays (Schmuckler & Fairhall, 2001).

Rochat and Striano (2002) further investigated infants’ responses to specular (mirror-like) images. In contrast to the above studies, the authors compared the behaviour of 4- and 9-month-old infants in four conditions involving images of self and other that varied contingent relations between the images: viewing self on-line (perfect contingency), viewing self with delay, viewing experimenter on-line (copying the infant’s behaviour; high contingency), viewing experimenter with delay. Regardless of age or contingency condition, infants preferred to view an image of the experimenter who copied them. They also tended to look more at the image that displayed on-line contingency, also regardless of condition (self or other). During a still-face episode (video display was frozen), infants engaged in more smiling and re-engagement attempts towards the specular image of the experimenter compared with the image of self, especially for the 9-month-olds. Rochat and Striano interpreted their findings as evidence that from 4 months of age, and clearly by 9 months, infants discriminate between an image of self and other, and that this discrimination involves multiple determinants such as featural, dynamic, and temporal dimensions.

Research on visual-proprioceptive intermodal processing and behavioural responses to socially contingent interactions has highlighted the importance of these in
the development of self-perception and self-other discrimination. In parallel, theories of imitation development have underscored the significance of the ability to identify correspondences between movements of self and other, and to translate those correspondences into actions matching the other. However, relationships between performance on visual-proprioceptive intermodal perception tasks and imitative ability have not been examined. Early variability in visual-proprioceptive intermodal processing may be related to individual differences in imitation skill towards the end of the first year, when infants begin to copy actions.

Findings from research on intermodal-processing in autism have been inconsistent (Loveland, Tunali-Kotoski, Chen, Brelsford, Ortgeon, & Pearson, 1995; Ozonoff, Pennington, and Rogers, 1990; Walker-Andrews, Haviland, Huffman, and Toci, 1994), yet few investigations have explicitly examined matching of events across modalities in children with autism, particularly for visual and proprioceptive stimuli which is most relevant for the study of imitation. In the context of their contingency perception hypothesis of autism, Gergely and Watson (1999) presented data indicating that, in contrast to typically developing children who preferred to view imperfectly contingent feedback of their actions, those with autism (n = 16) looked significantly longer at a display that generated perfectly contingent feedback (Magyar & Gergely, 1998). Though the supporting data are limited, deficits in imitation may be a by-product of differences or disruptions in intermodal processing (Barresi & Moore, 1996; Smith & Bryson, 1994), which may or may not be specific to the integration of vision and proprioception.

**Mother-infant play**

Imitative interactions involving young infants arise during the context of naturally occurring social situations, unlike laboratory-based tasks that may place different
demands upon infants. Given the mutual influences exerted during mother-infant play, imitative behaviour during a more naturalistic free play session may be very different than that elicited by an experimenter. Much research has been devoted to understanding early parent-infant interactions. Theories of imitation that emphasize social processes underscore the importance of mirroring of infant behaviour for the development of sensitivity to contingencies, which in turn has been suggested to contribute to imitation development (Gergely & Watson, 1999).

Early in infancy, parental responses during interactions with their infants are primarily imitative, and are characterized by their correspondence to their infants’ intensity, tempo, and affect, rather than being exact matches in form (Stern, 1985). This infant-directed social mirroring promotes infants’ cognitive, social, and affective development (Bowlby, 1979; Stern, 1985). Individual differences in mothers’ contingent responses to their infants vary considerably across maternal-infant pairs, but are stable within pairs (Stern, Hofer, Haft, & Dore, 1985). The quality of mothers’ contingent responding is reflected in infants’ attachments, affect regulation, emotional responsiveness, coping strategies, and cognitive mastery, and is thought to affect infants’ developing social expectancies, self-knowledge, and self-other discrimination (Bigelow & Birch, 1999; Blehar, Lieberman, & Ainsworth, 1977; Dunham & Dunham, 1990; Gergely & Watson, 1999; Neisser, 1991; Stern, 1985).

There are various experimental approaches to the study of early social interactions. Some researchers employ naturalistic face-to-face situations to examine patterns in reciprocal interactions and imitative routines. Changes in adult behaviour during these interactions (e.g., adopting a still-face) test infants’ social expectancies and
sensitivity to rules of social responsiveness. More recently, use of double closed-circuit television designs with delayed feedback permits the study of infants' sensitivity to manipulations of maternal contingencies (Bigelow & Birch, 1999; Legerstee & Varghese, 2002; Rochat, Neisser, & Marian, 1998). Research with these paradigms has demonstrated that infants are sensitive to interpersonal contingencies from early in the first year, showing preference (more smiling and vocalizing) for contingent interactions and distress when social expectancies are violated (Bigelow, MacLean, & MacDonald, 1996; Ellsworth, Muir, & Hains, 1993).

During the second half of the first year, infants become more interested in objects in their environment. Much of parent-infant play is then object-mediated, accounting for approximately half of all play episodes. In contrast, only one-third of parent-infant play interactions consisted of non-object social/affective episodes (Power & Parke, 1982; Tronick & Cohn, 1989). Mothers' imitations of their infants' actions, mostly vocalizations, continue (Pawlby, 1977). According to Stern (1985), a shift occurs around 9 months when mothers' imitative behaviours change to cross-modal "attunements" (e.g., as the infant visually orients and reaches towards a toy, her mother vocally attunes to her infant's behaviour). Towards the end of the first year, physical stimulation during plays tends to decrease, while toy play and responding to infant communicative behaviour increases (e.g., labelling object following showing of object; Bakeman & Adamson, 1984; Masur, 1982).

Contingencies in dyadic and object-mediated social interactions within the first year play a central role in early emotional, social, and self development. Through these interactions, infants become highly sensitive to imperfect social contingencies. Imitative
ability relies on similar mechanisms of detecting correspondences between actions of self and others, yet only a single study has examined relationships between individual differences in maternal-infant play behaviours and imitation performance during the first year. In a longitudinal study, Heimann (1989, 1991) examined relationships between mother-infant interactional behaviours at 3 months and infant imitation at 12 months. Infants who demonstrated high levels of imitation at 9 months displayed fewer instances of gaze aversion with their mother when they were younger. His findings suggest the need for further exploration of the connections between early mother-infant interactive processes and later infant imitative abilities. With respect to contingencies, one might expect that infants who have experienced a history of high levels of contingent interactions with their mothers to be more responsive when being imitated by others and to become better imitators at the end of the first year.

Temperament and self-regulation

The study of temperament in infancy has provided important insight into individual differences in how infants interact with the world and with others. Nonetheless, the role of temperament in imitation development has largely been unexplored, with the exception of relationships with neonatal matching behaviour (Heimann, 1998; Heimann & Ullstadius, 1999). Temperament has been defined by Rothbart and colleagues as constitutionally-based individual differences in reactivity and self-regulation (Derryberry & Rothbart, 1988; Rothbart & Derryberry, 1981). Reactivity refers to the arousability of an infant’s physiological and behavioural systems and self-regulation constitutes processes that act to modulate reactivity. Research has demonstrated that over time, infants move beyond being regulated by external inputs (e.g., maternal soothing) as their own self-regulatory processes develop and they become
more able to modulate their levels of arousal and reactivity to the environment (Rothbart & Posner, 1985). Susceptibility to distress and displays of negative reactivity are present at birth, particularly evident during the newborn period, and show some stability over time (Riese, 1987; Rothbart, 1989; van den Boom, 1989). By 2-3 months of age, positive reactivity emerges as infants begin to smile, laugh, and react vocally (Rothbart, 1981). Longitudinal observations of positive reactivity in the home demonstrate increases between 3-9 months of age, again exhibiting moderate degrees of stability within individuals up to 12 months (Rothbart, 1986). A further dimension of temperament for which individual differences appear between 2-3 months is duration of orienting to external stimuli. Mechanisms underlying orienting at this age are associated with the posterior attention system (Posner & Peterson, 1990), which undergoes maturation until late in the first year. By 5-6 months, infants’ approach tendencies can be observed; latency to make contact with objects that vary in novelty and intensity reflects an infant’s tendency to seek out interaction with the environment.

Within the first year, individual differences in infant temperament can be observed along a number of dimensions, including those reviewed above. Measurement of temperament in infancy has been refined within the last few decades. Rothbart’s (1981) caregiver-report instrument, the Infant Behavior Questionnaire (IBQ), was the first comprehensive approach to assessing dimensions of reactivity and self-regulation in infancy. The IBQ was based on dimensions originally proposed by Thomas, Chess and Birch (1968) and comprised 11 scales measuring conceptually independent constructs; it was recently revised (Gartstein & Rothbart, 2001).
The relationship between individual differences in imitative ability during infancy and dimensions of infant temperament has largely been overlooked (see Field, 1982 and Heimann, 2002, for exceptions). There are a number of possible mechanisms by which temperament may influence imitation. First, individual differences across dimensions such as approach, fear, duration of orienting, or distress to limitations may affect the tendency to imitate, rather than capacity or skill. Second, temperament might influence how readily infants acquire imitative ability. For example, infants who are more vocally reactive may begin to imitate others’ vocalizations sooner, potentially reflecting a vocal imitative feedback loop. Infants who enjoy calm, reciprocal social interactions may be more sensitive to dyadic imitative exchanges and through greater experience, come to imitate more quickly than infants who are more active and who enjoy high intensity stimulation. Third, temperament may affect the development of imitation via its relationship with visual orienting. Research indicates that infants who are more able to disengage attention are those who are more easily soothed and are less distressed by novel or intense stimuli (Johnson, Posner, & Rothbart, 1991). Positive affectivity is associated with infants’ ability to look away from arousing stimuli (Rothbart, Ziaie, & O’Boyle, 1992). Overall, relationships have been noted between attentional control and susceptibility to distress. Whether these relationships influence infants’ participation in social exchanges and emerging imitation skills has yet to be determined.

Empirical work on temperament in autism is limited. The few studies that have examined temperamental profiles in this group of children demonstrate high levels of variability and tendencies towards low persistence, low approach, and low adaptability (Bailey, Hatton, Mesibov, Ament, & Skinner, 2000; Bieberich & Morgan, 1998; Hepburn
& Stone, 2004). Temperamental differences have also been observed between children with autism and typical peers with respect to attentional functioning (e.g., shifting, focusing) and emotionality (e.g., soothability, anger/frustration) (Konstantareas & Stewart, 2001). As a group, children with autism have been characterized as having “difficult temperaments” (Kasari & Sigman, 1997). Associations between temperament and imitative abilities in autism have not been explored, however it might be predicted that attentional difficulties, low persistence, and the disinclination to approach novel situations might be related to poor imitation performance.

**Correlates of Imitative Ability at the End of the First Year**

The emergence of imitation (in particular, of actions on objects) in the second half of the first year occurs in the company of an impressive set of other skills, all demonstrated within the context of triadic social interactions. These include looking in the direction of an adult’s gaze, using adults as a social reference, and gestural communication. Very little work has investigated correlates of imitation and the role that imitation might play in social interactions towards the end of the first year. Bates and colleagues (1979) examined relationships longitudinally among imitation (gestural and vocal), communicative gestures, and words in a sample of 25 infants from 9½ to 12½ months and found that imitation predicted both gesture and language use. Carpenter, Nagell, and Tomasello (1998) conducted a comprehensive longitudinal study of social cognitive abilities in 24 infants from 9 to 15 months. Measures included imitation of both instrumental and arbitrary actions, sharing, following, and directing attention, and use of communicative gestures. No infants imitated instrumental actions (e.g., opening a hinge) at 9 months, and only 1 infant imitated an arbitrary action (e.g., touching head to the
surface of a box). Mean age of onset for imitation of both kinds of actions was approximately 12½ months, which is somewhat anomalous given the literature supporting the emergence of imitation of novel actions on objects between 9 and 12 months (e.g., Meltzoff, 1988a). A developmental sequence for the emergence of skills was revealed, beginning with joint engagement, followed by communicative gestures, attention following, imitative learning (instrumental and arbitrary actions combined), and lastly referential language. Modest interrelationships among the ages of emergence for behaviours were noted. Carpenter and colleagues interpreted these correlational findings as evidence of a developing abstract concept of intentional agent. Tomasello and Carpenter (2004) presented a theory of intention-reading and imitative learning in which social learning and imitation are intrinsically connected to other developing social-cognitive skills. They suggest that imitative learning at the end of the first year is dependent upon social-cognitive abilities because infants at this age are thought to imitate what they “understand others to be doing”.

Slaughter and McConnell (2003) similarly investigated relationships among joint-attention behaviours, including imitation, in a sample of 60 infants between 8 and 14 months of age. In contrast to the findings of Carpenter et al. (1998), no reliable pattern of emergence of skills was found, nor was performance on the various joint-attention behaviours related. Slaughter and McConnell advocate a “lean interpretation” of the development of social-cognitive behaviours in infancy. This parsimonious interpretation asserts that joint-attention behaviours develop independently, and that development occurs through mechanisms of learning (cf. Moore & Corkum, 1994). Whereas the “rich interpretation” (e.g., Tomasello & Carpenter, 2004) argues for a conceptual link between
joint-attention abilities across a variety of skills, (e.g., gaze following, imitation, communicative gestures), Moore (2004) has recently suggested that an “intentional islands” approach is more consistent with current data. This account of the development of social-cognitive skills asserts that joint-attention behaviours first arise independently as skill “islands”, with generalization across related acts occurring later in development. Verb learning in infants follows such a developmental course; infants learn individual verbs in isolation before acquiring general grammatical rules (e.g., Tomasello, 2003).

Though Carpenter et al. (1998) and Slaughter and McConnell (2004) included infants under a year old in their samples, the focus of both studies was on intentional imitation, and the novel imitative learning tasks that they employed were known to be beyond the imitative capacity of the youngest infants. No study has examined relationships among imitation, gaze following, and early communicative competence at 9 months of age, the beginning of the triadic period. The pattern of emergence in Carpenter and colleagues’ work suggests that gaze following and communicative gestures develop before novel, imitative learning. It is not known where early imitative abilities (occurring around 9 months) would fit into the developmental sequence, and whether they are related to gaze following and use of gestures (which, at least intuitively, should involve an imitative learning aspect). If different forms of imitation are linked and hierarchical (Tomasello & Carpenter, 2004), they should have the same, or similar sets of predictors/correlates. An alternative, lean interpretation of skill development during the triadic period suggests that these behaviours are not conceptually linked, but rather develop independently through experience and learning mechanisms such as reinforcement.
The Present Study

Research in both normal development and developmental psychopathology emphasizes the importance of imitation as a key foundation of cognitive and social growth. Despite the significance of imitation for infants and young children, surprisingly little research has empirically addressed what earlier or concomitant abilities contribute to the development of this important skill. Though numerous assumptions have been made about the psychological processes involved in imitation, tests of proposed relationships have not been undertaken.

The two primary objectives of the present study were to investigate precursor abilities and correlates that may be predictive of or related to imitative skill in infants at the end of the first year of life. During this watershed period there is considerable growth and change in cognitive and social abilities; this period is therefore particularly deserving of study.

As part of the overall aim of the present study, a comprehensive examination of imitation abilities at 9 months was undertaken. Many studies to date have been limited in their approach in a number of ways. In order to address some of these issues and obtain a rich picture of imitation at the end of the first year, a broad approach to assessing imitation abilities was employed. With the largest sample of infants that has been studied, we provide a detailed description of 9-month-old infants’ imitative capacities and tendencies.

Also in this study, infants were provided with multiple opportunities to imitate a given action with both an experimenter and their parent. The scoring system was also designed to capture both full imitations and approximations to imitation. Based in part on Kaye and Marcus’ (1981) findings, the scoring system was constructed to give higher
credit for behaviours that more closely approximated the demonstrated actions (e.g., a score of 1 for an action directed towards the experimenter such as touching her hand, a score of 3 for responding with a recognizable copy of the experimenter’s action). This methodology enabled us to examine individual differences in more detail.

The present study examined imitation of gestural, object-directed, and vocal actions, rather than only one or two types of actions, as in most studies. Moreover, most studies of imitation during infancy involve lab-based elicited imitation paradigms. In the current study, imitation performance was assessed both via an elicited imitation task and during a mother-infant free play period with toys.

Further to the aim of a broad approach to describing and understanding imitation in 9-month-olds, we also included parents’ perspectives on their infants’ imitative capabilities. Parent report provided information about infants’ imitation abilities across a wider range of contexts, actions, and partners. Although parent reports of imitation are routinely gathered in standardized developmental questionnaires (e.g., MacArthur Communicative Development Inventories, Fenson et al., 1979), no investigations to date have examined detailed parental reports of infants’ imitation skills, or whether parent report is related to imitation performance in a laboratory. Parents were asked to report not only their infants’ ability to imitate, but also their awareness of being imitated. The few studies of infants’ responses during imitative interactions have been with older, or much younger infants (Meltzoff, 1990; Nadel, 2000; Uzgiris, Vase, & Benson, 1984). In the present study, exploration of relationships with elicited imitation and parent report of imitation provides valuable information about the two aspects of imitation (perception and action) that have rarely been considered together. In addition, the analysis of
relationships between imitation perception and performance, and of these with other skills, permits examination of whether different cognitive and social processes underlie sensitivity to being imitated in infancy and the ability to imitate.

As stated previously, the objectives of the current research were to investigate predictors of imitative ability and concurrent relationships at 9 months. Predictor measures were assessed at four months, when significant changes occur in the nature of maternal-infant social interactions and in several of the abilities hypothesized to underlie the development of imitation. Research on visual attention in infancy supports a transition at 4 months in infants’ control over attentional operations, including an increase in the ability to disengage attention (Atkinson, 1984; Johnson, 1990; McConnell & Bryson, 2004). At the same time, visually guided reaching develops; infants grasp toys that they explore orally. From the perspective of social development, 4-month-olds are in transition between the dyadic period (approximately 2-6 months) and the period of object interest (approximately 5-9 months). Prior to four or five months, infants engage primarily in face-to-face interactions with parents. As infants become more skilled at reaching for and grasping objects in their environment, their interest in exploring toys increases. Increased variability in mother-infant interactions is observed at this time, and mothers differ in their level of contingent responding to their infant’s behaviours (Stern et al., 1985). Infant and parent exert mutual influences within imitative play contexts, and infants at this age demonstrate sensitivity to interpersonal contingencies. A related skill that emerges and develops between 3 and 5 months is the integration of visual and proprioceptive information specifying the self. Infants develop the ability to detect visual-proprioceptive invariants across observed and felt movements (Bahrick & Watson, 1985).
We tested the hypothesis that individual differences in these skills, and variability in mother-infant interactions at 4 months, would be related to the appearance of imitation at 9 months.

Theoretical components of imitation selected for examination include both social and non-social information processing tasks. While most theories of imitation emphasize the importance of early contingent social interactions for its development, imitation also involves the processing of non-social information, which may independently exert influence on the emergence of imitation. The tasks used to measure these components follow.

Intermodal processing was assessed at both 4 and 9 months. Both visual-proprioceptive and visual-auditory tasks were included in order to test whether any intermodal relationship, if observed, was attributable to a general (supramodal) or specific (visual-proprioceptive) process. A single visual-auditory inter-modal task (Spelke, 1977) was used at both 4 and 9 months. Bahrick and Watson's (1985) task was used to examine coordination of information specifying leg movements at 4 months. At 9 months, displays instead showed live and pre-recorded images of the infant’s head, face, and neck (“invisible imitation” of unseen actions involves head and facial movements).

Visual-spatial attention abilities were also measured at both 4 and 9 months, via a saccadic latency paradigm that assessed infants’ ability to shift and disengage their attention (Landry & Bryson, 2004). Given the developmental change in the disengage mechanism at 4 months, and findings of difficulties with attentional disengagement in autism, we hypothesized that if relationships were found between visual-spatial attention and imitation, they would be strongest for the ability to disengage. In addition to
nonsocial visual-spatial attention, joint attention abilities were measured at 9 months. These were assessed within the context of two social tasks: a gaze-following task, and an object exploration task in which infants' direction of adult attention was measured. If joint attention and imitation are linked conceptually, one would expect correlations between the two measures.

Aspects of mother-infant interaction were assessed at 4 and 9 months in the context of a period of unstructured play. At 4 months, face-to-face free play was followed by an imitative interaction during which mothers were instructed to copy their infants' actions and vocalizations. Infants of mothers who were skilled at imitating them at 4 months (both when explicitly instructed to do so, and spontaneously during free play) were expected to receive higher imitation scores and ratings at 9 months. We also expected that infants who were more sensitive to being imitated when they were younger would continue to be more aware at 9 months, and would demonstrate more imitation skill. At 9 months, mothers and infants participated in a free play session with a set of toys. We hypothesized that infants of mothers who actively sought to engage their infant in joint interactive episodes (e.g., made bids for joint engagement, created opportunities for their infant to imitate, scaffolded their infants' play) would demonstrate more imitation, both during free play and the elicited imitation task.

Temperament is an individual difference variable that is related to both attentional abilities and mother-child interactions. In the present study, parents completed the IBQ-R at both 4 and 9 months. We hypothesized that the orienting/regulation dimension of temperament would be related to imitation given evidence in the literature of the association between this construct and visual-spatial attention abilities. Outgoing, vocal
infants and those who orient for longer and enjoy low intensity activity were also hypothesized to receive higher imitation scores.

Previous research has found inter-relationships among some of the constructs examined in the current study (e.g., joint attention). However, no study has undertaken a comprehensive examination of relationships among both information processing and emerging social and communication behaviours. We expected that both non-social information processing and social variables would predict imitative skill, and hypothesized that social factors would primarily be related to infants’ engagement levels and interest in imitation, while non-social factors were expected to affect the accuracy of imitative responses. Though little attention has been paid to the connection between perception (sensitivity to being imitated) and performance (imitative skill) as two aspects of imitation ability, we hypothesized that sensitivity to being imitated might precede (predict) imitative skills, and that visual-spatial attention and visual-proprioceptive intermodal processing abilities would be required for both imitation performance and awareness. We also expected that infants’ ability to detect imperfect contingencies in an imitative context, and mothers’ skill at imitating their infant, would more strongly predict perception of imitation than imitative skill.

*Overall Aim of the Current Study: Informing Developmental Theory and the Study of Psychopathology*

The observation of longitudinal developmental patterns in early infancy will permit us to test hypothetical relationships among precursors and later-developing imitation skills. The aim is to improve our understanding of the complex interplay of abilities that permits very young children to demonstrate social-cognitive competence, and perhaps to offer insight into the breakdown of these processes in autism.
METHOD

Participants

Ninety (46 male, 44 female) 4-month-old infants (M = 18.6 weeks; SD = .96) and their parents participated in this longitudinal study. Seventy-seven of the same infants (38 male, 39 female) participated in a second visit when they were nine months of age (M = 39.9 weeks; SD = .80). Of the seventy-seven families that participated at 9 months, 48 also completed a questionnaire on imitation skills that was mailed to their home when their infant was 12 months of age. Data from an additional 3 infants are excluded based on screening at either 4 or 9 months of age.

Parent-infant dyads were seen twice in the laboratory: first when the infant was approximately four months old and again when the infant was approximately nine months old (+/- two weeks at each age). Due to scheduling constraints, 20 infants at the 4-month visit and 15 infants at the 9-month visit were seen within the week following the two-week cut-off.

Families were recruited through newspaper birth announcements (n = 67), advertisements for the study in local newspapers (n = 8), posters in community locations serving infants and their families (n = 2), family physicians (n = 2), prenatal “class reunions” (n = 5), and word of mouth (n = 6). Parents who were recruited through birth announcements were contacted by letter and / or phone. Parents who responded to advertisements or posters called the Child Study Centre to indicate their interest in participating. All families lived in or around Halifax, Nova Scotia, and received a toy and a certificate for participating at each visit. The majority of families (98%) were Caucasian and of middle- to upper-middle socioeconomic background. Sixty-four percent of mothers, and 55 percent of fathers had completed a university degree. For all families,
both mother and father were living in the same household. Ten percent of infants were
cared for on a daily basis by an adult in addition to their parents, typically nannies,
grandparents, or other relatives. Hours of care ranged from 3 to 48 hours per week.
Twenty-two percent of infants participated in one or more play groups with their parents.
Forty-eight percent of the infants in the study were first-borns. Thirty-nine percent had
one older sibling, while an additional thirteen percent had two or more older siblings.
Seven families reported being concerned about developmental or learning difficulties
with their infant’s sibling, while thirty-four families reported medical, developmental, or
learning difficulties with other first-degree relatives.

Screening (4 and 9 months)

Developmental screening was conducted for the current study as we were
recruiting typically developing infants and their families. This screening took place in
two stages – a general screen before the 4-month visit, and a more comprehensive screen
at the 9-month visit.

Families of 4-month-old infants who met selection criteria on a telephone
screening interview (see Appendix A) were invited to attend a one-hour experimental
session. For four families, a telephone screening interview could not be conducted. Of
these families, one mother-infant dyad participated in the study but was later found to
have not met eligibility criteria and was therefore excluded. Selection criteria for the
study included: (a) birth at full term (38-42 weeks); (b) birth weight of 2500 grams (5.5
pounds) or more; (c) an Apgar score of 7 or higher (42 families did not have a record of
their infant’s Apgar score, but were not informed of any difficulties at birth, and
experienced no concerns during the first few weeks with their baby); (d) no identified
visual, auditory, or motor difficulties; and (e) no serious medical disorders that would potentially affect cognitive abilities or the ability of the infant to interact socially with their parents.

A second screening was conducted when the families were contacted again for their infant’s second visit (9 months). Parents were mailed a copy of the Kent Inventory of Developmental Skills (KIDS; Reuter & Gruber, 2000), a parent report developmental screening questionnaire (see Measures for more detail on the KIDS). The KIDS was completed at home and returned at the 9-month appointment. Families of infants whose parent report on the KIDS suggested a developmental delay (Full Scale or individual subscale scores 2 SDs or greater below the mean) were contacted by a psychologist who specializes in developmental disorders to discuss the results of the questionnaire and to provide suggestions for follow-up assessment for their infant if needed (n = 6). Questions endorsed by parents that were of clinical concern were addressed with the infant’s mother. On all occasions for which follow-up was required, clarification indicated that the infant’s development was in fact within the typical range.

**Measures (4, 9, and 12 months)**

Table 1 summarizes the battery of questionnaires and tasks that were administered at each of the 4 and 9 month visits and the 12-month questionnaire mail-out.

**Questionnaires.**

*Demographics (4 and 9 months).*

The demographics questionnaire requested information about family demographics and composition such as number of siblings and birth order, parental education and occupation, and family history of medical and developmental difficulties.
See Appendix B for the 4-month demographics form. At 9 months, parents reviewed the information they had provided at their first visit. Any additions or changes to the information on file were made at this time.

*Infant Behaviour Questionnaire-Revised (IBQ-R; Rothbart & Garstein, 2000) (4 and 9 months).*

This caregiver report instrument is comprised of 191 temperament items within 14 scales and assesses multiple aspects of infant temperament (e.g. activity level, soothability, smiling and laughter, fear, perceptual sensitivity). The IBQ-R (see Appendix C) is a revised version of the original IBQ (Rothbart, 1981) which is a well-established, psychometrically strong measure of infant temperament. Preliminary research with the IBQ-R suggests that it maintains the robust psychometric properties of its predecessor, while enabling a more fine-grained assessment of individual differences in temperament within the first year of life (Gartstein & Rothbart, 2001). Items on the IBQ-R ask parents to rate on a seven-point Likert scale (never to always) the occurrence of particular behaviours during certain everyday situations over the past 7 days. For example, parents were asked, “After sleep, how often did the baby play quietly in the crib?”. Table 2 includes descriptions of each of the 14 scales.

*Kent Inventory of Developmental Skills (KIDS; Reuter & Gruber, 2000) (9 months).*

The KIDS is a parent-completed rating scale for assessing infant functioning. It contains 252 items and assesses multiple aspects of child functioning, including cognitive, motor, communication, self-help, and social abilities. The KIDS has been used in a variety of contexts and countries to assess the developmental status of typically developing infants as well as infants with medical conditions and developmental delays. It correlates highly with other measures of development, is a reliable measure of
developmental status independent of the rater, and has consistently strong test-retest reliability. In addition to its generally robust psychometric properties, the KIDS is user-friendly and accessible for parents.

Table 1

<table>
<thead>
<tr>
<th>Visit</th>
<th>Questionnaires</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Months</td>
<td>Demographics</td>
<td>Visual-Spatial Attention</td>
</tr>
<tr>
<td></td>
<td>IBQ-R</td>
<td>Visual Proprioceptive Inter-modal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Visual Auditory Inter-modal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parent-Infant Free Play</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parental Imitation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Object Exploration</td>
</tr>
<tr>
<td>9 Months</td>
<td>Demographics</td>
<td>Visual-Spatial Attention</td>
</tr>
<tr>
<td></td>
<td>IBQ-R</td>
<td>Visual Proprioceptive Inter-modal</td>
</tr>
<tr>
<td></td>
<td>KIDS</td>
<td>Visual Auditory Inter-modal</td>
</tr>
<tr>
<td></td>
<td>MacArthur</td>
<td>Parent-Infant Free Play</td>
</tr>
<tr>
<td></td>
<td>Imitation (9 months)</td>
<td>Object Exploration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gaze Following</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Infant Imitation</td>
</tr>
<tr>
<td>12 Months</td>
<td>Imitation (12 months)</td>
<td></td>
</tr>
<tr>
<td>(mailed to home)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. IBQ-R (Revised Infant Behaviour Questionnaire, Rothbart & Gartstein, 2003) KIDS (Kent Inventory of Developmental Skills, Reuter & Gruber, 2000) MacArthur (MacArthur Communicative Development Inventories, Fenson et al., 1979)*

*MacArthur Communicative Development Inventory: words and gestures (Fenson et al., 1993) (9 months).*

This parent-report measure contains two sections: a) early words, and b) actions and gestures. The early words section assesses the child’s first signs of responding to language, phrases understood, imitation of words, and labelling. It also includes a 396-
item vocabulary checklist. The actions and gestures section assesses early communicative and representational skills that are not dependent on verbal expression (i.e., pretend play, games and routines, imitation). Data on the reliability and validity of the MacArthur indicate that it is a psychometrically sound, user-friendly measure of communicative development in infancy and early childhood.

*Imitation questionnaires (9 and 12 months).*

The imitation questionnaires were designed by the investigators as brief, parent-reports of infants' emerging imitation abilities. The 9-month version of the questionnaire assesses (a) infants' awareness that a parent, caregiver, or sibling is copying them; (b) emerging imitation skills; and (c) circumstances under which imitation is more likely to occur (e.g., does the infant imitate more with a particular family member?). The 12-month version of the imitation questionnaire expands upon the 9-month questions and inquires about breadth and frequency of imitative abilities (e.g., actions, sounds, words, and daily household activities) across various situations, and emerging delayed imitation skills. See Appendix D for the imitation questionnaires administered at 9 and 12 months of age.
### Table 2

**Infant Behaviour Questionnaire-Revised (IBQ-R) Scale Descriptions**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity Level</td>
<td>Gross motor activity, including movement of arms and legs, squirming and locomotor activity. (“When put into the bath water, how often did the baby splash or kick?”)</td>
</tr>
<tr>
<td>Distress to Limitations</td>
<td>Fussing, crying or showing distress while a) in a confining place or position; b) in caretaking activities; c) unable to perform a desired action. (“When placed on his/her back, how often did the baby fuss or protest?”)</td>
</tr>
<tr>
<td>Fear</td>
<td>Startle or distress to sudden changes in stimulation, novel physical objects or social stimuli; inhibited approach to novelty. (“How often during the last week did the baby startle to a sudden or loud noise?”)</td>
</tr>
<tr>
<td>Duration of Orienting</td>
<td>Attention to and/or interaction with a single object for extended periods of time. (“How often during the last week did the baby stare at a mobile, crib bumper or picture for 5 minutes or longer?”)</td>
</tr>
<tr>
<td>Smile and Laughter</td>
<td>Smiling or laughter during general caretaking and play. (“How often during the last week did the baby smile or laugh when given a toy?”)</td>
</tr>
<tr>
<td>High Intensity Pleasure</td>
<td>Pleasure or enjoyment related to high stimulus intensity, rate, complexity, novelty, and incongruity. (“During a peek-a-boo game, how often did the baby smile?”)</td>
</tr>
<tr>
<td>Low Intensity Pleasure</td>
<td>Amount of pleasure or enjoyment related to low stimulus intensity, rate, complexity, novelty and incongruity. (“When playing quietly with one of his/her favorite toys, how often did the baby show pleasure?”)</td>
</tr>
<tr>
<td>Soothability</td>
<td>Reduction of fussing, crying, or distress when soothing techniques are used by the caregiver. (“When patting or gently rubbing some part of the baby’s body, how often did s/he soothe immediately?”)</td>
</tr>
<tr>
<td>Falling Reactivity/Rate of Recovery from Distress</td>
<td>Rate of recovery from peak distress, excitement, or general arousal; ease of falling asleep. (“When frustrated with something, how often did the babycalm down within 5 minutes?”)</td>
</tr>
<tr>
<td>Scale</td>
<td>Descriptions</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cuddliness</td>
<td>Expression of enjoyment and molding of the body to being held by a caregiver. (“When rocked or hugged, during the last week, how often did the baby seem to enjoy him/herself?”)</td>
</tr>
<tr>
<td>Perceptual Sensitivity</td>
<td>Detection of slight, low intensity stimuli from the external environment. (“How often did the baby notice fabrics with scratchy texture (e.g., wool)?”)</td>
</tr>
<tr>
<td>Sadness</td>
<td>Lowered mood and activity related to personal suffering, physical state, object loss, or inability to perform a desired action; general low mood. (“Did the baby seem sad when the caregiver was gone for an unusually long period of time?”)</td>
</tr>
<tr>
<td>Approach</td>
<td>Rapid approach, excitement, and positive anticipation of pleasurable activities. (“When given a new toy, how often did the baby get very excited about getting it?”)</td>
</tr>
<tr>
<td>Vocal Reactivity</td>
<td>Amount of vocalization exhibited by the baby in daily activities. (“When being dressed or undressed during the last week, how often did the baby coo or vocalize?”)</td>
</tr>
</tbody>
</table>

Note: Scale descriptions from Gartstein & Rothbart (2003)

**Tasks.**

*Computerized visual-spatial attention task (VSAT) (4 and 9 months).*

The VSAT is a measure of visual-spatial attention, modified for this study from that developed by Landry (1998; Landry & Bryson, in press). In the VSAT, infants were seated in an infant seat approximately 1 metre away from the center of a white projection screen (see Figure 1). Images appeared on the screen in 3 imaginary panels – left, center, and right. Two different patterns served as stimuli, each of which consisted of an 8x8 inch square comprised of brightly coloured geometric shapes that filled the square while appearing to fall on top of each other. Stimuli were projected from a Lightware Legend LS-8 800x600 colour data projector positioned two-and-a-half meters behind the infant at
a height of 1.8 metres. An IBM computer running Windows software presented the stimuli. During each trial, one of these patterns (rotating purple, pink, green, and blue triangles) appeared in the center panel (see Figure 2), and acted as a central fixation point, whereas the other pattern (rotating red, blue, yellow, and green rectangles) appeared in either the left or right panel. At a distance of approximately 1 metre, the central stimulus subtended a visual angle of 11.7 x 11.7 degrees. Total visual angle for the area in which stimuli were presented was 54 degrees, while visual angle between the central stimulus and either peripheral stimulus was 22 degrees. A pilot study found no difference between the attractiveness of the patterns used for the central and peripheral stimuli (Landry & Bryson, in press).

There were two kinds of trials in the VSAT: Shift trials and Disengage trials. In the Shift trials, a stimulus was first presented in the center panel. When the infant looked at the central stimulus, the experimenter pressed a computer key and the central stimulus disappeared. After 1000 ms, another stimulus appeared either in the left or the right panel. The Disengage trials were identical to the Shift trials except that the central stimulus remained on the center panel when the peripheral stimulus was presented. On each trial, the peripheral stimulus remained on the screen for a maximum of 8 seconds before a new trial began. There were 10 trials each of the Shift and Disengage conditions, 5 left and 5 right. Order of presentation of the trials for each infant was randomly generated by the computer software. If an infant did not fixate spontaneously upon presentation of the central stimulus, the experimenter shook a rattle or clapped in order to elicit orienting. Individual trials were repeated after the full set of 20 trials if the infant looked away from the center panel before the peripheral stimulus appeared.
Figure 1. Visual-spatial attention task setup

Figure 2. Central stimulus for the visual-spatial attention task
Infant looking was recorded by a colour video camera/recorder (SAMSUNG S CL630 22x optical zoom lens) positioned directly beneath the bottom edge of the projection screen. The image from this camera was displayed to the experimenter and parents on a 14-inch monitor outside the experimental area. A small mirror attached to the back of the infant’s chair was positioned so as to reflect the stimuli presented on the screen and to enable simultaneous recording of infant gaze and stimulus onset/offset (see Figure 1).

*VSAT coding.*

At each age (4 and 9 months), saccadic latencies (SLs: the length of time taken to initiate an eye movement towards the peripheral stimulus) were calculated for each of the 20 trials. Mean SLs were then derived for type of trial (disengage and shift), and side of presentation of the peripheral stimulus (left and right). SLs were calculated using a frame-by-frame analysis of the trials on videotape, where thirty frames represented one second of real time. For each of the 20 trials, the number of frames between the onset of the peripheral stimulus and the infant’s first eye movement towards that stimulus was counted, followed by conversion to milliseconds (33.3ms/frame). Infants who did not orient to the peripheral stimulus on a particular trial were assigned the maximum reaction time (8 seconds) for that trial. As in previous research, latencies that were less than 200 ms were not included in the analyses as they are considered anticipatory in nature (Canfield & Haith, 1991; McConnell & Bryson, 2004).

*Visual-auditory inter-modal processing task (VAIP) (4 and 9 months).*

*Displays.* Two object events were recorded in colour with sound onto separate videotapes. In each event, a female experimenter was filmed from shoulders to waist and each of the actions in the video occurred within that space (Eppler, 1995). She wore a
solid blue top as a uniform background for the events, and was facing straight toward the video camera. In the first event, a clear glass mason jar containing bright blue and green marbles was shaken up and down. In the second event, a metal spoon was banged against the bottom of a blue metal bowl. As in Eppler (1995), these actions were not rhythmic, but instead were produced in an irregular pattern. The sound produced by shaking the glass jar of marbles reflected multiple impacts, while the spoon banging on the bottom of the bowl made discrete, single-impact sounds.

**Apparatus.** Infants were seated in an infant seat 56 cm above the floor facing two 19-inch colour television monitors which were approximately 76 cm away. The television screens were positioned side-by-side on a table 73.7 cm tall at eye level from the infant’s slightly reclined position, and were approximately 46 cm apart (from the inside edge of one screen to the other). Two speakers were centered between the television screens and a mechanical toy dog was placed between the speakers. The infants viewed the two object displays simultaneously while hearing the soundtrack that matched one of the visual images (see Figure 3). The soundtrack alternated across trials, while the visual displays remained on the same viewing side throughout the duration of the trials. The mechanical dog was activated between trials to re-orient infant looking to center before the next trial began. At 9 months, a frog rattle was used for this purpose and was removed from sight between trials. A colour video camera/recorder (SAMSUNG S CL630 22x optical zoom lens) that was positioned behind a curtain centered between the two television monitors recorded infant looking. The image from this camera was displayed on a 14-inch monitor outside the experimental area for parents to watch.
Figure 3. Stimulus display for the visual-auditory inter-modal processing task.
VAIP coding and reliability.

Videotapes of the VAIP task at both 4 and 9 months were coded following the sessions. A coder blind to the position of the displays used a computer keyboard to code the amount of time infants spent looking left, right, and away from the displays during each of the six 20 second trials. For each trial, a proportion score was calculated for time spent looking at the sound-specified display (inter-modal matching) out of the total amount of time the infant spent looking at both displays. Proportions greater than .50 were considered a preference for the matching or non-matching display. Infants received a score out of 6 for the number of trials they preferred to watch the matching display, the non-matching display, and showed no preference (.50/.50). Average scores were calculated across the 6 trials for: (1) proportion of time spent looking at their preferred screen; and (2) proportion of time spent looking at the sound-specified display. Number of gaze switches (once the infant oriented to a display, the number of times they then looked back-and-forth between the two displays) was also calculated for each trial, and an average score for gaze switching across the 6 trials was computed.

At 4 and 9 months, a second coder blind to the position of the displays coded 26% of the tapes (n = 23) selected randomly. Reliability was assessed using intraclass correlation coefficients. For all analyses, coefficients ranged from .97 to .99 at 4 months and .88 to .99 at 9 months.

Visual-proprioceptive inter-modal processing tasks (VPPIPs) (4 months and 9 months).

The VPPIP task measures the infant’s ability to detect a temporal contingency between visual and proprioceptive information. The 4-month version of the VPPIP task measured detection of a temporal contingency between the infant’s live visual image of
their own legs, and the proprioceptive feedback they received from their body. The 9-month version of the VPIP task presented the infants with simultaneous live and pre-recorded images of their own face.

Equipment for the VPIP tasks was similar to that used for the VAIP task.

*4-month task – VPIP kicking.*

Infants were seated in an infant seat facing two television screens. The following apparatus was constructed to project the image of the infant’s legs for the camera (see Figure 4a): a 30.5 x 30.5 cm square mirror was positioned on the floor directly in line with the edge of a table. A colour video camera was positioned 122 cm behind the infant seat on a tripod 45.5 cm high facing, and angled towards the floor mirror. When infants were seated in the infant seat, a 64.5 x 43 cm framed mirror was positioned with the reflective surface above their legs with the top edge supported above the chair by wooden dowels (30.5 cm long), and the bottom edge attached by Velcro to the table. The mirror was approximately 6 cm above the infant’s legs and was positioned horizontally from the infant seat to the edge of the table. With this setup, infants were able to see the video displays over the top of the mirror but could not see their own legs and torso once a bib was attached from the front edge of the mirror to the back edge of the infant seat. The image of the infant’s legs was reflected in the mirror above them to the floor mirror, and from the floor mirror to the video camera. Striped black/red/yellow/white socks were put on the feet and legs of all infants to disguise individuals, maximize visibility, and to equate for colour and brightness (Rochat & Morgan, 1995). A green cloth was also placed across the infant’s torso to cover any clothing visible above the top of the socks. A colour video camera/recorder was positioned behind a curtain, centered between the monitors. This camera recorded the infant’s face during presentation of the stimuli.
Figure 4. Task set-up and stimulus displays for the visual-proprioceptive inter-modal processing task at 4 months.
One screen presented a live image of the infant’s own legs (as reflected from the floor mirror to the camera). This image was captured and presented such that the view was similar to what the infant would see if she looked down at her own legs. On the other monitor, the infant saw the pre-recorded image of the legs of the previous infant who participated (see Figure 4b). This yoked control design was used to address variability in activity level across infants (Bahrick & Watson, 1985). Side of presentation of the live and pre-recorded images was counterbalanced across infants.

9-month version – VPIP faces.

In the 9-month version of the VPIP task, infants were seated on their parents’ laps facing the two monitors approximately 76 cm away. Live and pre-recorded images of the infant’s own face, neck, and upper shoulders were presented simultaneously to the infant on the monitors for 2 minutes (see Figure 5). Side of presentation was counterbalanced across infants. The recording of the infant’s face during the VAIP task (approximately 10 minutes earlier) served as the pre-recorded image for the VPIP task. As before, a video camera positioned behind a curtain centered between the two monitors recorded infant looking.
Figure 5. Stimuli for the 9 month visual-proprioceptive inter-modal processing task
VPIP coding and reliability.

Variables that were coded for the 4-month VPIP task included looking time measures and other behavioural indicators of the infant’s discrimination between the two displays. An RA blind to side of presentation of the live and pre-recorded images coded the videotapes. Time spent looking at the left and right monitors, and away from the displays during the 4-minute task period was recorded. Looking proportions were calculated by dividing the time infants spent looking at the non-contingent image by the time they spent looking at either display.

Infants were also rated by blind coders on four-point Likert scales (0-3) for the following: (a) their level of interest in the displays and (b) amount of “testing” they engaged in (i.e., looking intently at the displays, kicking their feet, pausing, looking at the displays again as if to “test” what was happening on the screens).

Similar measures were derived at the 9 month visit. Looking proportions were calculated in the same manner. Behavioural measures coded included: (1) number of smiles/laughs, (2) number of frowns/grimaces, (3) number of times the infant reached towards or pointed at the displays, and (4) number of times infants leaned or rocked towards the displays. Similar to the 4-month coding, infants were rated on 4-point Likert scales (0-3) for: (a) amount of testing (e.g. looking intently, moving, pausing, looking again; pointing, repetitive hand/arm movements; tongue/mouth exploration while watching the displays), and (b) level of interest in the displays.

At 4 months, a second coder coded 29% of the data. Intraclass correlation coefficients for looking times ranged from .91 to .94. Behavioural measures were also coded; the intraclass correlation coefficient for “testing” was .85, and .82 for interest in the displays. Similar reliability coding occurred at 9 months (27% of infants). Looking
time correlation coefficients ranged from .82 to .88. The coefficient for “testing” was .83, and .78 for interest in the displays. Rocking/leaning correlation coefficients ranged from .80 to .87. For reaching/pointing, the coefficients ranged from .78 to .82.

Mother-infant dyadic play (4 and 9 months) and imitation (4 months).

4-month version.

At 4 months the free play and imitation task took place with the infant seated in an infant seat facing their parent who was seated across from them. Parent-infant dyads first participated in one-and-a-half minutes of free play, followed by a two-minute maternal imitation session. Once the parent and infant were seated comfortably, instructions were given for the free play. Parents were asked to play with their infant as they would do at home when they are face-to-face without toys. After one-and-a-half minutes, the experimenter presented instructions for the imitation segment. Parents were asked to copy exactly what their infant said and did – gestures, facial expressions, and vocalizations. They were told that if their infant did something with his or her toes, they could do the same thing with their knees. Imitative play continued for two minutes.

Throughout both the free play and imitation segments, a camera situated behind a curtain filmed the mother and infant together. A small 37 x 20 cm mirror that was attached 16.5 cm above the upper right corner of the infant’s chair reflected the parent’s face for the camera. Parents were unable to see their own image during this task. Set-up for the play and imitation sessions is illustrated in Figure 6a.
Figure 6. Free play session at (a) 4 months and (b) 9 months
9-month version.

At 9 months, free play took place on the floor (see Figure 6b). The play area was demarcated by a 2.6 x 3.2 meter blanket. A set of standard toys was laid out on the blanket including: a small plastic hammer, a colourful board book, an octopus “cause and effect” ring set that made noises when the rings were removed or replaced, a noisy plastic frog rattle with a mirror on the reverse side, a squishy camel rattle, a plush duck puppet, and a fleece bee puppet. Each infant sat across from his or her parent with the toys between them. Parents were instructed to play with their infant as they would typically do at home when playing with toys. The play session lasted for 3 minutes. A colour video camera partially hidden by a screen filmed the play session.

Coding and reliability.

During the 4 month free play session, eight measures were derived from behaviour coded from videotape. Observers recorded the duration of time the infant spent watching their parent’s face and the amount of time spent watching their parent’s actions. Duration of time spent vocalizing was also recorded, as was frequency of infant movements. Ratings on a 5-point Likert scale (1-5) were made for infants’ engagement with their parents during the free play session. Parental behaviour coded during the free play session included time spent touching the infant, time spent vocalizing, and a rating of level of engagement with their infant.

During the imitation segment, the same infant behaviours were coded as during the initial free play segment. An additional measure of infant behaviour (a yes/no score) indicated whether or not the infant attempted to “test” their imitating parent (as an indication of recognition that one is being imitated, defined after Meltzoff 1990). This
infant “testing” behaviour was seen as a parallel to that engaged in during the VPIP task at 4 months.

Three observers coded 3 subsets of the data and overlapped on 10%. A fourth independent coder overlapped with each of the 3 primary coders on 14-18% of the data. Intraclass correlation coefficients for the set of 4 month measures from the free play segment ranged from .77 to 1.00. For the imitation segment, coefficients ranged from .79 to 1.00.

At 9 months, a number of play session measures were coded using keyboard strokes on a computer while watching the videotaped sessions. Appendix E presents the list of measures from the 9 month play session. Inter-rater reliability was established by having a second coder code 26% (n = 18) of the tapes. Coefficients ranged from .78 to .89.

Object exploration task (4 and 9 months).

At both 4 and 9 months, an object exploration task was administered. Data from the 4-month version of this task are not included in the current study. Partial data from the 9-month task measuring initiation of joint attention is included.

9 months

At 9 months, infants were seated in a highchair with a tray top across from the experimenter (see Figure 7). Parents sat diagonally behind their infants and were instructed not to participate in their infant’s play, either physically or verbally. If the infant turned around to look at them, show, or give them an object, they were instructed to smile and nod and provide a single-word positive comment (e.g., “wow”, “yes”) while handing the object back. Throughout the session, the experimenter smiled and nodded at
the infant if she made eye contact with her. A video camera recorded infants’ object exploration, showing and giving, and looks towards the experimenter and parent.

*Figure 7.* Object exploration task at 9 months
Coding and reliability

Variables coded from the object exploration task included (a) number of looks to the experimenter, (b) number of looks to the parent, and (c) number of times the infant showed/gave an object to the experimenter or their parent. Three coders overlapped on 15% of the data. Intraclass correlation coefficients were as follows: number of looks to experimenter $= .92$, number of looks to parent $= .84$, number of shows/gives $= .82$.

Imitation task (9 months).

During the imitation task, infants were seated in a highchair across from the experimenter while parents sat diagonally beside and behind their infants (see Figure 8). After a warm-up phase during which infant and experimenter played together with a puppet, the imitation trials began. The experimenter demonstrated nine actions for the infant to copy, presented in a random order. Actions fell into one of three categories: manual gestures, actions with objects, and vocalizations. As seen in Table 3, three actions were included in each category. For each action involving discrete components, the experimenter performed the movement (or vocalized) five times (e.g., clapped 5 times). After each demonstrated action, the experimenter paused and looked excitedly towards the infant. If the infant did not imitate after 5 seconds, the experimenter demonstrated the action a second time. If the infant did imitate, the experimenter and the parent clapped and responded with excitement and demonstrated the action a second time for the infant to imitate. After the experimenter had demonstrated each of the 9 actions, the parent then took the experimenter’s place and demonstrated the same nine actions, pausing to encourage the infant to imitate. The experimenter sat diagonally behind the infant and instructed the parent. A camera positioned on a tripod 3 feet in front of the infant recorded infant behaviour, including looks to both parent and experimenter.
Figure 8. Imitation task at 9 months
### Table 3

**Actions Demonstrated for the Infants During the Imitation Task**

<table>
<thead>
<tr>
<th>Category</th>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gesture</td>
<td>Clapping</td>
<td>While clapping 5 times, the experimenter said “clap”, “clap”, “clap”, “clap”, “clap” in an excited voice.</td>
</tr>
<tr>
<td></td>
<td>Waving</td>
<td>While waving, the experimenter said “bye bye” 3 times in a row in an excited voice.</td>
</tr>
<tr>
<td></td>
<td>Tapping Cheek</td>
<td>While tapping her cheek 5 times, the experimenter said “tap”, “tap”, “tap”, “tap”, “tap” in an excited voice.</td>
</tr>
<tr>
<td>Object-Directed</td>
<td>Shaking Rattle</td>
<td>While shaking the rattle up and down 5 times, the experimenter said “shake”, “shake”, “shake”, “shake”, “shake” in an excited voice.</td>
</tr>
<tr>
<td></td>
<td>Tapping Table</td>
<td>While tapping the table 5 times, the experimenter said “tap”, “tap”, “tap”, “tap”, “tap” in an excited voice.</td>
</tr>
<tr>
<td></td>
<td>Knocking Over Block</td>
<td>The experimenter slowly knocked over the block with an open palm 3 times while saying “OH” before providing the infant with the opportunity to knock it over</td>
</tr>
<tr>
<td>Vocal</td>
<td>Saying “Ahhhh”</td>
<td>The experimenter said “Ahhhhhhh” for a count of approximately 3 seconds.</td>
</tr>
<tr>
<td></td>
<td>Saying “Mama” or “Dada”</td>
<td>The experimenter said “Mama” 5 times and “Dada” 5 times.</td>
</tr>
<tr>
<td></td>
<td>Making Kissing Noise</td>
<td>The experimenter made 5 kissing/pucker noises, pausing briefly in between each one.</td>
</tr>
</tbody>
</table>

*Note: Actions were demonstrated in a random order for each infant.*
Coding and reliability.

In order to maximize the opportunities each infant had to imitate the actions, the experimenter demonstrated each action twice (Trials 1 and 2) followed by the parent who demonstrated each action once (Trial 3). Scoring was designed to capture differences in performance across model (experimenter versus parent) and trial (1 vs 2 vs 3). Additionally, we were interested in infants’ approximations to imitation, rather than solely using an all-or-none approach to performance. Videotapes were coded by two independent raters.

For all-or-none imitation, infants received an overall score from 0-9. This score represented infants’ ability to fully imitate the 9 actions regardless of who demonstrated or on what trial they imitated. This overall score permitted the maximum opportunity (3 trials across experimenter and parent) for infants to demonstrate their imitation ability; their best performance across the three trials contributed to the overall score. Full imitation was defined as a clearly recognizable copy of the experimenter’s action. The imitative response did not need to be perfect or exact (e.g. clapped once, not five times) however it did need to meet the defining criteria of the action (e.g. two hands with palms facing inwards brought together forcefully to touch). Other scores derived from all-or-none imitation performance include a 0-9 score for experimenter Trial 1, experimenter Trial 2, and parent Trial 3. Broken down into categories, 0-3 scores were calculated for gesture, vocal, and object-directed imitation across the 3 trials (see Figure 9 for the all-or-none imitation scores).
Figure 9. Breakdown of scores for full imitation and approximation to imitation
During each of the 9 demonstrations, infants responded in a variety of ways ranging from watching but not responding, engaging in behaviour directed towards the experimenter, responding with a partial imitation, and fully imitating the action. Infants’ approximations to imitation were scored on a 0-3 scale: 0 for no response, 1 for experimenter-directed actions (e.g., touch experimenter’s hands) and “other” behaviour in response to the demonstration (e.g., banging the table after seeing a clapping demonstration), 2 for partial imitation (e.g., hands brought together to clasp, or touch softly), and 3 for full imitation of the action. A list of the approximations to imitation that infants engaged in for each demonstrated action can be found in Table 11 in the Results section. Similar to the all-or-none scoring, infants received a 0-27 overall score regardless of who demonstrated or on what trial the infant’s response occurred. Scores were then broken down into 0-27 for Trials 1 through 3, and 0-9 for each category of imitation: gesture, vocal, and object-directed (see Figure 9).

Three other scores were derived from the imitation task. Infants were rated on a 0-4 scale by naïve coders for how engaged in/excited by the imitation task with the experimenter they appeared. Engagement/excitement was to be rated independently of imitation performance; some infants were very engaged in the task, yet did not demonstrate much imitation. Using videotapes of the imitation task, the proportion of time infants spent watching the experimenter’s demonstrations was calculated. Finally, since infants sometimes engaged in vocal or gesture imitation after the experimenter had moved on to another demonstration, the number of such delayed imitations was recorded.

Inter-rater reliability for imitation was assessed by a second coder coding 25% of the tapes. Intra-class correlation coefficients for imitation scores were as follows: 0-9 full
imitation .90, Trial 1 full imitation .89, Trial 3 full imitation .94, 0-27 approximations to imitation .89, Trial 1 approximations to imitation .88, Trial 3 approximations to imitation .96, engagement .83, delayed imitation 1.00.

*Gaze following task (9 months).*

While infants were seated in the highchair and playing with the experimenter, an assistant exposed two attractive, brightly coloured targets that were located on the walls to the left and right, each at a distance of 64 inches from the infant. The targets were positioned at eye level and at a 90 degree angle from the infant such that infants were easily able to see the targets if they turned their heads in the correct direction (see Figure 10). Once the infant’s attention was engaged, the experimenter proceeded with four gaze-following trials. The first two trials were to the left and right targets (direction of looking counterbalanced across infants). The experimenter called the infant’s name and established eye contact. She then immediately turned her head slowly and deliberately to look at one of the targets, maintaining an interested expression. After 3 seconds of gazing at the target, the experimenter called the infant’s name a second time. The trial ended 3 seconds later. Trials two through four proceeded in the same manner, with the exception that on the third and fourth trials the experimenter said “Look!” in an excited voice as she turned her head to look at the target. Following the experimenter trials, the infant’s parent completed four identical gaze-following trials. Parents watched while the experimenter delivered the trials, and were coached as needed to administer the trials. All four parent trials were counterbalanced as per the instructions of the experimenter (parents were instructed to look at the left or the right target on each trial).
Figure 10. Gaze following task at 9 months
Coding and reliability

On each of the 8 trials (4 with experimenter, 4 with parent), infants' head turns were classified as one of the following responses: Correct (turns head in direction of the experimenter's), Incorrect (turns head in the opposite direction of the experimenter's), Failure to Orient (infant does not respond with a head turn), or Orients Elsewhere (e.g., looking down at tray table, looking up at ceiling). Infants received a gaze following difference score ranging from -4 to 4 for the experimenter trials, a score out of 4 for parent trials, and an overall score out of 8. The trial on which infants first demonstrated gaze following (0 through 4) was noted for experimenter trials. In addition, infants received a score for the number of trials during which they oriented correctly and located the target. We were also interested in the behavioural responses infants made following detection of the target such as checking (infant looks back and re-establishes eye contact with the experimenter or the parent), vocalizing (infant makes positive or negative vocalizations while watching the target), reaching (infant reaches towards the target), and smiling (infant smiles while watching the target). Two coders blind to side of head turn of the experimenter coded infant looking. Intraclass correlation coefficients were as follows: gaze following score out of four = .88, locating target score out of 4 = .84, checking score out of 4 = .86.

Procedure (4 months)

Prior to attending their first session at 4 months, families were mailed an introductory letter and two questionnaires (demographics, IBQ-R (Gartstein & Rothbart, 2000)) which they completed at home and then brought with them to their appointment.
Ten of the families received their questionnaires at the session itself to complete at home and mail back to the Child Study Centre.

At the initial appointment, a female experimenter explained the study to the parents and outlined what they could expect during the test session. Informed consent was obtained at this time (see Appendix F for informed consent document at 4 months). The order of tasks during the test session was fixed and as follows: (1) Visual-spatial attention task; (2) Inter-modal tasks (counterbalanced visual-proprioceptive and visual-auditory); (3) parent-infant play session (free play then imitative play); (4) object exploration task.

After any questions were answered by the experimenter, infants were seated in an infant seat on a chair 75 centimetres away from a blank white screen in a sectioned off corner of the laboratory room. The first task was explained to the parents, who were shown a television monitor on which they could watch their infant throughout the task. Parents sat near, but out of sight of their infants. Once the infants were seated comfortably, the visual-spatial attention task began and lasted approximately 4 minutes. Overhead lights were dimmed during this task in order to maximize brightness of the stimuli and to minimize distractibility of the infants.

Following the attention task, the setup was arranged for either the visual-proprioceptive inter-modal processing task (VPIP) (46 infants) or the visual-auditory inter-modal processing task (VAIP) (47 infants). For both inter-modal processing tasks, infants were seated in an infant seat on a chair 56 centimetres away from two monitors. The infants who first participated in the VPIP task had their shoes removed by their parent, their pants rolled up (if worn), and had long striped socks placed on their feet and
legs. For most infants, the socks covered to just above their knees. Once the infant was positioned correctly and comfortably in the seat, the experimenter zoomed in on the image of their legs on the floor mirror. When it was clear that the camera was not recording any part of the infant’s clothing other than the socks and the green cloth (see Measures), the task began. Infants viewed the two colour screens side by side for 4 minutes. One screen displayed a live transmission of the infant’s legs and feet (contingent display) and the other screen displayed the legs and feet of the previous infant who participated in the study (non-contingent display).

Infants who first received the VAIP task were positioned similarly in the infant seat in front of the two monitors. Once they were seated correctly and comfortably, the task began. Object events were presented during six 20-second trials with a 3-second blank screen between trials. The soundtrack for the six trials alternated across object events (i.e., spoon, marbles, spoon, marbles, spoon, marbles) with the sound for the first object event (spoon or marbles) counterbalanced across infants. Each object event itself however was presented on a fixed monitor (i.e., left monitor spoon, right monitor marbles), also counterbalanced across infants.

After the visual-spatial attention and inter-modal tasks, infants were removed from their seats and had a short break with their parents (approximately 2 to 10 minutes). Afterwards, the dyadic free play session began. Parents were seated across from their infants (who had been returned to the seat) and were instructed to play as they would typically do at home when they are face to face without toys. After an initial 1.5 minutes of free play, parents were then instructed to copy their babies’ actions, vocalizations, and facial expressions. Imitative play lasted for 2 minutes.
Following the dyadic free play and a second short break (2 to 5 minutes), the experimenter took the place of the parent across from the infant and the object exploration task began.

Upon completion of the object exploration task, any questions parents had were answered. Parent and infant were presented with a toy and a certificate in appreciation for their participation.

_Procedure (9 months)_

Parents were re-contacted approximately two-and-a-half weeks before their infant turned 9 months of age. Those parents who were able to attend the 9-month visit ($n = 77$) were mailed a set of questionnaires to complete including the IBQ-R (Gartstein & Rothbart, 2003), the KIDS (Reuter & Gruber, 2000), the MacArthur CDI (Fenson et al., 1993), an imitation questionnaire, and an abbreviated demographics questionnaire requesting an update of the information provided at the 4-month visit. At that time an appointment was scheduled for their second visit (within two weeks of their infant turning 9 months).

On arrival at the Child Study Centre, informed consent for the 9-month visit was reviewed (see Appendix F) and questions regarding the visit and the questionnaires were addressed. As during the 4-month visit, the order of task presentation was fixed. Infants first participated in the visual-spatial attention task (VSAT) which proceeded in a manner identical to the 4-month version of the task (see 4-month Measures and Procedure). Following the VSAT, the visual-auditory inter-modal perception task took place (VAIP). Again, this task proceeded in a similar manner to the 4-month version (see 4-month Measures and Procedure) with the exception that the mechanical toy dog was not used to
re-direct attention between trials. During piloting at 9 months, the infants tended to continue watching the dog during the trials. In its place, a frog rattle was used to direct their attention but was removed from view during the actual trials.

Following the VAIP task, parents and infants had a short break (2 to 5 minutes) while the experimenter prepared for the imitation task. Once the infant was seated in the high chair, the experimenter explained the task to the parents and requested that they observe the actions as they would be asked to demonstrate each one to their infant when the experimenter was finished. After a short warm-up period, the imitation trials began (see Measures) and the experimenter and parent demonstrated each of the actions for the infant to copy. The imitation task took approximately 10-13 minutes to complete.

During the imitation trials, an assistant cued the tape of the infant from the VAIP task to serve as one of the stimuli for the visual-proprioceptive inter-modal processing task. When the imitation task was finished, parents were asked to sit with their infant on their lap facing the two television monitors. Parents were instructed not to comment on or respond in any way to what they observed on the television screens. For two minutes, infants were presented with a silent live image of their face, neck, and top of shoulders and a similar pre-recorded image of themselves during the VAIP task. Side of presentation was counterbalanced across infants. A colour video camera positioned behind a curtain in front of the infant projected the live image of the infant to the television and simultaneously recorded infant looking.

Following the VPIP task, parent and infant had a second break (approximately 5 minutes) while the room was re-arranged for object exploration and gaze following. Infants were seated in a high chair across from the experimenter while their parents sat
diagonally behind their infant. A video camera recorded the infant’s exploration of the
objects, showing and giving, and looks towards the experimenter and parent.

Gaze following proceeded immediately after object exploration. Infants remained
seated in the high chair and played with the objects and the experimenter while the
assistant placed the targets in their correct locations (see 9 month Measures). Parents
continued to sit behind their infant during the first half of the task, then took the
experimenter’s place for the latter trials.

Upon completion of gaze following, parents and infants had a third break while
the room was re-arranged for the play session. A standard set of toys was arranged on a
blanket on the floor (see 9 month Measures) and parents were asked to play with their
infant as they would do at home. A camera partly hidden from view recorded the parent-
infant object play session for 3 minutes.

At the end of the session, parents and infants were presented with a certificate and
toy for participating, and any questions were answered.

Procedure (12 months)

Approximately two weeks before their infant’s first birthday, parents were mailed
a final imitation questionnaire to complete and return in the self-addressed, stamped
envelope that was provided. Parents were asked to contact the experimenter if they had
any difficulties with the questionnaire.
RESULTS

Overview of Analyses

All analyses were conducted using the SPSS statistical package (SPSS Inc., 1988). Not all infants were able to complete every task, resulting in missing data. Technical difficulties, which occurred on occasion, also impacted completeness of datasets. Results of screening procedures indicated that missing values were non-systematic. Parent-provided explanations for infants who were unable to complete tasks included poor sleep the previous night, hunger, and illness. Missing data were not replaced; all analyses were conducted with listwise deletion of cases with missing data. A series of screening analyses were conducted to evaluate relevant assumptions for the various analyses conducted in the current study (e.g., normality, linearity, homoscedasticity, ratio of cases to independent variables). Evaluations of assumptions for the various analyses were acceptable, though missing data resulted in a low cases to IVs ratio for some of the multiple regression analyses. Concerns about sample size and other methodological limitations will be addressed further in the discussion.

The current study proposed to address three primary questions related to imitation development in infancy. First, a comprehensive description of imitation abilities at 9 months is presented, including sensitivity to being imitated and imitation skill. Second, analyses examine whether individual differences in imitation at 9 months can be predicted on the basis of performance on social and non-social tasks at 4 months. Lastly, concurrent relationships between imitation and other social and non-social skills at 9 months are explored.

Results from the current study will be organized around these primary questions. The first section will present comprehensive quantitative and qualitative data on “the
picture of imitation” at 9 months. The second section will examine performance on the predictor and concurrent relationship tasks. Data presented from these tasks is limited to the central variables thought to be associated with the emergence of imitation skills. A third section presents findings from a series of regression analyses investigating prediction of individual differences in imitation at 9 months from 4-month social and non-social measures. Lastly, the fourth section of the results will focus on concurrent relationships between imitation and other 9-month task scores.

*Imitation Abilities and Sensitivity to Being Imitated*

*Imitation Measures*

Traditionally, imitation ability in infants is assessed within an elicited imitation paradigm in a laboratory-based study. While this enables maximum control over the research setting, it does not permit the study of spontaneous imitation in more naturalistic conditions with which the infant is most familiar. In an attempt to measure different aspects of infant imitation, the current study assessed imitation ability in three ways: (1) parent report of imitation skill at 9 and 12 months, including sensitivity to being imitated and actual copying behaviour; (2) performance on a lab-based elicited imitation task at 9 months; and (3) spontaneous imitation during a short play session with a parent at 9 months. Parental imitation of their infant and creating opportunities for their infant to imitate during free play will also be examined in relation to infant imitation.

*Imitation Questionnaire at 9 and 12 months*

When infants were both 9 and 12 months of age, parents were asked to rate their imitation abilities on a 5-point scale from 0-4. Imitation recognition (noticing when you are being copied by another person) and imitation production (ability to imitate another
person) were both assessed. At 12 months, parents were asked to rate their infant’s emerging delayed imitation abilities. Qualitative information about imitation performance was also collected at both ages. At 9 months, parents were asked how they could tell their infant had noticed they were being imitated, what kinds of imitative actions their infant typically noticed, what actions/vocalizations their infant imitated more readily, and under what circumstances their infant was most likely to imitate. At 12 months, detailed information was gathered about the breadth and frequency of imitation across various situations.

*Parent Report of Infant Imitation – Quantitative Ratings at 9 and 12 Months*

Descriptive data for the imitation questionnaire can be found in Table 4. At both 9 and 12 months, infants received a higher mean score for noticing when their vocalizations rather than their actions were being imitated (see Table 5). “Recognition of imitation” scores were also higher at both ages than ratings of actual imitation. At 12 months, infants’ mean delayed imitation score was lower than both imitation recognition and immediate imitation ability at that age. No gender differences were found at either age for parent ratings of imitation skill (recognition or performance: all $p$-values $> .10$).
Table 4

Descriptive Data for the Imitation Questionnaire at 9 and 12 months

<table>
<thead>
<tr>
<th>Question</th>
<th>9 months</th>
<th>12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your baby notice if you copy what he/she is doing (his/her movements)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>3.03</td>
<td>3.26</td>
</tr>
<tr>
<td>$SD$</td>
<td>.79</td>
<td>.61</td>
</tr>
<tr>
<td>$Range$</td>
<td>0-4</td>
<td>2-4</td>
</tr>
<tr>
<td>Does your baby notice if you copy what he/she says (sounds)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>3.22</td>
<td>3.44</td>
</tr>
<tr>
<td>$SD$</td>
<td>.77</td>
<td>.58</td>
</tr>
<tr>
<td>$Range$</td>
<td>1-4</td>
<td>2-4</td>
</tr>
<tr>
<td>Has your baby started to copy what other people are doing?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>2.23</td>
<td>2.87</td>
</tr>
<tr>
<td>$SD$</td>
<td>1.11</td>
<td>.81</td>
</tr>
<tr>
<td>$Range$</td>
<td>0-4</td>
<td>1-4</td>
</tr>
<tr>
<td>Has your baby started to do “delayed imitation” (after a delay of at least 10 minutes, your baby copies something he/she saw someone do)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td></td>
<td>1.48</td>
</tr>
<tr>
<td>$SD$</td>
<td>N/A</td>
<td>1.38</td>
</tr>
<tr>
<td>$Range$</td>
<td></td>
<td>0-4</td>
</tr>
</tbody>
</table>

Note. Ratings for each question were made on a 0(never) – 4(always) Likert scale. Sample sizes for each of the questions at 9 months ranged from 71-72 and from 46-48 at 12 months.
Table 5

*Within Age Differences Between Parent Report Ratings of Imitation at 9 (N = 72) and 12 Months (N = 48)*

<table>
<thead>
<tr>
<th>Paired Comparison</th>
<th>M (SD)</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notice movements - 9 months</td>
<td>3.03 (.79)</td>
<td>-2.34*</td>
</tr>
<tr>
<td>Notice sounds - 9 months</td>
<td>3.22 (.77)</td>
<td></td>
</tr>
<tr>
<td>Notice movements - 9 months</td>
<td>3.03 (.79)</td>
<td>6.58***</td>
</tr>
<tr>
<td>Starting to copy - 9 months</td>
<td>2.23 (1.11)</td>
<td></td>
</tr>
<tr>
<td>Notice sounds - 9 months</td>
<td>3.22 (.77)</td>
<td>7.82***</td>
</tr>
<tr>
<td>Starting to copy - 9 months</td>
<td>2.23 (1.11)</td>
<td></td>
</tr>
<tr>
<td>Notice movements - 12 months</td>
<td>3.26 (.61)</td>
<td>-2.07*</td>
</tr>
<tr>
<td>Notice sounds - 12 months</td>
<td>3.43 (.58)</td>
<td></td>
</tr>
<tr>
<td>Notice movements - 12 months</td>
<td>3.26 (.61)</td>
<td>2.85**</td>
</tr>
<tr>
<td>Starting to copy - 12 months</td>
<td>2.87 (.81)</td>
<td></td>
</tr>
<tr>
<td>Notice sounds - 12 months</td>
<td>3.43 (.58)</td>
<td>3.66**</td>
</tr>
<tr>
<td>Starting to copy - 12 months</td>
<td>2.87 (.81)</td>
<td></td>
</tr>
<tr>
<td>Starting to copy - 12 months</td>
<td>2.87 (.81)</td>
<td>6.74***</td>
</tr>
<tr>
<td>Delayed copying - 12 months</td>
<td>1.54 (1.38)</td>
<td></td>
</tr>
</tbody>
</table>

Note: *p < .05, **p < .001, ***p < .0005.

As expected, age-related improvements were found in parent-reported imitation (see Table 6). A repeated measures analysis of variance (ANOVA) revealed a significant increase from 9 and 12 month scores for all three measures.
Table 6

*Age-Related Changes in Parent Report Imitation Performance From 9 to 12 months (n=44)*

<table>
<thead>
<tr>
<th>Question</th>
<th>9 months</th>
<th>12 months</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your baby notice if you copy what he/she is doing (his/her movements)?</td>
<td>3.00</td>
<td>3.25</td>
<td>4.88*</td>
</tr>
<tr>
<td>M</td>
<td>.89</td>
<td>.61</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your baby notice if you copy what he/she says (sounds)?</td>
<td>3.16</td>
<td>3.43</td>
<td>4.58*</td>
</tr>
<tr>
<td>M</td>
<td>.81</td>
<td>.59</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has your baby started to copy what other people are doing?</td>
<td>2.11</td>
<td>2.86</td>
<td>17.66**</td>
</tr>
<tr>
<td>M</td>
<td>1.13</td>
<td>.82</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Ratings for each question were made on a 0(never) – 4(always) Likert scale. n = 44 (sample comprised of infants whose parents completed the imitation questionnaire at both 9 and 12 months)*

*p < .05. **p < .0005.

Relationships among parent report imitation scores at 9 and 12 months were also examined (see Table 7). At 9 months, recognition by infants of their movements being copied was highly related to recognition of their vocalizations being copied. Parent report of imitation recognition was also strongly related to parent report of imitation performance for both movements and sounds. At 12 months, a similar relationship was found between noticing copying of movements and vocalizations. In contrast, there was no relationship between imitation recognition and imitation performance at 12 months for either movements or vocalizations. Parental ratings of immediate imitation ability at 12
months were related to ratings of delayed imitation at 12 months. Ratings of infant ability to notice when they are being copied at either 9 or 12 months were not associated with ratings of delayed imitation performance at 12 months.

Table 7

*Interrelationships Among Parent Report Imitation Scores at 9 and 12 months of age*

<table>
<thead>
<tr>
<th></th>
<th>9 months</th>
<th></th>
<th></th>
<th>12 months</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Movements</td>
<td>Sounds</td>
<td>Imitating</td>
<td>Movements</td>
<td>Sounds</td>
<td>Imitating</td>
</tr>
<tr>
<td>Movements</td>
<td>1.0</td>
<td>.59***</td>
<td>.43***</td>
<td>.55***</td>
<td>.24</td>
<td>.06</td>
</tr>
<tr>
<td>Sounds</td>
<td>1.0</td>
<td>.41***</td>
<td>.48**</td>
<td>.29*</td>
<td>.17</td>
<td>.08</td>
</tr>
<tr>
<td>Imitating</td>
<td>1.0</td>
<td>.53***</td>
<td>.42***</td>
<td>.29*</td>
<td>.37*</td>
<td></td>
</tr>
</tbody>
</table>

12 months

|                      |                  |                  |                  |           |                  |                  |
| Movements            | 1.0              | .55***           | .16              | .07       |
| Sounds               | 1.0              | -.11             | .05              |
| Imitating            | 1.0              | .35*             |
| Delayed              | 1.0              |

*Note.* Ratings for each question were made on a 0(never) – 4(always) Likert scale.

*p < .05.  *p < .01.  **p < .001.  ***p < .0005.

Sample size for each correlation at 9 months ranged from 71-72. Sample size for each correlation at 12 months ranged from 46-48. Sample size for each longitudinal correlation ranged from 44-46.

Longitudinal associations between ratings were also found. Infants who were more likely to notice their movements being imitated at 9 months continued to do so at 12 months. The same was true, but to a lesser degree, for noticing imitation of vocalizations, and for imitation performance. Interestingly, infants who were skilled at noticing that their vocalizations were being copied at 9 months received higher ratings for recognition of movement imitation at 12 months, however the inverse relationship was not found.
between recognition of movement imitation at 9 months and noticing imitation of vocalizations at 12 months. Imitation performance ability at 9 months was related to recognition of movement imitation and recognition of vocalization imitation at 12 months. Infants who were rated as better immediate imitators at 9 months also received higher delayed imitation ratings at 12 months.

In summary, parents reported that their infants are more sensitive to noticing when their vocalizations are copied than their movements. This was true for ratings at both 9 and 12 months of age. At both ages, infants were also rated as being better at noticing when they were being copied than imitating themselves; recognition ratings were higher than performance ratings. Consistent with expectations, parents reported that their infants were better at immediate than delayed imitation at 12 months. Also as expected, age-related improvements were seen for both sensitivity to being imitated and imitation skill. Relationships between ratings were also found: recognition of sounds being imitated at 9 and 12 months was strongly related with recognition of movements being imitated, and at 9 months, infants who received higher recognition ratings also received higher ratings for performance. Similar longitudinal findings emerged; infants who received higher ratings at 9 months for sensitivity and skill were the same infants who received high ratings at 12 months.

*Parent Report of Infant Imitation – Qualitative Information at 9 and 12 Months*

Qualitative data collected from parents at 9 and 12 months about their infant’s imitation abilities provides information about context, what situations facilitate imitation, and what models infants are more likely to copy at these ages. It also gives some insight into how infants typically respond when they are being copied by another person.
9 month imitation questionnaire

At 9 months, parents were asked how they could tell their infant has noticed that they are being imitated. The examples that parents provided can be captured under two different categories: responsivity and enjoyment (see Figure 11). Many parents reported that their infant smiles at them (68%), laughs (36%), or becomes excited (8%) (e.g., waved arms, clapped) when they copy their movements/vocalizations. Infants appear to enjoy being copied and communicate that enjoyment to their parents. One parent reported that their infant “smiles, laughs, and tries to continue the game”. Infants also demonstrate behaviours that suggest they have recognized that their parent has responded contingently to their own action/vocalization. Infants stop what they are doing, look at their parent, and sometimes repeat the action their parent copied. Following repetition, some infants pause and wait for their parent to copy them again. One parent reported that their infant “looks at my action, then looks back at what she is doing”. Some parents indicated that their infants try to reach out and touch them (e.g. their face, their arms) following their own imitative behaviour. Infants appear to display a number of behaviours that suggest that they are able to notice their parent’s contingent behaviour, and that they greatly enjoy this type of interaction.
Figure 11. Infant behaviour when imitated by parent (questionnaire) at 9 months ($N = 72$).
At 9 months parents were also asked to indicate what kinds of imitative actions their infants were most likely to notice. Consistent with quantitative ratings, parents reported that imitative sounds were noticed most frequently (85%), followed by arm and hand movements (39%). When asked about what actions their infant was more likely to copy, sounds were again reported most frequently (81%), followed by waving (51%) and clapping (31%). When asked what object-related actions their infant was most likely to copy, 58% of parents reported that there was no such action, and no single action was listed by more than 11% of parents. With respect to actions that do not involve objects, one third of parents reported that their infant was not more likely to copy particular actions. Other parents reported that gesture imitation was common (e.g. clapping (21%), waving (14%), and shaking head (10%)). Copying parent’s babbling (e.g. “la la, pa pa”) was also common for 10% of infants. Parents were also asked if there were particular people that their infant was likely to imitate. Not surprisingly the mother (65%) and father (53%) were the most common responses, followed by other family members. Some parents reported that imitative routines themselves tended to be person-specific (e.g., yelling or banging the table with father, peek-a-boo or singing with mother).

12-month imitation questionnaire

At 12 months, parents were again asked about their infant’s imitation abilities. With respect to recognition of imitation, parents were asked to rate how often their infant engaged in particular behaviours when they were being imitated. The rating scale provided for parents ranged from 1 (rarely) to 4 (often), and the list of possible behaviours was generated from the findings of the 9-month questionnaire (see Appendix D). Infants were rated by parents as most likely to look at them and smile. Touching the parent was rated as the most infrequent behaviour, whereas stopping, repeating the
action, and laughing were intermediate. Other behaviours that parents indicated their infant engaged in when being imitated included wrinkling their noses, grabbing own face, getting louder, becoming excited and shaking arms, making a sound, and running away playfully.

Parents were asked to rate what actions their infants were most likely to notice when being copied. Similar to the findings at 9 months, parents indicated that their infants most frequently noticed imitation of their vocalizations, followed by body movements, facial expressions, and finally toy play.

Parents were provided with a list of 24 actions their infant might copy (e.g., sounds, touch head, push a car) and 6 “other” opportunities to provide examples (see the 12-month imitation questionnaire in Appendix D for the complete list). They were asked to indicate which their infant imitated and to rate (1 to 4) how often their infant copied each of these behaviours. Of 30 possible actions, infants imitated a mean of 15.73 behaviours \((SD = 6.19; \text{range 2-28})\). The mean frequency rating was 3.1 \((SD = .46; \text{range 2-4})\). The most frequently imitated actions that parents reported for their infants were waving (94%), clapping (84%), throwing a ball (84%), pushing a car (80%), sounds (78%), and knocking over blocks (78%).

Parents were provided with a list of 24 activities around the home that their infant might copy (e.g., sweeping, talking on the phone, hammering) and 5 opportunities to report “other” activities. As before, they were asked to check the activities that their infant copied and to rate (1 to 4) how frequently each action was imitated. Of 29 possible activities, infants imitated a mean of 10.0 activities \((SD = 6.56; \text{range 1-26})\). The mean frequency rating for household activities was 3.0 \((SD = .65; \text{range 1-4})\). The most
common household activities parents reported that their infants imitated were reading a book (88%), playing a musical instrument (68%), talking on the phone (66%), hammering (62%), and typing on a computer keyboard (58%).

As at the 9-month visit, parents were asked whether there was a particular object-related action their infant was most likely to copy, but again no single action was reported by a large number of parents. Actions that parents reported their infants were most likely to copy that did not involve an object included clapping (40%), waving (22%) and sounds (20%). Parents were asked if there was a particular person that their infant was more likely to imitate. Similar to the 9-month findings, infants were most likely to copy their mother (76%) and father (42%) followed by other family members.

On the 12-month questionnaire, parents were also asked about their infant’s demonstrations of delayed imitation. Parents indicated the period of time after which they have seen their infant engage in delayed imitation. While 19% of parents reported that their infant does not yet imitate following a delay, others reported a wide range from 10 minutes to a few days. In addition to noting the length of the delay, parents were asked to provide examples of actions their infant has copied after a delay. Behaviours included waving goodbye, making animal sounds (e.g. barking, roaring, “gorilla”), doing chores (e.g., dusting, wiping table), brushing their hair, clapping, and reading a book.

Qualitative findings from the 9- and 12-month questionnaires provide important information about infants’ emerging imitation abilities. Parent report indicates that infants respond to being copied in a variety of ways and enjoy imitative interactions/games, and that their behaviour at 12 months is similar to that at 9 months. At both ages, parents reported that infants were more likely to notice when their
vocalizations were being copied, which was consistent with the findings from the quantitative ratings. Gestures such as clapping and waving were reported as the next most likely behaviours infants would copy. With respect to imitation performance, parents indicated that infants at 9 months were also more likely to copy vocalizations, while at 12 months of age, gestures had become the most frequent imitated behaviour. Twelve-month-old infants had also begun to copy activities around the home that were often social in nature (e.g., talking on the phone). Imitation of actions on toys had become more sophisticated (e.g., playing a guitar, driving a truck) than at 9 months (e.g., shaking a rattle, banging a block).

*Imitation Task at 9 Months*

Prior to their infant participating in the imitation task, parents were asked whether their infant could perform the actions that were going to be demonstrated for them later in an imitative context. The list of actions presented to parents included 3 vocal (“ahhh”, kiss noise, “mama/dada”), 2 gestural (clap, wave), and 4 object-directed (tap table, bang toy during play, knock over block, shake rattle) behaviours. By parent report, not all infants were able to perform each of the actions prior to participation in the current study. Table 8 presents a list of the actions demonstrated to the infants during the imitation task and the percentages of infants who, by parent report, were able to perform each action (not necessarily in an imitative capacity). Over 90% of infants were reportedly able to say “mama” or “dada”, say “ah”, shake a rattle, and tap a table. Approximately half of the infants were reported as able to wave, clap, and make a kissing noise. Two thirds of the infants were able to perform at least 6 of the 8 actions (“bang toy during play” was not included as “tap table” was the actual action demonstrated during the imitation task).
Table 8 also presents information on the number of infants who were able to fully imitate each of the 9 actions during the imitation task (regardless of the trial during which the actions were demonstrated) (to be discussed in a later section).

Completion of imitation trials

Despite considerable effort to engage infants in the imitation task by including a playful warm-up period, reinforcing successful imitation (clapping and cheering), and taking short breaks as needed, not all infants were able to complete the two experimenter trials (T1 and T2) and the parent trial (T3). Infants varied in how engaged they were, and how willing they were to sit in the infant seat for the duration of the imitation task. Successful completion was defined as the infant being able to sit through the duration of the 9 sub-trials without fussing to the extent that it precluded participation. Of the 77 infants who attended the 9-month session, 66 successfully completed all 9 sub-trials of T1, 65 completed all sub-trials of T1 and T2, and 49 were able to complete all sub-trials of T1, T2, and T3.

For infants who successfully completed all of the 9 imitation trials, we were interested in how attentive they were to the demonstrated action / vocalization. Proportion of time spent watching the demonstration (time watching / length of the demonstration) was calculated for each action separately, for the average of the three gesture, vocal, and object demonstrations, and for the average across all nine actions. Infants spent a majority of the demonstration time watching the modeled action / vocalization (average across all 9 actions: $M = .80$, $SD = .12$). Actions on objects ($M = .88$, $SD = .12$) were observed significantly more than gestures ($M = .80$, $SD = .16$: $t(65) = -.308$, $p < .003$) or vocalizations (watching the experimenter’s mouth) ($M = .70$, $SD = .12$).
\[SD = .21: t(67) = 6.01, p < .0005\], while gestures were observed more than vocalizations \((t(64) = 4.70, p < .0005)\).

Table 8

**Number of Infants Who Can Perform and Imitate the Actions Demonstrated During the Imitation Task**

<table>
<thead>
<tr>
<th>Action Demonstrated</th>
<th>Percentage of Infants Who Can Do the Action</th>
<th>Percentage of Infants Who Fully Imitated the Action During the Imitation Task (Regardless of Trial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waving</td>
<td>57%</td>
<td>8%</td>
</tr>
<tr>
<td>Clapping</td>
<td>44%</td>
<td>9%</td>
</tr>
<tr>
<td>Tapping Cheek</td>
<td>Not Asked</td>
<td>3%</td>
</tr>
<tr>
<td>Say “Mama” or “Dada”</td>
<td>92%</td>
<td>19%</td>
</tr>
<tr>
<td>Say “Ahhhhh”</td>
<td>91%</td>
<td>7%</td>
</tr>
<tr>
<td>Make kissing noise</td>
<td>48%</td>
<td>1%</td>
</tr>
<tr>
<td>Shake Rattle</td>
<td>100%</td>
<td>83%</td>
</tr>
<tr>
<td>Bang a Toy During Play</td>
<td>100%</td>
<td>Not Demonstrated</td>
</tr>
<tr>
<td>Tap Table</td>
<td>95%</td>
<td>56%</td>
</tr>
<tr>
<td>Knock Over a Block</td>
<td>88%</td>
<td>41%</td>
</tr>
</tbody>
</table>

*Note. Sample size was \(N = 77\) for each action on the parent questionnaire while sample size for each action demonstrated during the imitation task ranged from \(N = 69-74\).*
Imitation Task Performance – Approaches to Scoring

As discussed under Measures, infants were provided with two opportunities to imitate each of the 9 actions with the experimenter and one opportunity with their parent. For all-or-none “full” imitation, infants received 4 possible scores:

1. overall “best performance” score from 0-9 which represented infants’ ability to fully imitate the 9 actions regardless of who demonstrated (parent or experimenter) or on what trial they imitated (1, 2, or 3).
2. 0-9 full imitation score for experimenter Trial 1.
3. 0-9 full imitation score for experimenter Trial 2.
4. 0-9 full imitation score for parent Trial 3.

Broken down into categories, 0-3 full imitation scores were also calculated for gesture, vocal, and object-directed imitation across the 3 trials for the all-or-none imitation scores) (see Figure 9 in the Methods).

Infant approximations to imitation were scored on a 0-3 scale (see Measures for a detailed description of the scale). Similar to the all-or-none imitation scoring, infants received 4 scores:

1. 0-27 overall score regardless of who demonstrated or on what trial their response occurred.
2. 0-27 score for experimenter Trial 1.
3. 0-27 score for experimenter Trial 2.
4. 0-27 score for parent Trial 3.
Full imitation (0-9 score) results for trials one through three and for best performance

A main question of interest for the imitation task was to determine how many of the nine demonstrated actions infants were able to fully imitate, where full imitation was defined as an imitative response by the infant that was highly similar in form to the demonstrated action of the experimenter. This was examined across trials (score out of 9 for T1, T2 and T3), and also for “best” performance out of 9 (highest performance for each action regardless of the trial during which it occurred). Zero to three scores were also examined in order to address performance by category of imitation (vocal, gesture, action on object). Table 9 illustrates the percentage of infants receiving scores ranging from 0-9 on each of the three trials and their “best” performance while Table 10 presents the percentage of infants receiving scores ranging from 0-3 (for categorical imitation) on each of the three trials and their “best” performance.

Of the infants who attended the 9 month session (N = 77), 72 completed all 9 actions on at least one of the three trials and were therefore assigned a “best” full imitation score from 0 to 9. Five of these infants received an overall score of zero: although they successfully completed the imitation task, they were unable to fully imitate any of the 9 actions. The other 67 infants received scores ranging from 1 to 5. The mean “best” full imitation score for the group was 2.28 (SD = 1.17). In addition to receiving a “best” score across any of the three trials, scores were calculated separately for each trial. As discussed above, 67 infants successfully completed all of the 9 sub-trials for the first trial with the experimenter and were given a T1 score. For T2, 65 infants received scores, while 49 infants received scores for T3 with their parent. Table 9 presents data for the percentage of infants receiving the full range of scores (0-9) on each of the 3 trials and

113
for their "best" performance regardless of trial. On each individual trial, approximately 25% of infants received a score of 0. In contrast, when "best" performance across trials is considered, only 7% of infants received a score of 0.

Table 9

Percentage of Infants Who Fully Imitated the 9 Actions Across Trials 1-3 and Their Best Score

<table>
<thead>
<tr>
<th>Score(0-9)</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Best Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25.8</td>
<td>24.6</td>
<td>24.5</td>
<td>6.9</td>
</tr>
<tr>
<td>1</td>
<td>39.4</td>
<td>29.2</td>
<td>14.3</td>
<td>13.9</td>
</tr>
<tr>
<td>2</td>
<td>22.7</td>
<td>33.8</td>
<td>38.8</td>
<td>41.7</td>
</tr>
<tr>
<td>3</td>
<td>9.1</td>
<td>9.2</td>
<td>14.3</td>
<td>23.6</td>
</tr>
<tr>
<td>4</td>
<td>3.0</td>
<td>3.1</td>
<td>6.1</td>
<td>9.7</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2.0</td>
<td>4.2</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. Of N = 72, n = 66 completed T1, n = 65 completed T2, n = 49 completed T3.
Table 10

Percentage of Infants Who Fully Imitated the 9 Actions Across Trials 1-3 and Their Best Performance for Category of Imitation (0-3 score)

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Best Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gest</td>
<td>Obj</td>
<td>Voc</td>
<td>Gest</td>
</tr>
<tr>
<td>0</td>
<td>91.7</td>
<td>29.2</td>
<td>91.7</td>
</tr>
<tr>
<td>1</td>
<td>8.3</td>
<td>38.9</td>
<td>6.9</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
<td>25.0</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>6.9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. N ranged from 68-72 across categories and trials.

Imitation performance on each trial and for "best" performance was also examined by category of imitation: 0-3 scores for each category of gesture (clap, wave, tap cheek), object (shake rattle, tap table, knock block), and vocal imitation (kiss, mama/dada., ahhh). Table 10 presents the percentages of infants receiving full imitation scores from 0 to 3 for each category. To receive scores, infants were required to have successfully participated (i.e., no crying, fussing) in each of the three actions for a particular category. For this reason, sample sizes across categories ranged from 68-72.

In summary, the data indicated that not all 9-month-old infants are imitating during an elicited imitation task. Almost 25% of infants did not imitate a single action of the demonstration (either experimenter or parent). As expected, infants better imitated object-directed actions than gestures or vocalizations. Also as expected, infants engaged in more gesture and vocal imitation with their mother than with the experimenter.
Approximations to imitation (0-27 score) results for trials 1 to 3 and for best performance

In addition to looking at infants’ overall imitation abilities, we were interested in whether infants engaged in approximations to imitation. Using Kaye and Marcus’ (1981) categories of behaviour as a guide, we established a hierarchical set of responses to the model for each of the 9 demonstrated actions. Coders characterized infant behaviours following the demonstration as non-responsive or irrelevant, or as falling within one of the categories in the set of hierarchical responses for that particular action (e.g. waving). Infants engaged in a variety of approximations to imitation. Table 11 presents the hierarchical sets of responses for each of the 9 actions. Scores assigned to each of the behaviours fell into four categories:

0 = no response/irrelevant response;

1 = approximation - response directed towards the experimenter (e.g., touches experimenter’s hand after she modeled clapping), a required precursor behaviour (e.g., picks up rattle), or a relevant response directed elsewhere (e.g., infant hits the table with her hand when the experimenter claps);

2 = approximation - an imprecise action that is related to the modeled action (e.g., infant touches her own hands together once lightly after the experimenter modeled clapping);

3 = full imitation - a precise copy of the experimenter’s demonstrated action (a temporal match was not required, e.g., infant claps her hands together at least once after the experimenter modeled five claps).

Table 11 also presents the number of infants engaging in the approximations to imitation (scores of 1 and 2) across the three trials.
Table 11

Number of Infants Engaging in Approximations to Imitation on Each of the 3 Trials

<table>
<thead>
<tr>
<th>Action Demonstrated</th>
<th>Approximation (in hierarchical order)</th>
<th># of Infants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>T1</td>
</tr>
<tr>
<td>Waving</td>
<td>touches experimenter’s/parent’s hand</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>engages in an “other” related behaviour</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>raises own hand</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>moves own hand in wave approximation</td>
<td>2</td>
</tr>
<tr>
<td>Clapping</td>
<td>touches experimenter’s/parent’s hand</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>engages in an “other” related behaviour</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>touches own hands together</td>
<td>2</td>
</tr>
<tr>
<td>Tapping Cheek</td>
<td>touches/reaches for experimenter’s/parent’s hand</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>engages in an “other” related behaviour</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>raises own hand</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>places own hand on face</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>touches own cheek</td>
<td>0</td>
</tr>
<tr>
<td>Tapping Table</td>
<td>touches/reaches for experimenter’s/parent’s hand</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>tries to make experimenter’s/parent’s hand tap table</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>engages in an “other” related behaviour</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>places own hand on table</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>rubs own hand on table</td>
<td>2</td>
</tr>
<tr>
<td>Knocking Over Block</td>
<td>touches block</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>picks up block</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>puts block in mouth</td>
<td>16</td>
</tr>
<tr>
<td>Shaking Rattle</td>
<td>takes rattle from experimenter/parent</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>brings rattle to lips</td>
<td>14</td>
</tr>
<tr>
<td>Saying “Mama/Dada”</td>
<td>reaches for experimenter’s/parent’s mouth</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>opens own mouth</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>moves mouth with no sound</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>makes a noise</td>
<td>9</td>
</tr>
<tr>
<td>Saying “Ahhhh”</td>
<td>reaches for experimenter’s/parent’s mouth</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>opens mouth</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>makes a noise</td>
<td>8</td>
</tr>
<tr>
<td>Making kissing noise</td>
<td>reaches for experimenter’s/parent’s mouth</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>opens mouth</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>moves mouth with no sound</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>makes a noise</td>
<td>1</td>
</tr>
</tbody>
</table>
To incorporate credit for approximate responses, infants received a 0-27 “best” approximations to imitation score in addition to the 0-9 full imitation score. 72 infants received a “best” performance approximations to imitation score ($M = 10.75; SD = 3.73$), while 0-27 scores were also examined across the three trials (see Table 12). The highest best performance score achieved by one infant was 20, while across trials, the highest score ranged from 15-18.

Table 12

<table>
<thead>
<tr>
<th>Score (0-27)</th>
<th>Trial 1 Mean</th>
<th>Trial 2 Mean</th>
<th>Trial 3 Mean</th>
<th>Best Score Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M = 7.03$</td>
<td>$M = 6.41$</td>
<td>$M = 7.66$</td>
<td>$M = 10.75$</td>
</tr>
<tr>
<td></td>
<td>$SD = 3.42$</td>
<td>$SD = 3.59$</td>
<td>$SD = 4.30$</td>
<td>$SD = 3.73$</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8.2</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>4.7</td>
<td>2.0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>7.7</td>
<td>9.4</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>6.2</td>
<td>12.5</td>
<td>6.1</td>
<td>1.4</td>
</tr>
<tr>
<td>4</td>
<td>13.8</td>
<td>9.4</td>
<td>8.2</td>
<td>1.4</td>
</tr>
<tr>
<td>5</td>
<td>12.3</td>
<td>7.8</td>
<td>4.1</td>
<td>2.8</td>
</tr>
<tr>
<td>6</td>
<td>9.2</td>
<td>9.4</td>
<td>12.2</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>9.2</td>
<td>6.3</td>
<td>10.2</td>
<td>11.1</td>
</tr>
<tr>
<td>8</td>
<td>12.3</td>
<td>17.2</td>
<td>10.2</td>
<td>13.9</td>
</tr>
<tr>
<td>9</td>
<td>3.1</td>
<td>4.7</td>
<td>8.2</td>
<td>11.1</td>
</tr>
<tr>
<td>10</td>
<td>9.2</td>
<td>4.7</td>
<td>2.0</td>
<td>9.7</td>
</tr>
<tr>
<td>11</td>
<td>6.2</td>
<td>4.7</td>
<td>10.2</td>
<td>5.6</td>
</tr>
<tr>
<td>12</td>
<td>1.5</td>
<td>6.3</td>
<td>2.0</td>
<td>8.3</td>
</tr>
<tr>
<td>13</td>
<td>3.1</td>
<td>0</td>
<td>6.1</td>
<td>5.6</td>
</tr>
<tr>
<td>14</td>
<td>4.6</td>
<td>1.6</td>
<td>2.0</td>
<td>9.7</td>
</tr>
<tr>
<td>15</td>
<td>1.5</td>
<td>0</td>
<td>4.1</td>
<td>8.3</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>0</td>
<td>4.1</td>
<td>4.2</td>
</tr>
<tr>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>18</td>
<td>0</td>
<td>1.6</td>
<td>0</td>
<td>2.8</td>
</tr>
<tr>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.4</td>
</tr>
<tr>
<td>21-27</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. T1 $N = 65$. T2 $N = 64$. T3 $N = 49$. Best Score $N = 72$. 

118
As can be seen in Figure 12, there was a wide range of partial imitation scores for any given full imitation score, suggesting that these scores are capturing somewhat different aspects of imitation performance.

*Imitation task performance across trials*

A question of interest with respect to imitation performance was whether infants maintained or improved upon their performance across the two trials with the experimenter and whether they performed better on trial 3, with their parent. A series of repeated measures ANOVAs were run to examine imitation performance over trials for the 0-9 full imitation score and the 0-27 approximations to imitation score.

For 0-9 imitation, a repeated measures ANOVA revealed that performance improved across the 3 trials ($F(2,46) = 4.05, \ p < .02$) (see Figure 13). Paired $t$-tests revealed that performance on T3 with parents ($M = 1.71, SD = 1.29$) was significantly better than performance on T1 ($M(1,19, SD = 1.08) \ (t (47) = -2.88, \ p < .006$) and T2 ($M = 1.29, SD = 1.11) \ (t (47) = -2.02, \ p < .04$) with the experimenter. There was no difference between performance on T1 and T2 ($t(47) = -0.68, \ p > .05$).

For the 0-27 approximations score, there was a trend towards overall improvement in performance across the 3 trials ($F(2,45) = 2.56, \ p < .08$). On T1, infants received higher scores ($M = 6.89, SD = 3.62$) than on T2 ($M = 6.30, SD = 3.79$), while T3 scores with parents were the highest of the three trials ($M = 7.83, SD = 4.25$). Paired $t$-tests revealed significant differences between performance on T2 and T3 ($t(46) = -2.17, \ p < .03$), and a trend towards a difference between T1 and T2 ($t(46) = 1.71, \ p < .09$), wherein infants performed slightly better on T1 than on T2.
Figure 12. Relationship between 0-9 and 0-27 imitation scores (N=72).
Figure 13. Performance across trials for (a) 0-9 full imitation and (b) 0-27 approximations to imitation scores. Error bars represent 95% confidence intervals.
In summary, infants performed better on the imitation task with their parent than with the experimenter. This was true for 0-9 scores and partially true for 0-27 scores.

Patterns of imitation performance

To examine patterns of performance across the 9 actions, a cluster analysis was performed using the default squared Euclidian distance with a weighted between-groups analysis. Variables entered into the cluster analysis included the nine 0-3 approximations to imitation scores for each of the 9 actions. Cluster memberships were saved for a range of solutions (2-6). An examination of the means and standard deviations of group memberships for each of the saved solutions (2-6) revealed that a 4-group solution best fit the data. Figure 14 presents the results of the 4-group solution from the cluster analysis for the range of possible scores (0-3) for each of the 9 actions; the mean number for each score (0-3) out of 9 is presented for the 4 clustered groups. A one-way ANOVA examined differences in the mean number of 0s, 1s, 2s, and 3s across the 4 groups. Significant findings emerged for 0s ($F(3,63) = 8.39, p < .0005$) and 3s ($F(3,63) = 14.52, p < .0005$) whereas no differences were found between the groups for scores of 1 or 2.

Infants in Group 1 ($n = 25$) primarily received scores of 0, with some infants able to achieve higher scores for a small number of actions. Infants in Group 2 ($n = 38$) were starting to be able to fully imitate some actions, but still received a number of zero scores. The few infants in Group 3 ($n = 3$), and the only infant in Group 4 ($n = 1$), demonstrated the most advanced imitation skill in this sample of 9-month-olds. Approximately 1/3 to 1/2 of their scores on the 9 actions received full credit (a score of 3).
Figure 14. 4-group solution from the cluster analysis of approximations to imitation scores. Error bars represent standard deviations.
Examination of KIDS and MacArthur scores revealed that the 4 infants in groups 3 and 4 were superior to the others in terms of their general development and early communication scores. While sample size precluded analysis, developmental age scores on the KIDS were a full month higher for infants in Groups 3 and 4 on the cognitive scale and the full scale. The single infant in Group 4 also had highly developed motor skills (developmental age score 11.6 months), and his developmental age score was 2 months higher than infants in the other 3 groups. With respect to early communication scores on the MacArthur, the infants in Groups 3 and 4 reportedly understand 4-6 more phrases than the other infants, and are using 2-3 more gestures themselves. Age in weeks at the 9-month visit indicated that the infant in Group 4 was a half to one full week older than the other infants in Groups 1-3 whose ages did not differ from each other.

*Delayed imitation*

During the imitation task, delayed responses were also recorded. On occasion, when the experimenter had moved on to the next demonstrations, infants then imitated the previous action. Of the 72 infants, 19 engaged in a single delayed fully imitative response, while 3 infants engaged in 2 delayed fully imitative responses. While it was not possible to engage in delayed imitation for shaking the rattle or knocking the block over, some of the remaining 7 actions prompted a delayed response more frequently than others. No infants imitated tapping cheek or kissing following a delay. Ten infants demonstrated delayed imitation for tapping the table, and 9 infants said “mama” or “dada” following a delay. Finally, two infants clapped, three infants waved, and one infant said “ahh” after the experimenter had moved on to a subsequent demonstration. Note that we did not code spontaneous infant behaviours that may have occurred prior to
a demonstration (e.g. clapping before clapping was modeled), however no instances of relevant spontaneous infant behaviour were noted during the sessions.

*An imitative state*

Infants differed in their level of interest and engagement with the demonstrator during the imitation task. Coders, who were not blind to imitation performance, rated from videotape infants’ overall interest/engagement level on a 0-4 Likert scale. Coders were instructed only to pay attention to infants’ interest in the dyadic activity, regardless of their skill at imitating. Ratings of “imitative state” consisted of looking at infants’ eye contact with the examiner, facial expressions (smiling), and mood (pleasant, happy). Engagement ratings were made for 71 of the 72 infants who participated in the imitation task. The average engagement score for the group was 1.96 (SD = 1.03).

Correlations between engagement ratings and performance on the imitation task were examined in addition to relationships with parent ratings of imitation skill. Table 13 presents data addressing the question of whether infants who were in an “imitative state” performed better on the imitation task, and had been rated as more skilled at imitation by their parents. Results indicate that there is a significant relationship between level of engagement and performance on the imitation task, with strongest associations being found between level of engagement and performance on T3 with parents. Importantly, a significant and strong relationship was found between ratings of engagement during the imitation task and independent parent ratings of whether infants had begun to imitate.
Table 13

*Relationships Between Ratings of Infant Engagement During the Imitation Task and Imitation Performance (Task and Parent Questionnaire) (N = 71)*

<table>
<thead>
<tr>
<th>Imitation Measure</th>
<th>Rating of Infant Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 Trial 1 Score</td>
<td>.44**</td>
</tr>
<tr>
<td>0-9 Trial 3 Score</td>
<td>.50**</td>
</tr>
<tr>
<td>0-9 Overall Best Performance Score</td>
<td>.48**</td>
</tr>
<tr>
<td>0-27 Trial 1 Score</td>
<td>.45**</td>
</tr>
<tr>
<td>0-27 Trial 3 Score</td>
<td>.61**</td>
</tr>
<tr>
<td>0-27 Overall Best Performance Score</td>
<td>.56**</td>
</tr>
<tr>
<td>9-month Noticing Sounds</td>
<td>.21**</td>
</tr>
<tr>
<td>9-month Noticing Movements</td>
<td>.18</td>
</tr>
<tr>
<td>9-month Starting to Imitate</td>
<td>.42**</td>
</tr>
<tr>
<td>12-month Noticing Sounds</td>
<td>.04</td>
</tr>
<tr>
<td>12-month Noticing Movements</td>
<td>.26*</td>
</tr>
<tr>
<td>12-month Starting to Imitate</td>
<td>.27*</td>
</tr>
<tr>
<td>12-month Starting to Imititate After a Delay</td>
<td>.17</td>
</tr>
</tbody>
</table>


*Relationships between Performance on the Imitation Task and Questionnaire Ratings*

An important question of interest related to imitation was whether parent report of infant imitation ability was associated with performance on the laboratory imitation task (see Table 14). Correlations were examined between 9 and 12 month parent report ratings and imitation scores for full imitation (0-9: T1, T3, and Best Performance) and approximations to imitation (0-27: T1, T3, and Best Performance). Interestingly,
relationships between laboratory performance and parent report at 9 months were greatest for noting when one is being copied rather than imitation skill itself. In contrast, no relationships between noticing imitation and task performance were found at 12 months. The strongest associations were noted between 9-month parent report of infants' noticing when their movements were being copied and performance on the imitation task. Parent report at 9 months as to whether infants were starting to imitate was related to approximations to imitation and full imitation on the first trial with the experimenter, while parent report of imitation skill at 12 months was related to full imitation scores only.

Table 14

*Relationships Between Parent Report of Infant Imitation Ability and Performance on the Laboratory Imitation Task*

<table>
<thead>
<tr>
<th>Laboratory Imitation Task Measure</th>
<th>Parent Report Imitation Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9-mon Notice Sounds</td>
</tr>
<tr>
<td>0-9 Trial 1 Score</td>
<td>.18</td>
</tr>
<tr>
<td>0-9 Trial 3 Score</td>
<td>.28*</td>
</tr>
<tr>
<td>0-9 Overall Best Performance Score</td>
<td>.20*</td>
</tr>
<tr>
<td>0-27 Trial 1 Score</td>
<td>.31*</td>
</tr>
<tr>
<td>0-27 Trial 3 Score</td>
<td>.29*</td>
</tr>
<tr>
<td>0-27 Overall Best</td>
<td>.26*</td>
</tr>
</tbody>
</table>

Note. *N for each correlation ranged from 46-72.

*p < .10. *p < .05. **p < .01. ***p < .001.
Secondary Imitation Measures

Infant imitation ability was assessed primarily with two measures: imitation task performance and parent report on our imitation questionnaire. In addition to these measures, four secondary imitation scores were also examined. These included instances of spontaneous infant imitation during a free play session with their parent, and three measures derived from imitation-related questions on the KIDS and the MacArthur questionnaires. Appendix G presents the questions from the KIDS and the MacArthur that comprised the three secondary parent report imitation scores. From the MacArthur at 9 months, infants received an imitation score ranging from 0-15 \((M = 1.51, SD = 1.69)\) based on parent responses (yes or no) to the 15 questions regarding imitation of complex actions (e.g., putting a key in a lock, washing dishes). Scores were not expected to be high for our sample of infants given that they were only 9 months old when the questionnaire was completed. From the KIDS at 9 months, two separate scores were calculated, one from 0-5 for simple imitation (e.g., able to copy sounds, imitates “ma-ma” or “da-da”, \(M = 3.59, SD = 1.35\)) and another from 0-5 for complex imitation (e.g., imitates pat-a-cake, imitates an action of an adult long after it occurred, \(M = 1.73, SD =1.42\)). Again given the age of our sample at the time of questionnaire completion, we expected infants’ scores for simple imitation to be higher than their scores for complex imitation, which was indeed true \((t(66) = 10.46, p < .0005)\).

In the interest of validating our parent report measure of imitation, we wanted to determine whether scores would be correlated with parent report of imitation from the KIDS and the MacArthur. To this end, relationships among the three measures were examined (see Table 15). Parent report of imitation on the MacArthur was not related to parent report scores of noticing or starting to imitate on our measure at 9 months.
Table 15

*Relationships Between Parent Report of Infant Imitation Ability on the KIDS and the MacArthur Questionnaires and Our Parent Report Imitation Questionnaire*

<table>
<thead>
<tr>
<th>Our Parent Report Imitation Measure</th>
<th>0-5 KIDS Simple Imitation</th>
<th>0-5 KIDS Complex Imitation</th>
<th>0-15 MacArthur Imitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-month Noticing Sounds</td>
<td>.15</td>
<td>.21*</td>
<td>.10</td>
</tr>
<tr>
<td>9-month Noticing Movements</td>
<td>.19</td>
<td>.08</td>
<td>.12</td>
</tr>
<tr>
<td>9-month Starting to Imitate</td>
<td>.33***</td>
<td>.20</td>
<td>.18</td>
</tr>
<tr>
<td>12-month Noticing Sounds</td>
<td>.10</td>
<td>.09</td>
<td>-.04</td>
</tr>
<tr>
<td>12-month Noticing Movements</td>
<td>.34**</td>
<td>.35**</td>
<td>.23</td>
</tr>
<tr>
<td>12-month Starting to Imitate</td>
<td>.46***</td>
<td>.43***</td>
<td>.17</td>
</tr>
<tr>
<td>12-month Starting to Imitate After a Delay</td>
<td>.34**</td>
<td>.28*</td>
<td>.29**</td>
</tr>
</tbody>
</table>

*Note. N for each correlation ranged from 46-72.*

*p < .10. **p < .05. ***p < .001.

At 12 months however, there was a trend towards a relationship between parent report of infants starting to imitate after a delay and the MacArthur imitation score (r(44) = .29, p < .06). In contrast, parent report for simple imitation on the KIDS was highly related to parent report of infants starting to imitate at 9 months on our measure (r(64) = .33, p < .008). As expected, no relationship was found with the complex imitation
measure on the KIDS, though there was trend towards significance for parent report of noticing sounds. At 12 months, relationships with simple imitation on the KIDS were noted for infant recognition of when their movements were copied \((r(40) = .34, p < .03)\), starting to imitate \((r(39) = .46, p < .003)\), and starting to imitate after a delay \((r(31) = .34, p < .03)\). Relationships at 12 months were also noted for complex imitation on the KIDS. Similar to simple imitation, associations were noted for recognition of movements being imitated \((r(40) = .35, p < .03)\), starting to imitate \((r(39) = .43, p < .006)\), and a trend for starting to imitate following a delay \((r(41) = .28, p < .08)\).

*Maternal and infant imitation during free play at 9 months*

In addition to measuring elicited imitation during a laboratory tasks, we wanted to provide infants with an opportunity to demonstrate spontaneous imitation during a less contrived play session with their parent. Free play lasted for 3 minutes and instances of spontaneous infant imitation of their parent’s actions or vocalizations were recorded. Frequency of infant imitation during the 3 minutes ranged from 0 instances to 9 \((M = 1.41; SD = 1.95)\). Relationships between spontaneous imitation during free play, parent report of imitation, and performance on the imitation task were examined (see Table 16). As expected, spontaneous imitation during free play was related to performance on the imitation task on Trial 3 with their parent. At 12 months, noticing when one’s movements were being copied was related to spontaneous imitation at 9 months. No relationships were found with the 9-month questionnaire.

Spontaneous imitation during free play was also coded categorically; infants were classified as imitators (sample size ranged from \(N = 28-40\) depending on the analysis being performed) or non-imitators \((N = 6-10)\). A one-way ANOVA explored differences in scores between imitators and non-imitators for parent report and for imitation task
performance. As seen in Table 17, infants who spontaneously imitated their parents during free play at 9 months received higher parent report scores at 12 months for starting to imitate. Scores on the imitation task were also higher for these infants for 0-9 Best Performance, 0-9 T1, and 0-9 T3. There were no differences between imitators and non-imitators on approximations-to-imitation scores.

Table 16

*Relationships Between Spontaneous Infant Imitation During Free Play, Parent Report of Imitation Ability, and Performance on the Imitation Task*

<table>
<thead>
<tr>
<th>Spontaneous Infant Imitation During Free Play</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-month Noticing Sounds</td>
</tr>
<tr>
<td>9-month Noticing Movements</td>
</tr>
<tr>
<td>9-month Starting to Imitate</td>
</tr>
<tr>
<td>12-month Noticing Sounds</td>
</tr>
<tr>
<td>12-month Noticing Movements</td>
</tr>
<tr>
<td>12-month Starting to Imitate</td>
</tr>
<tr>
<td>12-month Starting to Imitate After a Delay</td>
</tr>
<tr>
<td>0-9 Best Performance Score</td>
</tr>
<tr>
<td>0-9 Trial 1 Score with Experimenter</td>
</tr>
<tr>
<td>0-9 Trial 3 Score with Parent</td>
</tr>
<tr>
<td>0-27 Best Performance Score</td>
</tr>
<tr>
<td>0-27 Trial 1 Score with Experimenter</td>
</tr>
<tr>
<td>0-27 Trial 3 Score with Parent</td>
</tr>
</tbody>
</table>

*Note. N for each correlation ranged from 42-67.*

*p < .05. **p < .01.
Table 17

*Performance by Free Play Imitators and Non-Imitators on the Imitation Task and on Parent Report of Imitation*

<table>
<thead>
<tr>
<th>Imitation variable</th>
<th>Spontaneous Imitation Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Imitator</td>
</tr>
<tr>
<td>9-month Noticing Sounds</td>
<td>3.26</td>
</tr>
<tr>
<td></td>
<td>.79</td>
</tr>
<tr>
<td>9-month Noticing Movements</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>.89</td>
</tr>
<tr>
<td>9-month Starting to Imitate</td>
<td>2.47</td>
</tr>
<tr>
<td></td>
<td>1.11</td>
</tr>
<tr>
<td>12-month Noticing Sounds</td>
<td>3.51</td>
</tr>
<tr>
<td></td>
<td>.57</td>
</tr>
<tr>
<td>12-month Noticing Movements</td>
<td>3.34</td>
</tr>
<tr>
<td></td>
<td>.72</td>
</tr>
<tr>
<td>12-month Starting to Imitate</td>
<td>3.10</td>
</tr>
<tr>
<td></td>
<td>.75</td>
</tr>
<tr>
<td>12-month Starting to Imitate After a Delay</td>
<td>1.66</td>
</tr>
<tr>
<td></td>
<td>1.45</td>
</tr>
<tr>
<td>0-9 Best Performance Score</td>
<td>2.43</td>
</tr>
<tr>
<td></td>
<td>1.17</td>
</tr>
<tr>
<td>0-9 Trial 1 Score with Experimenter</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>.95</td>
</tr>
<tr>
<td>0-9 Trial 3 Score with Parent</td>
<td>1.89</td>
</tr>
<tr>
<td></td>
<td>1.17</td>
</tr>
<tr>
<td>0-27 Best Performance Score</td>
<td>10.65</td>
</tr>
<tr>
<td></td>
<td>4.02</td>
</tr>
<tr>
<td>0-27 Trial 1 Score with Experimenter</td>
<td>6.92</td>
</tr>
<tr>
<td></td>
<td>3.41</td>
</tr>
<tr>
<td>0-27 Trial 3 Score with Parent</td>
<td>8.00</td>
</tr>
<tr>
<td></td>
<td>4.47</td>
</tr>
</tbody>
</table>

*Note. *p < .10. **p < .05. ***p < .01.*

For each comparison, \( N \) for non-imitators ranged from 6-10, while \( N \) for imitators ranged from 28-40.
During the free play session at 9 months, two maternal imitation behaviours were coded: mothers’ spontaneous imitation of their infants and mothers’ creation of opportunities ("set-ups") for their infants to imitate them (e.g., demonstrated an action with a toy and then handed the toy to their infant). Of the 69 mothers, 40 did not imitate their infant during play. The mean number of instances of maternal imitation was .70 and ranged from 0 to 4 instances. Instead, mothers created "set-ups" for their infants to imitate them (range 0 – 13, $M = 4.09$, $SD = 2.67$); only 4 mothers did not provide a single intentional set up for their infants to imitate. Mothers' set-ups were related to infant imitative behaviour during free play. Mothers of infants who imitated during free play created more opportunities for their infant to copy ($M = 4.71$, $SD = 2.59$) than did mothers of infants who did not imitate during free play ($M = 3.18$, $SD = 2.55$) ($F(1,67) = 5.86, p < .02$). Mothers of infants who imitated and those who did not did not differ in the frequency of their spontaneous imitations of their infants ($F(1,67) = 1.20, p > .05$).

Maternal and infant imitative behaviour during free play was also examined together categorically according to whether or not each imitated the other (see Table 18). A Chi-Square analysis revealed no difference between expected and observed counts for the four possible combinations of mother-infant performance ($\chi^2(1) = 1.89, p > .05$).

Table 18

Percentage of dyads within each categorical classification of free play imitation

<table>
<thead>
<tr>
<th></th>
<th>Mother imitated infant</th>
<th>Mother did not imitate infant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant imitated mother</td>
<td>29%</td>
<td>30.5%</td>
</tr>
<tr>
<td>Infant did not imitate mother</td>
<td>13%</td>
<td>27.5%</td>
</tr>
</tbody>
</table>
Relationships between maternal behaviours and parent report of infant imitation were examined (see Table 19). Mothers who were categorized as having imitated their infants during free play gave their infants lower ratings for noticing when their actions and their vocalizations were being copied at 9 months. At 12 months, ratings of noticing when actions and vocalizations are being copied were negatively associated with the number of maternal spontaneous imitations during free play and the maternal imitation categorical variable (at 9 months). As at 9 months, infants of mothers who imitated less during free play received higher ratings on these measures. No relationships were noted between maternal “set-ups” for the infant to imitate and parent report of imitation at either 9 or 12 months. Of note, relationships were found only for ratings of infants noticing that they were being copied, and not for imitation itself. No relationships were found between maternal imitative behaviours during free play and the parent report imitation scores from the KIDS and the MacArthur questionnaires.

Relationships between maternal imitative behaviours during free play and infant performance on the imitation task at 9 months were also noted (see Table 20). No relationships were found for maternal imitation of infants, however a number of relationships emerged for creating opportunities for their infant to imitate them. Infants whose mothers provided more “set-ups” for infant imitation during free play received lower total scores on the imitation task (significant for 0-9 score, marginal for 0-27 score), a marginally lower Trial 1 score for 0-9, significantly lower Trial 1 and Trial 2 scores for 0-27, and a significantly lower Trial 2 score for 0-9. No relationships were found for the Trial 3 score with their mother.
Table 19

*Relationships between maternal imitative behaviours during 9-month free play and parent report of infant imitation at 9 and 12 months*

<table>
<thead>
<tr>
<th>Parent Report of Infant Imitation</th>
<th>Number of Mother's Spontaneous Imitations</th>
<th>Categorical Score (0 or 1) for Mother's Imitation</th>
<th>Number of Mother’s “set-up”s for their Infant to Imitate</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-month Noticing Sounds</td>
<td>-.18</td>
<td>-.28*</td>
<td>-.10</td>
</tr>
<tr>
<td>9-month Noticing Movements</td>
<td>-.18</td>
<td>-.26*</td>
<td>-.08</td>
</tr>
<tr>
<td>9-month Starting to Imitate</td>
<td>-.08</td>
<td>-.14</td>
<td>.03</td>
</tr>
<tr>
<td>12-month Noticing Sounds</td>
<td>-.35*</td>
<td>-.43***</td>
<td>-.09</td>
</tr>
<tr>
<td>12-month Noticing Movements</td>
<td>.37**</td>
<td>-.42***</td>
<td>.04</td>
</tr>
<tr>
<td>12-month Starting to Imitate</td>
<td>.16</td>
<td>.10</td>
<td>-.24</td>
</tr>
<tr>
<td>12-month Starting to Imitate After a Delay</td>
<td>.14</td>
<td>.06</td>
<td>-.18</td>
</tr>
</tbody>
</table>

Note. N ranged from 42-64.

*p < .05. **p < .01. ***p < .001.

A series of one-way ANOVAs also examined differences in parent report of imitation and imitation task performance between mothers who imitated their infant during free play (n = 29) and mothers who did not (n = 40). Significant differences emerged for noticing when actions were being copied at 9 months ($F(1,62) = 5.28, p < .03$) and 12 months ($F(1,40) = 8.92, p < .005$), and noticing when vocalizations were
being copied at 9 months \((F(1,62) = 4.43, p < .04)\) and 12 months \((F(1,40) = 8.50, p < .006)\). In each case, parent report scores were higher for infants whose mothers did not imitate them during free play.

Table 20

*Relationships between maternal imitative behaviours during 9-month free play and infant imitation on the imitation task*

<table>
<thead>
<tr>
<th>Imitation Task Measure</th>
<th>Number of Mother’s Spontaneous Imitations</th>
<th>Categorical Score (0 or 1) for Mother’s Imitation</th>
<th>Number of Mother’s “set-up”s for their Infant to Imitate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score out of 9</td>
<td>-.00</td>
<td>.00</td>
<td>-.29**</td>
</tr>
<tr>
<td>Trial 1 Score out of 9</td>
<td>.09</td>
<td>.03</td>
<td>-.21a</td>
</tr>
<tr>
<td>Trial 2 Score out of 9</td>
<td>.03</td>
<td>-.03</td>
<td>-.38***</td>
</tr>
<tr>
<td>Trial 3 Score out of 9</td>
<td>-.12</td>
<td>-.09</td>
<td>-.16</td>
</tr>
<tr>
<td>Total Score out of 27</td>
<td>-.04</td>
<td>-.12</td>
<td>-.22a</td>
</tr>
<tr>
<td>Trial 1 Score out of 27</td>
<td>-.01</td>
<td>-.09</td>
<td>-.29*</td>
</tr>
<tr>
<td>Trial 2 Score out of 27</td>
<td>.02</td>
<td>-.04</td>
<td>-.26*</td>
</tr>
<tr>
<td>Trial 3 Score out of 27</td>
<td>-.10</td>
<td>-.14</td>
<td>-.18</td>
</tr>
</tbody>
</table>

*Note. \(N\) ranged from 45-67.*

\(*p < .10. \ *p < .05. \ **p < .01. \ ***p < .001.*

In summary, infant and maternal imitative behaviour during free play at 9 months was mutually influential and, importantly, related to other imitation measures. Infants engaged in some spontaneous imitation of their mothers during free play. Those who did performed better on the imitation task and received higher “starting to copy” parent ratings at 12 months. Many mothers did not imitate their infants during free play, however most created opportunities for their infant to imitate them, which was positively
related to infant imitation in free play. Parent report ratings of sensitivity to being
imitated at 9 months were related to maternal imitative behaviour during free play.
Infants of mothers who imitated during free play had previously received lower parent
ratings for noticing when their movements and vocalizations were copied. At 12 months,
a similar negative relationship was found for creating set-ups for their infant to imitate.

*Patterns of Performance Across All Imitation Measures*

Patterns of performance across 5 imitation performance measures at 9 months
were examined. A cluster analysis was performed using the default squared Euclidian
distance with a weighted between-groups analysis. Variables entered into the cluster
analysis included spontaneous imitation during free play, parent report of starting to
copy, parent report for KIDS Advanced imitation, the 0-9 best imitation task score, and
the 0-27 best approximations to imitation task score. Cluster memberships were saved for
a range of solutions (2-6). An examination of the means and standard deviations of group
memberships for each of the saved solutions (2-6) revealed that a 3-group solution best fit
the data. Figure 15 presents the results of the 3-group solution from the cluster analysis;
the mean score for each of the 5 imitation measures is presented for the 3 clustered
groups. One-way ANOVAs examined differences in the mean imitation scores across the
3 groups. Significant findings emerged for spontaneous imitation ($F(2,50) = 23.58, p <
.0005$), starting to copy ($F(2,50) = 4.34, p < .02$), 0-9 imitation ($F(2,50) = 26.16, p <
.0005$), and 0-27 imitation ($F(2,50) = 64.82, p < .0005$) whereas no differences were
found between the groups for the KIDS Advanced imitation score. Infants in Group 1 ($n
= 31$) were characterized by receiving low scores across all measures. The defining
feature of infants in Group 2 ($n = 19$) was higher scores on the imitation task scores (0-9
and 0-27). The pattern of performance for the three infants in Group 3 was different than that of the others. These infants received high spontaneous imitation scores, and also received higher ratings by their parents for starting to copy. Examination of temperament, KIDS, and MacArthur scores revealed no differences between the 3 groups.
Figure 15. 3-group solution from the cluster analysis of imitation performance measure. Error bars represent standard deviations.
Performance on Predictor and Concurrent Relationships Tasks

In the following section, analyses are conducted examining group performance and individual differences on tasks measuring constructs expected to be associated with imitative ability.

*Infant Behaviour Questionnaire - Revised (IBQ-R) 4 and 9 months*

The IBQ-R is a recent revision of the original parent-report infant temperament questionnaire, the IBQ, which is a well-established, valid and reliable measure of infant temperament (Rothbart, 1981). It is comprised of 184 items organized into 14 separate subscales. See Measures for more detail about the IBQ-R, including Table 2 which provides a detailed description of the subscales. A single published study to date by the authors of the IBQ-R has presented data supporting the reliability and validity of the revised questionnaire (Gartstein & Rothbart, 2003). An independent replication of their findings is yet to be published, thus we provide data consistent with the authors’ which justifies our use of the revised IBQ as a parent-report measure of infant temperament.

Preliminary analysis of the data included an examination of the distributions and descriptive statistics for each of the 14 subscales and the 3 temperament factors. Each of the distributions for the subscales and composite factors were normally distributed with no outliers. Subsequent analyses examining age and sex differences and concurrent and longitudinal relationships between individual subscales and composite scores replicate the findings from Gartstein and Rothbart’s (2003) original paper. Appendix H presents detailed analyses and results for the IBQ-R.
Visual-Spatial Attention Task (VSAT)

At each age (4 and 9 months), mean saccadic latencies (SLs) were calculated for type of trial (disengage/shift), and side of presentation of the peripheral stimuli (left/right). Each infant had 8 mean SLs overall. As in previous research, latencies that were under 200 ms were considered anticipatory and excluded from the analyses (Canfield & Haith, 1991; Haith, Hazan, & Goodman, 1988; McConnell & Bryson, 2003).

A preliminary analysis was undertaken to determine whether there was an effect of side of presentation of the peripheral stimuli. For both shift and disengage trials separately, a two-way repeated measures analysis of variance (ANOVA) was performed on Age and Side. Distributions were examined for normality and an alpha level of .05 was used for all statistical tests. There was no effect of Side for Shift trials \( F(1, 58) = .19, p > .05 \) or Disengage trials \( F(1,62) = .72, p > .05 \), nor was the interaction between Age and Side significant for either Shift \( F(1,58) = 2.93, p > .05 \) or Disengage trials \( F(1,62) = .04, p > .05 \). As a result, data were collapsed across side of peripheral stimuli for subsequent analyses which were conducted on 4 means SLs for each infant (2 Age Levels and 2 Trial Types).

A two-way ANOVA conducted on Age (4 & 9 months) and Trial Type (Shift & Disengage) resulted in significant main effects of both Age \( F(1,57) = 5.40, p < .02 \), and Trial Type \( F(1,57) = 100.26, p < .0005 \). The interaction between Age and Trial Type was not significant \( F(1,57) = 1.39, p > .05 \). Figure 16 presents the mean SLs for Disengage and Shift trials at each age.
Figure 16. Mean reaction times for shift and disengage trials at 4 and 9 months. Error bars represent 95% confidence intervals.
As expected, SLs to shift attention decreased significantly from 4 months ($M = 341.52, SD = 61.42$) to 9 months ($M = 308.62, SD = 76.99$) ($F(1,58) = 8.70, p < .005$). An age-related decrease was also found for SLs to disengage attention: 4 months ($M = 656.58, SD = 346.43$), 9 months ($M = 544.64, SD = 241.78$) ($F(1,62) = 5.17, p < .03$). Marked within-age differences across shifting and disengaging were found at both 4 months ($F(1,77) = 79.42, p < .0005$) and 9 months ($F(1,77) = 75.09, p < .0005$). At both ages, mean latencies to shift were significantly shorter than were mean latencies to disengage.

**Visual Proprioceptive Inter-modal Processing Task (VPIP)**

Looking proportions and behavioural variables were examined at both 4 and 9 months in order to evaluate developmental changes in the ability to detect visual-proprioceptive correspondences. Looking proportions were derived by dividing the time infants spent looking at a display (contingent and non-contingent) by the total time spent looking at both displays across the 4-minute experimental period for the “kicking” task at 4 months and the 2-minute period for the “faces” task at 9 months.

**4-month VPIP: Attention to the displays, discrimination and preference**

At 4 months, infants ($N = 62$) spent a greater proportion of time viewing either of the two displays ($M = .77, SD = .18$), than looking away from the screens ($M = .23, SD = .18$), $t(61) = 11.96, p < .0005$). As a group, they also demonstrated a preference for looking at one screen over the other (where preference was defined as spending more time viewing either screen). Infants spent an average of $.66 (SD = .09)$ of their total time watching the screens viewing the display to which they attended longest – their “preferred” display. This proportion of time differed significantly from the expected
chance value of .54 according to a t-test, \(t(61) = 9.63, p < .0005\), suggesting that as a group, infants discriminated between the two screens (see Appendix I for the derivation of the chance value .54). During the presentation of the displays, there were many instances of infants switching their attention from one screen to the other (\(M = 42.60, SD = 17.33\)), indicating that they were engaged in active comparison and did not get “stuck” viewing a single display.

An examination of time spent viewing the left and the right display revealed a significant side bias. Of the total time looking at the screens, proportions of looking to the right display (\(M = .57, SD = .19\)) were significantly higher than proportions of looking to the left display (\(M = .43, SD = .19\)) (\(t(61) = -2.75, p < .008\)). Infants for whom the non-contingent display was on the right spent a greater time looking at the non-contingent display (\(M = .58, SD = .20\)) than did infants for whom the non-contingent display was on the left (\(M = .45, SD = .19\)) (\(F(1,60) = 7.72, p < .007\)). Forty infants spent a greater amount of time watching the display on the right (proportion of time looking at the displays higher than .50), while only 22 infants spent more time watching the display on the left.

The preferred method to correct for this side bias was to divide the infants into two separate distributions based on the side of the contingent display and compute the z-score for each infant within their distribution. This z-score, used for all regression analyses, provides a normalized measure of the infant’s preference (contingent vs. non-contingent) compared to the other infants. Adjusted scores for proportions of time looking at the contingent and non-contingent displays were also computed by translating the distributions by equal amounts in opposite directions to give them the same means.
This adjustment is based on the model which represents side bias as a fixed offset \( \delta \) from an infant’s “true score” whose sign (positive or negative) depends on whether the contingent display is on the right or on the left.

Using adjusted scores to correct for the side bias, infants as a group spent an average of .51 (SD = .19) of their total looking time viewing the non-contingent display and an average of .49 (SD = .19) viewing the contingent display. These proportions did not differ significantly according to a paired t-test analysis, \( t(61) = .60, p > .05 \). An examination of the mean ages of the 33 infants who preferred the non-contingent display (\( M = 4.37, SD = .25 \)), and the 28 infants who preferred the contingent display (\( M = 4.31, SD = .19 \)) showed no significant differences in age, \( F(1,59) = 1.14, p > .05 \). Sex was also not a factor: the proportion of time spent looking at the non-contingent display was .53 for females (SD = .21) and .50 for males (SD = .19) and these were not significantly different \( F(1,59) = .37, p > .05 \).

4-month VPIP: Behavioural findings

While viewing the displays, infants engaged in a number of “exploratory” behaviours, as if they were “testing” what was happening on the screens. Infants looked intently at the screens, kicked their legs, paused, then looked intently again. Raters blind to which screens displayed the contingent and non-contingent images rated infants on a 0-3 scale for their “testing” behaviour: 0 – “no testing”, 1 – “minimal testing”, 2 – “some testing”, 3 – “more testing”. Of the 57 infants who received ratings for testing, 17 engaged in some degree of testing: 1 with a score of 3, 5 with a score of 2, and 11 with a score of 1.
Infants were also rated on a 0-3 scale for how interested they appeared to be in the displays \((0 = \text{no interest}, 3 = \text{considerable interest})\) \((M = 2.32, SD = .74)\). As expected, an independent samples \(t\)-test indicated that infants who “tested” during the 4-minute period were rated by coders as being more interested in the displays \(t(55) = -3.25, p < .002\).

We were also interested in whether infants who “tested” more, or who appeared more interested in the displays, spent more time viewing the non-contingent image. Correlation analyses examined relationships between testing, interest level, and proportion of time spent viewing the non-contingent display. Testing was highly related to time spent viewing the non-contingent image \((r(55) = .43, p < .001)\), as were ratings of interest level \((r(55) = .32, p < .01)\). When infants were categorized as “testers” and “non-testers”, a significant difference was found for proportion of time viewing the non-contingent display \(t(53) = -2.26, p < .03\). Testers spent more time viewing the non-contingent screen \((M = .61, SD = .21)\) than non-testers \((M = .48, SD = .20)\).

Differences were also noted in infants’ affect and vocalizations while viewing the non-contingent and contingent displays. As the findings were complex, and the question was not central to the current study, results from these analyses will not be discussed. Future exploration of infants’ emotional responses to viewing contingent and non-contingent displays of self is warranted.

In summary, infants were interested in the displays and engaged in active comparison (looked back-and-forth between displays). As a group, infants demonstrated a preference for a particular display, indicating that they could discriminate between them. After correcting for a side bias towards the right display, infants as a group spent an equal amount of time viewing the contingent and non-contingent displays.
Approximately 30% of infants engaged in exploratory “testing” behaviour, which occurred more frequently while viewing the non-contingent display.

**9-month VPIP: Attention to the displays, discrimination and preference**

As at 4 months, 9-month-old infants \( n = 64 \) spent a greater proportion of time viewing either of the two displays \( (M = .69, SD = .17) \), than looking away \( (M = .31, SD = .17) \) \( t(63) = 9.22, p < .0005 \). They spent an average of .62 \( (SD = .09) \) of their total time viewing their preferred display. This proportion differed significantly from the expected chance value of .56 according to a \( t \)-test \( t(63) = 5.42, p < .0005 \) (see Appendix I for the derivation of the chance value of .56). Similar to the findings at 4 months, 9-month-olds switched their attention from one display to the other numerous times during the 2 minutes \( (M = 19.66, SD = 9.13) \), indicating that again they were engaging in active comparison of the displays.

An examination of time spent viewing the left and the right display again revealed a significant side bias. Proportions of looking to the right display \( (M = .56, SD = .16) \) were significantly higher than proportions of looking to the left display \( (M = .44, SD = .16) \) \( t(61) = -3.10, p < .003 \). Infants for whom the non-contingent display was on the right spent a greater time looking at the non-contingent display \( (M = .51, SD = .14) \) than did infants for whom the non-contingent display was on the left \( (M = .35, SD = .14) \) \( F(1,62) = 19.18, p < .0005 \). Forty-four infants spent a greater amount of time watching the display on the right (proportion of time looking at the displays higher than .50), while only 20 infants spent more time watching the display on the left. In order to correct for this side bias both \( z \)-scores and adjusted scores were computed as described in the 4 month VPIP results.
Using adjusted scores to correct for the side bias, infants as a group spent an average of .43 (SD = .14) of their total looking time viewing the non-contingent display and an average of .57 (SD = .14) viewing the contingent display. These proportions differed significantly according to a paired t-test analysis, $t(63) = -4.07, p < .0005$. An examination of the mean ages of the 21 infants who preferred the non-contingent display ($M = 9.27$, $SD = .24$), and the 43 infants who preferred the contingent display ($M = 9.33$, $SD = .16$) showed no significant differences in age, $F(1,62) = 1.51, p > .05$). Sex was again not a factor: the proportion of time spent looking at the non-contingent display was .45 for females ($SD = .16$) and .45 for males ($SD = .17$) and these were not significantly different ($F(1,62) = .02, p > .05$).

9-month VPIP: Behavioural findings

At 9 months, a number of behavioural measures were examined including “testing”, positive and negative facial affect, reaching/pointing, and rocking/leaning. The testing measure was similar to that at 4 months; infants who received a score of 0 demonstrated no testing behaviour, whereas infants who did engage in testing received possible scores in the range of 1-3. Of the 66 infants who received ratings for testing, 8 received scores of 0, 29 were scored 1, 19 scored 2, while 10 infants received a score of 3.

As at 4 months, infants were also rated on a 0-3 score for how interested they appeared to be in the displays ($M = 2.17$, $SD = .67$). Consistent with the findings at 4 months, infants who engaged in more testing were rated as being more interested in the displays ($r(64) = .34, p < .007$).

We were also interested in whether infants who “tested” more, or who appeared more interested in the displays spent more time viewing one image. Correlation analyses
examined relationships between testing, interest level, and proportion of time spent viewing the displays. In contrast to the findings at 4 months, no relationships were found between either testing or interest level and time spent viewing the contingent or non-contingent displays.

At 9 months, no soundtrack was available; coders were therefore unable to code vocalizations during the task. Other behavioural measures in addition to testing at 9 months were facial expressions (both positive and negative), rocking/leaning and reaching/pointing. For all measures, two proportions were derived by dividing the time infants spent demonstrating the behaviour while viewing the non-contingent and contingent displays by two minutes, the total time of the experimental task. A comparison of means revealed a significant difference for facial expression and rocking/leaning and a trend towards a difference for reaching/pointing (see Figure 17).

In summary, at 9 months infants were also interested in the displays, demonstrated a preference, and engaged in active comparison. The side-bias towards the right display was again evident at 9 months. Analyses run on adjusted scores revealed that infants spent more time viewing the contingent display than the non-contingent display, which was not the case at 4 months. More infants engaged in some degree of testing behaviour at 9 months (88%), which was not related to time spent viewing a particular display. Other behaviours were, however, associated with viewing the contingent display; infants displayed more positive affect and spent more time rocking/leaning and marginally more time reaching/pointing.
Figure 17. Comparison of mean proportions of time spent performing four observed behaviours while looking at the contingent and non-contingent displays at 9 months. Error bars represent 95% confidence intervals.
Visual Auditory Inter-modal Perception Task (VAIP)

A central purpose of the current study was to examine relationships between visual-proprioceptive inter-modal processing and imitation abilities. In order to determine the specificity of any relationships and interpret the findings, we included a measure of visual-auditory inter-modal processing. We were interested in whether relationships existed between visual-proprioceptive and visual-auditory inter-modal processing abilities, and between visual-auditory inter-modal processing and imitation. We predicted that any association between visual-proprioceptive inter-modal processing abilities and imitation would be specific to the processes underlying integration of external and internal stimuli and not to those involved in the co-ordination of two external stimuli (i.e., vision/hearing).

Although infants at 4 months were attentive and interested, and demonstrated the ability to discriminate between the displays, they did not preferentially attend to the matching display as expected. At 9 months, proportion of time spent viewing the matching display did differ from chance performance, yet was only slightly above (56%). Given that infants’ performance at both ages was close to chance, data from the VAIP task is not included in further analyses. See Appendix J for the complete set of analyses for the VAIP task.

Play session – 4 Months

At 4 months, mothers and infants participated in a face-to-face play session. One-and-a-half minutes of free play were followed by 2 minutes during which mothers copied their infants’ actions, vocalizations, and facial expressions. Both maternal and infant behaviours were coded from the play session. Proportion of time infants spent vocalizing,
looking at their mother’s face, watching their mother’s actions, and frequency of movements were calculated for both the play segment and the imitation segment. Ratings of how engaged infants were during the session were made for both the play and imitation segments. Lastly, it was noted whether infants demonstrated “testing” behaviour (paused, looked at their mothers, and repeated the imitated action) during imitation. Maternal behaviour during play included proportion of time spent vocalizing and touching their infant, and frequency of spontaneous imitations of their infant’s actions, facial expressions, and vocalizations. Ratings on a 5-point Likert scale were also made of how well (accuracy, synchrony) mothers imitated their infants’ behaviour.

Questions of interest relating to play behaviour at 4 months included (1) How well do mothers copy their infants’ vocalizations, actions, and facial expressions? (2) Are infant behaviours affected or changed as a result of their mother being a “good imitator”? (3) Do infants demonstrate evidence of noticing that they are being imitated and is this associated with how well the mother copied?

*Maternal imitation*

Ratings of maternal accuracy of copying were made separately for facial expressions, actions and vocalizations and summed to create a total accuracy score. Mothers were rated as better at copying infant vocalizations ($M = 4.01, SD = .99$) than actions ($M = 3.36, SD = 1.35$) ($t(71) = 4.12, p < .0005$) or facial expressions ($M = 3.37, SD = 1.23$) ($t(70) = 5.64, p < .0005$). Accuracy for copying movements and facial expressions did not differ. Qualitatively, mothers reported during the sessions that imitating their infant was more difficult than they had expected. Of the 72 mothers, 59 (81.9%) imitated their infants actions as though using a mirror image. Six mothers (8.3%) used the same hand as their infant, while 4 (5.6%) used both. Three mothers did not
imitate their infant’s actions at all during the imitation segment despite explicit
instructions to do so.

During the play segment of the session, instances of spontaneous imitation by
mothers of their infants were recorded. Mothers more frequently copied their infants’
facial expressions ($M = 3.24, SD = 1.96$) than they did their vocalizations ($M = 1.28, SD$
$= 1.70: t(71) = -8.10, p < .0005$) or actions ($M = 1.17, SD = 1.54: t(71) = -7.25, p <$
.0005). We were interested in whether mothers who engaged in more spontaneous
imitation of their infants during free play would be rated as better imitators during the
imitation segment of the session. Spontaneous imitation of infant vocalizations was
positively correlated with ratings of how well mothers copied vocalizations ($r(72) = .19,$
$p < .10$), actions ($r(72) = .26, p < .02$), and their total imitation accuracy score ($r(71) =$
$.26, p < .03$). Mothers who more often copied their infants’ vocalizations during free play
were rated as better at copying vocalizations and actions during the imitation segment.
No relationships were found for copying facial expressions or actions.

**Maternal imitation and infant behaviour**

During the imitation period, the proportion of time infants spent watching their
mother’s face and actions and the time they spent vocalizing and moving was recorded.
Ratings of engagement during imitation were also made. We were interested in whether
mothers’ ability to copy their infants influenced the extent to which infants engaged in
these behaviours. A series of stepwise regression analyses looked at prediction of infant
behaviour from maternal imitation accuracy. Mothers’ imitation ability did not predict
frequency of infants’ movements or time spent vocalizing. However, the proportion of
time infants spent watching their mother’s face was predicted by how well mothers
copied their infants’ facial expressions ($F(1,69) = 17.52, p < .0005$) and accounted for
20% of the variance in infant behaviour. Infants of mothers who were better imitators spent more time watching their mothers’ faces. A similar finding emerged for watching actions. How well mothers were able to copy their infant’s movements predicted the proportion of time infants spent watching their mothers’ actions ($F(1, 69) = 11.90, p < .001$), accounting for 14% of the variance. Ratings of infant engagement were predicted by a model including maternal ability to copy facial expressions and infant movements ($F(2, 68) = 22.71, p < .0005$). This model accounted for 40% of the variance in ratings of infant engagement.

A series of paired $t$-tests examined whether infant behaviour changed from free play to the imitation phase. Frequency of movements increased from play ($M = .16, SD = .13$) to imitation ($M = .30, SD = .20$: $t(71) = -8.25, p < .0005$). Proportion of time spent vocalizing also showed a marginal increase (play: $M = .10, SD = .14$; imitation: $M = .14$, $SD = .15$: $t(71) = -1.79, p < .07$). Proportion of time infants spent looking at their mothers’ face and actions, and ratings of infants’ engagement did not differ across the play segments.

Given that free play always occurred before imitation, it was not possible to determine whether changes in infant behaviour across task periods were due to maternal imitation for the group as a whole. However, it was possible to examine whether changes in infant behaviour were predicted by mothers’ ability to imitate. How well mothers imitated infants’ movements, vocalizations, and facial expressions were entered into separate stepwise regression analyses predicting change in infant behaviours and level of engagement (imitation score minus play session score). Accuracy in imitating infants’ facial expressions was the sole predictor of change in the proportion of time infants spent
watching their mother’s face ($F(1,69) = 6.94, p < .01$), accounting for approximately 10% of the variance. Mothers’ accuracy in imitating facial expressions also predicted change in infant engagement from play to imitation ($F(1,69) = 15.32, p < .0005$), and accounted for 18% of the variance in infant engagement ratings. Maternal ability to imitate did not predict change in action watching, vocalizing, or frequency of infant movements.

Change in infant behaviour was also explored as a function of classifying mothers as being “high maternal imitators” (HMI mothers: $n = 37$) or “low maternal imitators” (LMI mothers: $n = 34$), based on a median split of their total imitation accuracy score out of 15. Difference scores for infant behaviour were compared to a test-value of 0 (no change from play to imitation) in a series of separate independent sample $t$-tests for HMI mothers and LMI mothers. Behaviours of infants of LMI mothers changed from play to imitation. They looked less at their mothers actions ($t(69) = -2.10, p < .04$), vocalized more ($t(69) = 2.16, p < .04$), moved more ($t(69) = 5.31, p < .0005$), and were less engaged ($t(69) = -3.16, p < .003$). For infants of HMI mothers, the sole change in behaviour was an increase in movements ($t(69) = 6.35, p < .0005$).

A one-way ANOVA directly examined differences in infant behaviour change across the two maternal groups (see Figure 18). The difference score for action watching (imitation – play) was significantly higher for infants of HMI mothers ($M = .03, SD = .25$) than it was for infants of LMI mothers ($M = -.09, SD = .24$) ($F(1,69) = 3.98, p < .05$). A similar finding emerged for infant engagement. Engagement difference scores for infants of HMI mothers ($M = .35, SD = 1.55$) were higher than for infants of LMI mothers ($M = -.74, SD = 1.36$) ($F(1,69) = 9.81, p < .003$).
Figure 18. Mean difference scores in action watching and engagement ratings for infants of LMI and HMI mothers. Error bars represent 95% confidence intervals.
A further question of interest was whether the behaviours of HMI and LMI mothers differed during the initial free play segment. Maternal behaviours that were coded included amount of time spent touching their infant, amount of time spent vocalizing to the infant, frequency of spontaneous imitations, and level of engagement with their infant. A one-way analysis of variance ANOVA revealed differences between HMI and LMI mothers for frequency of spontaneous imitation of infants' vocalizations \((F(1,69) = 6.57, p < .01)\) and their total imitation score \((F(1,69) = 4.22, p < .05)\). In both cases, HMI mothers imitated more frequently than LMI mothers (see Figure 19).

Results indicate that infant behaviour differed as a function of whether their parent was a good imitator. Some infants also demonstrated “testing” behaviour during the imitation session (paused, looked at the mother, and repeated the imitated action). Of the 71 infants, 18 showed testing behaviour. A stepwise regression analysis examined maternal imitation skill as a predictor of testing. Mothers’ ability to imitate their infants’ movements was the sole predictor of whether infants engaged in testing \((F(1,69) = 14.69, p < .0005)\). A chi-square analysis also demonstrated that infants who tested were more likely to have an HMI mother \((\chi^2(1, N = 71) = 13.07, p < .0005)\) (see Table 21).

Table 21

<table>
<thead>
<tr>
<th>Accuracy of maternal imitation and testing behaviour in infants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Number of Infants who Tested</td>
</tr>
<tr>
<td>Expected</td>
</tr>
<tr>
<td>Observed</td>
</tr>
<tr>
<td>Number of Infants who Did Not Test</td>
</tr>
<tr>
<td>Expected</td>
</tr>
<tr>
<td>Observed</td>
</tr>
</tbody>
</table>

*Note. N = 71.*
Figure 19. Differences in maternal behavior during the free play segment of the play session for HMI and LMI mothers. Error bars represent 95% confidence intervals.
In summary, mothers differed in how well they were able to imitate their infant's actions, vocalizations, and facial expressions. Overall, vocalizations were easier to copy than other behaviours, however during free play, mothers were more likely to spontaneously copy their infant's facial expressions. Spontaneous imitation during free play was also related to copying during the imitation segment: mothers who received higher ratings for imitation ability had more often copied their infant's vocalizations during free play. Maternal imitative behaviour also exerted an influence on infant behaviour. Infants of mothers who were rated as good imitators of facial expressions spent more time watching their mother's face, and the same was true for action imitation. Maternal imitation also affected change in infant behaviour from the play session to imitation. Infant behaviour of mothers classified as “high” imitators changed very little from play to imitation while infants of “low” imitating mothers became less engaged, moved more, and vocalized more. It was observed that some infants engaged in exploratory “testing” behaviour during the imitation session. Results indicated that those infants were more likely to have a mother who was a skilled imitator.

Play session - 9 Months

At 9 months, infants participated in a free play session with their mother. Seated on a blanket on the floor, mother and infant were presented with a number of toys to "play with as they would at home" for 3 minutes. Sessions were videotaped and scored by independent coders. Both maternal and infant behaviours were coded (see Appendix E for descriptions of the measures).
Relationships among maternal play behaviours

Relationships among maternal behaviours during free play were examined (see Table 22). Moderate associations emerged between a number of behaviours. Mothers’ imitation of their infants and creation of opportunities (“set-ups”) for their infants to imitate them are discussed earlier in the results (section header “Maternal and Infant Imitation During Free Play at 9 Months”). Mothers who more frequently made bids for joint engagement with their infant were also most likely to move toys into their infant’s line of sight and to describe the toys. They were also marginally more likely to demonstrate actions with the toys. Moving toys into infants’ line of sight was also highly related to mother’s use of sound effects or exclamations. Mothers who physically assisted their infants were less likely to move toys for their infant to see them better, and less likely to use sound effects/exclamations. Pointing to toys was marginally positively related to saying “look” and describing toys, while mothers who tended to demonstrate actions with toys both pointed at and named toys less. Mothers who positioned their infants during play were more likely to call their infant’s names and were marginally more likely to say “look”. Calling the infant’s name was also positively related to saying “look”, and marginally negatively associated with describing the toys.
Table 22

*Relationships amongst maternal behaviours during play at 9 months (N = 69)*

<table>
<thead>
<tr>
<th>Play Behaviour</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bids for Joint Engagement</td>
<td></td>
<td>.23*</td>
<td>.15</td>
<td>.21*</td>
<td>-.19</td>
<td>-.19</td>
<td>-.14</td>
<td>.12</td>
<td>.15</td>
<td>.06</td>
<td>.29**</td>
</tr>
<tr>
<td>2. Moving Toy into Infant’s Line of Sight</td>
<td></td>
<td></td>
<td>-.13</td>
<td>.11</td>
<td>-.07</td>
<td>-.25*</td>
<td>.05</td>
<td>-.05</td>
<td>.14</td>
<td>.47****</td>
<td>-.09</td>
</tr>
<tr>
<td>3. Pointing</td>
<td></td>
<td></td>
<td></td>
<td>-.25*</td>
<td>-.02</td>
<td>.09</td>
<td>.03</td>
<td>.21*</td>
<td>.12</td>
<td>.00</td>
<td>.21*</td>
</tr>
<tr>
<td>4. Demonstrating</td>
<td></td>
<td></td>
<td></td>
<td>-.19</td>
<td>.10</td>
<td>-.11</td>
<td>.08</td>
<td>-.21*</td>
<td>-.03</td>
<td>.12</td>
<td></td>
</tr>
<tr>
<td>5. Positioning Infant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.11</td>
<td>.39***</td>
<td>.20j</td>
<td>-.17</td>
<td>-.15</td>
<td>-.06</td>
<td></td>
</tr>
<tr>
<td>6. Physically Assisting Infant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.01</td>
<td>-.07</td>
<td>-.05</td>
<td>-.23*</td>
<td>-.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Calling Infant’s Name</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.25*</td>
<td>.10</td>
<td>.00</td>
<td>-.21*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Saying “Look”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.11</td>
<td>-.05</td>
<td>.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Naming Toy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.15</td>
<td>.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Sound Effects / Exclamations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Describing Toy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* *p < .10. **p < .05. ***p < .01. ****p < .001. *****p < .0005.
*Relationships between infant and maternal play behaviours and ratings*

Infant measures from the free play session included imitation (discussed earlier), time spent seated, number of times infants moved from being seated, and the number of toys they played with (see Table 23). Infant activity level was related to some maternal behaviour during play. Mothers positioned their infants less if they stayed seated for a longer period of time. The more times an infant moved from being seated, the more mothers attempted bids for joint engagement and described the toys. The number of toys infants played with was marginally related to how frequently they moved from being seated, and was related to how often mothers named the toys.

After watching the free play session, coders rated mothers’ involvement in their infant’s play (following and scaffolding) on a 4-point scale. They also rated infants’ enjoyment of the play session and their level of engagement with their mother. Relationships among the ratings and between ratings and maternal and infant behaviours were examined (see Table 23). Ratings of maternal scaffolding were not associated with ratings of maternal following. Ratings of infant enjoyment was marginally positively related to maternal following of play, and significantly associated with maternal scaffolding. Infant engagement was also marginally positively related to maternal following, while there was a strong positive relationship between engagement and maternal scaffolding. Infants who were rated as enjoying play were also rated as being more engaged with their mother. Ratings for following were associated with a number of maternal behaviours during play. Mothers who received high ratings for following were less likely to move toys into their infant’s line of sight. They were also marginally less likely to use sound effects or exclamations. A positive relationship was found between providing physical assistance and following play.
A high rating of scaffolding was marginally positively related to pointing to toys and demonstrating, and significantly related to using sound effects and exclamations, and to the amount of time infants spent seated during play. Infant enjoyment was positively associated with mothers’ use of sound effects and exclamations. Infants’ engagement with their mothers during play was negatively related to the number of times they moved from being seated. It was also marginally negatively associated with the number of time mothers moved toys into their line of sight. A marginal positive association was found with mothers’ use of sound effects and exclamations.

In summary, maternal behaviours during free play at 9 months were related to each other in logical ways (e.g., bids for joint engagements associated with more frequent moving of toys into infant’s line of sight). Infant and maternal behaviours were also related, particularly infant activity level (e.g., mothers of more active infants made more bids for joint engagement). Ratings of maternal scaffolding and following were associated with a variety of maternal behaviours (e.g., demonstrating with a toy) and infant ratings. Infants of mothers who engaged in more scaffolding of their play were rated as more engaged in the interaction. Overall, mothers used more verbal play behaviours than non-verbal.
Table 23

*Relationships among parent and infant behaviours and ratings during play at 9 months (N = 69)*

<table>
<thead>
<tr>
<th>Play Behaviour</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bids for Joint Engagement</td>
<td>-.09</td>
<td>.49****</td>
<td>-.01</td>
<td>.17</td>
<td>-.06</td>
<td>-.19</td>
<td>.08</td>
</tr>
<tr>
<td>2. Moving Toy into Infant’s Line of Sight</td>
<td>.08</td>
<td>.14</td>
<td>-.43****</td>
<td>-.02</td>
<td>-.04</td>
<td>-.20*</td>
<td>-.10</td>
</tr>
<tr>
<td>3. Pointing</td>
<td>-.03</td>
<td>.07</td>
<td>-.06</td>
<td>.22a</td>
<td>-.05</td>
<td>-.05</td>
<td>.00</td>
</tr>
<tr>
<td>4. Demonstrating</td>
<td>.14</td>
<td>.12</td>
<td>-.03</td>
<td>.21*</td>
<td>-.13</td>
<td>.04</td>
<td>.08</td>
</tr>
<tr>
<td>5. Positioning Infant</td>
<td>-.55****</td>
<td>.05</td>
<td>-.07</td>
<td>-.16</td>
<td>-.14</td>
<td>.09</td>
<td>-.21a</td>
</tr>
<tr>
<td>7. Calling Infant’s Name</td>
<td>-.16</td>
<td>-.14</td>
<td>-.14</td>
<td>-.04</td>
<td>-.04</td>
<td>.07</td>
<td>-.17</td>
</tr>
<tr>
<td>8. Saying “Look”</td>
<td>-.12</td>
<td>.17</td>
<td>.03</td>
<td>.13</td>
<td>-.16</td>
<td>.16</td>
<td>-.18</td>
</tr>
<tr>
<td>9. Naming Toy</td>
<td>.11</td>
<td>.10</td>
<td>-.10</td>
<td>.06</td>
<td>.08</td>
<td>-.11</td>
<td>.24a</td>
</tr>
<tr>
<td>10. Sound Effects / Exclamations</td>
<td>.19</td>
<td>-11</td>
<td>-.21a</td>
<td>.25*</td>
<td>.31**</td>
<td>.21a</td>
<td>-.18</td>
</tr>
<tr>
<td>11. Describing Toy</td>
<td>.00</td>
<td>.26*</td>
<td>-.10</td>
<td>.13</td>
<td>.00</td>
<td>-.08</td>
<td>.00</td>
</tr>
<tr>
<td>12. Time Infant Spent Seated</td>
<td>—</td>
<td>-.47****</td>
<td>.08</td>
<td>.23*</td>
<td>.01</td>
<td>.13</td>
<td>-.02</td>
</tr>
<tr>
<td>13. Number of Times Infant Moved from Being Seated</td>
<td>—</td>
<td>-.04</td>
<td>-.18</td>
<td>-.08</td>
<td>-.34***</td>
<td>.21a</td>
<td></td>
</tr>
<tr>
<td>14. Rating of Mother’s Following of Infant’s Play</td>
<td>—</td>
<td>.06</td>
<td>-.22a</td>
<td>-.23a</td>
<td>-.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Rating of Mother’s Scaffolding of Infant’s Play</td>
<td>—</td>
<td>.30**</td>
<td>.42****</td>
<td>.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Rating of Infant’s Enjoyment During Play</td>
<td>—</td>
<td>.44****</td>
<td>.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Rating of Infant’s Engagement With Mother Play</td>
<td>—</td>
<td>.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Number of Toys Infant Plays With</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. *p < .10. **p < .05. ***p < .01. ****p < .001. *****p < .0005.*

164
Gaze Following Task (9 months)

The gaze following task consisted of 8 trials, of which the first 4 were led by the experimenter and the last 4 were led by the parent. During the parent-led trials infants often became fussy, resulting in the task being terminated prematurely. Additionally, on a substantial proportion of the trials (17%) parents failed to establish eye contact with their infant prior to turning their heads. For these reasons limited information was available from the parent trials and these data were excluded from the analyses.

For the experimenter trials, the number of correct responses made by the infant (turned head in direction of experimenter’s head turn) was summed to create a gaze following total score out of 4 ($M = 2.44$, $SD = 1.41$). To receive a total score, infants had to have successfully completed all of the trials (3 infants completed only 2 or 3 trials). Figure 20a presents the number of infants ($n = 57$) receiving total scores ranging from 0-4.

Given that a number of infants ($n = 16$) looked in the direction opposite to that of the experimenter’s head turn on some of the trials, a difference score was also computed (number of correct trials – number of incorrect trials). Taking into account incorrect head turns, the distribution of infants’ scores ranged from -3 to 4 ($M = 2.05$, $SD = 1.73$) (see Figure 20b).

For the infants who correctly looked in the direction of the experimenter’s head turn, it was also noted whether they located the target on the wall. Locating the target was scored if infants looked directly at the toy. On each trial, over half of the infants who followed the experimenter’s gaze located the target on the wall. See Figure 21 which depicts the percentage of infants on each trial who did not follow the experimenter’s gaze, who turned in the direction of the experimenter’s head turn but did not locate the
target, and who turned in the correct direction and located the target. Considering all 4 trials together, regardless of whether gaze was followed correctly on these trials, infants ($N = 60$) received scores ranging from 0-4 for locating the target (see Figure 22). Infants who did not locate the target on any trial ($n = 22$) made up the largest sub-group (37%). Only 10% of the group ($n = 6$) located the target on all 4 trials.

Lastly, we were interested in infants’ behaviour following head turns in the correct direction. Frequencies of the following behaviours were coded: (1) checking – the infant turns her head and then looks back at the experimenter; (2) positive vocalizations – the infant coos, laughs, or babbles after seeing the target; (3) negative vocalizations – the infant whines or cries after seeing the target; (4) reaching – the infant reaches towards the target after seeing it; (5) smiling – the infants smiles after seeing the target. Table 24 presents the number of infants engaging in the above behaviours. Most of the infants engaged in checking only ($n = 18$), followed by vocalizing positively and reaching ($n = 8$), vocalizing positively and smiling ($n = 7$), and reaching only ($n = 5$). Checking also occurred most frequently in combination with other behaviours. As such, 27 infants engaged in at least one instance of checking back with the experimenter across the 4 trials. Checking by the infant was considered an attempt to initiate joint attention, and was thus included in analyses to follow.

In summary, many infants were able to follow the experimenter’s gaze on at least one trial. Locating the target on the wall occurred less frequently, as did engaging in checking behaviour following location of the target.
Figure 20. (a) Gaze following score out of 4. (b) Number of infants receiving total gaze following scores (-4 to +4) when using a difference score.
Figure 21. Percentage of infants demonstrating gaze following and target location ($N = 60$).
Figure 22. Number of infants achieving scores (out of 4) for target location.
Table 24

*Number of infants engaging in confirmatory behaviours on each of the four trials*

<table>
<thead>
<tr>
<th>Confirmatory Behaviour</th>
<th>Trial 1 (n = 34)</th>
<th>Trial 2 (n = 23)</th>
<th>Trial 3 (n = 34)</th>
<th>Trial 4 (n = 26)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking Only</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Positive Vocalization Only</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Negative Vocalization Only</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Reaching Only</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Smiling Only</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Checking + Positive</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Checking + Reaching</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Checking + Smiling</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Positive + Reaching</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Positive + Smiling</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Negative + Reaching</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Reaching + Smiling</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Checking + Positive + Reach</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Checking + Positive + Smile</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Positive + Reaching + Smile</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>13</td>
<td>21</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

*Object Exploration Task – Initiating Joint Attention Behaviours*

At 9 months, infants completed a task in which they explored a set of novel objects that were presented on a tray table in front of them (N = 75). Parents sat behind and to the side of their infants; thus, infants could turn and look at their parents. Measures
of initiation of joint attention were derived from the object exploration task. Infants received scores for:

1. Number of looks to the experimenter
2. Number of looks to their parent
3. Number of showing / giving objects to parent or experimenter
4. Duration showing / giving objects to parent or experimenter

The mean number of looks to the experimenter was 21.93 (SD = 11.49) and ranged from 4 to 60 looks. Infants also looked at their parents while they explored the objects (M = 3.65, SD = 3.86), ranging from 0 to 18 looks. Approximately half of the infants did not engage in any showing/giving behaviour (n = 35), while for the others, instances of showing/giving the objects ranged from 1 to 18 (M = 2.13, SD = 5.82).

Relationships Between Initiating and Responding to Joint Attention

Correlation analyses were run between scores from the gaze following task and those from object exploration. Number of looks to parents or experimenter during object exploration was not related to scores on the gaze following task. Relationships were found however between number of shows / gives object and the total gaze following score out of 4 (r(57) = .27, p < .05) and the score out of 4 for locating the target (r(60) = .36, p < .008). Checking back with the experimenter during gaze following was not related to showing/giving during object exploration.

Prediction of Imitation Abilities at 9 and 12 Months From 4-Month Measures

The following section presents a series of analyses examining prediction of imitation abilities at 9 and 12 months from the 4-month measures. Data will be presented first for prediction of imitation performance. Measures included task performance,
spontaneous imitation during free play, and parent report of infants starting to imitate. Analyses regarding sensitivity to being imitated will follow imitation performance data.

*Imitation and Temperament at 4 Months*

IBQ-R subscale scores at 4 months were entered into a series of step-wise multiple regression analyses predicting imitation at 9 months. Findings from five sets of analyses examining prediction of imitation will be presented. The first four focus on imitation performance while the final set of analyses is related to sensitivity to being imitated.

*Prediction of imitation task performance*

Six regression equations were calculated between the 14 predictor temperament variables and measures of imitation performance from the elicited imitation task:

1. Overall best all-or-none imitation (0-9) score
2. Trial 1 all-or-none imitation (0-9) score
3. Trial 3 all-or-none imitation (0-9) score
4. Overall best approximations to imitation (0-27) score
5. Trial 1 approximations to imitation (0-27) score
6. Trial 3 approximations to imitation (0-27) score

Scores from Trials 1 and 3 were included in addition to the overall best all-or-none imitation (0-9) score and the overall best approximations to imitation (0-27) score as we were interested in relationships between temperament and performance during the infant’s first opportunity to imitate, and also with their parent. For each of the following analyses, see Table 25 for $t$-values and beta weights for individual predictors.
Rate of Falling Reactivity and Vocal Reactivity at 4 months predicted 0-9 full imitation (overall best score) at 9 months \(F(2,69) = 5.96, p < .004\) and together accounted for 15% of the variance in the score. For Trial 1 (0-9), Rate of Falling Reactivity and Vocal Reactivity were again significant predictors of imitation, in addition to Sadness as a third predictor \(F(3,62) = 5.85, p < .001\). These three IBQ-R subscale scores accounted for 22% of the variance in infants’ all-or-none Trial 1 imitation score. Different relationships emerged for Trial 3 all-or-none imitation with parents. Smiling and Approach scores were significant predictors of imitation performance \(F(2,46) = 5.46, p < .007\), accounting for 19% of the variance in the imitation score.

A different pattern of predictors were found for approximations to imitation scores. Significant predictors of the overall best 0-27 score were 4 month Vocal Reactivity and Approach scores \(F(2,69) = 8.34, p < .001\). Together, these subscale scores predicted 20% of the variance in imitation performance. For Trial 1 (0-27) performance with the experimenter, a number of IBQ-R subscales scores emerged as significant predictors including High Intensity Pleasure, Approach, Vocal Reactivity, Perceptual Sensitivity, and Sadness. In the final model, High Intensity Pleasure was removed from the regression analysis \(F(4,60) = 9.36, p < .0005\). 38% of the variance in Trial 1 (0-27) imitation performance was accounted for by the 5 subscale scores in the final model. In contrast, none of the IBQ-R subscale scores predicted Trial 3 approximations to imitation with their parent \(F(14,34) = .90, p > .05\).
Table 25

Summary of Regression Analyses for 4-Month Temperament Variables Predicting Performance on the Imitation Task

<table>
<thead>
<tr>
<th>Imitation Task Score</th>
<th>Temperament Model</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 Best</td>
<td>Model 1: Rate of Falling Reactivity</td>
<td>-.33</td>
<td>.07</td>
<td>-2.20*</td>
</tr>
<tr>
<td></td>
<td>Model 2: Rate of Falling Reactivity</td>
<td>-.39</td>
<td>.15</td>
<td>-2.66**</td>
</tr>
<tr>
<td></td>
<td>Vocal Reactivity</td>
<td>.36</td>
<td></td>
<td>2.58**</td>
</tr>
<tr>
<td>0-9 Trial 1</td>
<td>Model 1: Vocal Reactivity</td>
<td>.32</td>
<td>.09</td>
<td>2.46**</td>
</tr>
<tr>
<td></td>
<td>Model 2: Vocal Reactivity</td>
<td>.36</td>
<td>.14</td>
<td>2.76***</td>
</tr>
<tr>
<td></td>
<td>Rate of Falling Reactivity</td>
<td>-.27</td>
<td></td>
<td>-2.01*</td>
</tr>
<tr>
<td></td>
<td>Model 3: Vocal Reactivity</td>
<td>.34</td>
<td>.22</td>
<td>2.79***</td>
</tr>
<tr>
<td></td>
<td>Rate of Falling Reactivity</td>
<td>-.39</td>
<td></td>
<td>-2.82***</td>
</tr>
<tr>
<td></td>
<td>Sadness</td>
<td>-.36</td>
<td></td>
<td>-2.51**</td>
</tr>
<tr>
<td>0-9 Trial 3</td>
<td>Model 1: Smiling and Laughter</td>
<td>.45</td>
<td>.12</td>
<td>2.53**</td>
</tr>
<tr>
<td></td>
<td>Model 2: Smiling and Laughter</td>
<td>.63</td>
<td>.19</td>
<td>3.25***</td>
</tr>
<tr>
<td></td>
<td>Approach</td>
<td>-.31</td>
<td></td>
<td>-2.03*</td>
</tr>
<tr>
<td>0-27 Best</td>
<td>Model 1: Vocal Reactivity</td>
<td>1.19</td>
<td>.09</td>
<td>2.60**</td>
</tr>
<tr>
<td></td>
<td>Model 2: Vocal Reactivity</td>
<td>1.75</td>
<td>.20</td>
<td>3.72****</td>
</tr>
<tr>
<td></td>
<td>Approach</td>
<td>-1.09</td>
<td></td>
<td>-3.02****</td>
</tr>
<tr>
<td>0-27 Trial 1</td>
<td>Model 1: High Intensity Pleasure</td>
<td>1.18</td>
<td>.11</td>
<td>2.74***</td>
</tr>
<tr>
<td></td>
<td>Model 2: High Intensity Pleasure</td>
<td>1.38</td>
<td>.16</td>
<td>3.21***</td>
</tr>
<tr>
<td></td>
<td>Approach</td>
<td>-.68</td>
<td></td>
<td>-2.06*</td>
</tr>
<tr>
<td></td>
<td>Model 3: High Intensity Pleasure</td>
<td>.94</td>
<td>.25</td>
<td>2.13*</td>
</tr>
<tr>
<td></td>
<td>Approach</td>
<td>-.96</td>
<td></td>
<td>-2.89***</td>
</tr>
<tr>
<td></td>
<td>Vocal Reactivity</td>
<td>1.23</td>
<td></td>
<td>2.68**</td>
</tr>
<tr>
<td></td>
<td>Model 4: High Intensity Pleasure</td>
<td>.80</td>
<td>.32</td>
<td>-3.83****</td>
</tr>
<tr>
<td></td>
<td>Approach</td>
<td>-1.37</td>
<td></td>
<td>2.67**</td>
</tr>
<tr>
<td></td>
<td>Vocal Reactivity</td>
<td>1.18</td>
<td></td>
<td>2.52**</td>
</tr>
<tr>
<td></td>
<td>Perceptual Sensitivity</td>
<td>.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imitation Task Score</td>
<td>Temperament Model</td>
<td>$\beta$</td>
<td>$R^2$</td>
<td>$T$</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------</td>
<td>---------</td>
<td>-------</td>
<td>-----</td>
</tr>
<tr>
<td>Model 5: High Intensity Pleasure Approach</td>
<td>-1.41</td>
<td>.39</td>
<td>.39</td>
<td>.88</td>
</tr>
<tr>
<td>Vocal Reactivity</td>
<td>1.27</td>
<td></td>
<td></td>
<td>2.99***</td>
</tr>
<tr>
<td>Perceptual Sensitivity</td>
<td>.91</td>
<td></td>
<td></td>
<td>2.81***</td>
</tr>
<tr>
<td>Sadness</td>
<td>-1.11</td>
<td></td>
<td></td>
<td>-2.59**</td>
</tr>
<tr>
<td>Model 6: Approach</td>
<td>-1.41</td>
<td>.38</td>
<td></td>
<td>-4.15****</td>
</tr>
<tr>
<td>Vocal Reactivity</td>
<td>1.41</td>
<td></td>
<td></td>
<td>3.57***</td>
</tr>
<tr>
<td>Perceptual Sensitivity</td>
<td>.95</td>
<td></td>
<td></td>
<td>2.98***</td>
</tr>
<tr>
<td>Sadness</td>
<td>-1.25</td>
<td></td>
<td></td>
<td>-3.12***</td>
</tr>
<tr>
<td>High Intensity Pleasure Removed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0-27 Trial 3 N.S.

*Note. *$p < .05$. **$p < .01$. ***$p < .001$. ****$p < .0005$.

For all of the above regression analyses, the direction of the relationships between the 4 month IBQ-R subscale scores and performance on the separate imitation measures at 9 months were consistent:

1. Infants who were more vocal (Vocal Reactivity) performed better on the imitation task.

2. Infants who recovered from distress (Rate of Falling Reactivity) more slowly performed better on the imitation task.

3. Infants who were less inclined to rapidly approach novel environments and toys (Approach) performed better on the imitation task.

4. Infants who were rated as being more sad (Sadness) did less well on the imitation task.

5. Infants who were rated as smiling and laughing (Smiling and Laughter) more during care-giving / play situations performed better on the imitation task.
6. Infants who were rated as enjoying high stimulus intensity (High Intensity Pleasure) performed better on the imitation task.

7. Infants who were rated as being more sensitive to slight, low intensity stimuli from the environment (Perceptual Sensitivity) performed better on the imitation task.

*Prediction of infant engagement during the imitation task*

A single regression equation was calculated between the 14 predictor temperament variables and infant engagement during the elicited imitation task. Simple correlations yielded trends ($p$-values < .06) for the following analyses. Infants rated as more fearful (Fear) were less engaged. Infants who were rated as more vocal (Vocal Reactivity), who took longer to recover from distress (Rate of Falling Reactivity), and who approached novel environments and toys less (Approach) were rated as more engaged during the imitation task. The regression equation, however, was not significant ($F(14,56) = 1.08, p > .05$).

*Prediction of spontaneous imitation during free play*

As with infant engagement, a single regression equation was calculated. Rate of Falling Reactivity and Low Intensity Pleasure emerged as significant predictors of the number of infant spontaneous imitations of their mother during free play ($F(1,66) = 4.43, p < .01$) and together accounted for 12% of the variance in the imitation score. The number of infant imitations was also predicted by both the Rate of Falling Reactivity subscale ($\beta = -.59, t = -2.36, p < .02$) and the Low Intensity Pleasure subscale ($\beta = .56, t = 2.00, p < .05$). Infants who were rated by their parents as enjoying low stimulus intensity activities spontaneously imitated their mother more often during free play with toys at 9
months, as did infants whose parents reported that they took longer to recover from distress.

Prediction of parent report of infants starting to copy (at 9 and 12 months)

Six regression equations were calculated between the 14 predictor temperament variables and parent report measures of imitation performance at 9 and 12 months. For each of the following analyses, see Table 26 for t-values and beta weights for individual predictors.

Table 26

Summary of Regression Analyses for 4-Month Temperament Variables Predicting Parent Report of Infants Starting to Copy at 9 and 12 Months

<table>
<thead>
<tr>
<th>Parent Report Score</th>
<th>Temperament Model</th>
<th>β</th>
<th>R²</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Starting to Copy</td>
<td>Model 1: High Intensity Pleasure</td>
<td>.57</td>
<td>.22</td>
<td>4.39****</td>
</tr>
<tr>
<td></td>
<td>Model 2: High Intensity Pleasure</td>
<td>.44</td>
<td>.29</td>
<td>3.22***</td>
</tr>
<tr>
<td></td>
<td>Vocal Reactivity</td>
<td>.33</td>
<td></td>
<td>2.52**</td>
</tr>
<tr>
<td>9 Months KIDS Advanced</td>
<td>Model 1: Vocal Reactivity</td>
<td>.66</td>
<td>.17</td>
<td>3.53***</td>
</tr>
<tr>
<td></td>
<td>Model 2: Vocal Reactivity</td>
<td>.84</td>
<td>.23</td>
<td>4.19****</td>
</tr>
<tr>
<td></td>
<td>High Intensity Pleasure</td>
<td>-.41</td>
<td></td>
<td>2.18*</td>
</tr>
<tr>
<td>12 Months Starting to Copy</td>
<td>Model 1: Low Intensity Pleasure</td>
<td>.31</td>
<td>.09</td>
<td>2.09*</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001. ****p < .0005.

Scores on the High Intensity Pleasure and Vocal Reactivity subscales at 4 months predicted parent ratings of infants "starting to copy" at 9 months (F(2,68) = 13.57, p < .0005) and together accounted for 29% of the variance in the ratings. For the KIDS Advanced Imitation score, Vocal Reactivity and High Intensity Pleasure again emerged as predictors (F(2,61) = 8.84, p < .0005), accounting for 23% of the variance in the KIDS imitation scores. At 12 months, the Low Intensity Pleasure subscale score was the sole
predictor of parent ratings of “starting to copy” \( F(1,44) = 4.36, p < .04 \): 9% of variance accounted for).

For each of the above regression analyses, the direction of the relationships between the 4 month IBQ-R subscale scores and performance on the parent ratings of imitation at 9 and 12 months were as follows:

1. Infants who were more vocal (Vocal Reactivity) and enjoyed high stimulus intensity (High Intensity Pleasure) were rated as starting to copy more at 9 months.

2. Infants who were rated as enjoying low stimulus intensity (Low Intensity Pleasure) were rated as starting to copy more at 12 months.

3. Infants who were rated as less vocal (Vocal Reactivity) and as enjoying high stimulus intensity (High Intensity Pleasure) received lower scores for KIDS Advanced Imitation.

\textit{Prediction of parent report of sensitivity to being imitated (at 9 and 12 months)}

Four regression equations were calculated between the 14 predictor temperament variables and parent report measures of infants’ sensitivity to being imitated at 9 and 12 months. For each of the following analyses, see Table 27 for \( t \)-values and beta weights for individual predictors.
Table 27

*Summary of Regression Analyses for 4-Month Temperament Variables Predicting Parent Report of Sensitivity to Imitation at 9 and 12 months*

<table>
<thead>
<tr>
<th>Imitation Task Score</th>
<th>Temperament Model</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Noticing Sounds</td>
<td>Model 1: Low Intensity Pleasure</td>
<td>.40</td>
<td>.19</td>
<td>3.98****</td>
</tr>
<tr>
<td></td>
<td>Model 2: Low Intensity Pleasure</td>
<td>.35</td>
<td>.25</td>
<td>3.52***</td>
</tr>
<tr>
<td></td>
<td>Perceptual Sensitivity</td>
<td>.16</td>
<td></td>
<td>2.38**</td>
</tr>
<tr>
<td>9 Months Noticing Movements</td>
<td>Model 1: Vocal Reactivity</td>
<td>.29</td>
<td>.12</td>
<td>3.11***</td>
</tr>
<tr>
<td></td>
<td>Model 2: Vocal Reactivity</td>
<td>.23</td>
<td>.18</td>
<td>2.76***</td>
</tr>
<tr>
<td></td>
<td>Perceptual Sensitivity</td>
<td>.16</td>
<td></td>
<td>2.13*</td>
</tr>
<tr>
<td>12 Months Noticing Sounds</td>
<td>Model 1: Vocal Reactivity</td>
<td>.18</td>
<td>.09</td>
<td>2.13*</td>
</tr>
<tr>
<td>12 Months Noticing Movements</td>
<td>Model 1: Smiling and Laughter</td>
<td>.26</td>
<td>.11</td>
<td>2.40*</td>
</tr>
<tr>
<td></td>
<td>Model 2: Smiling and Laughter</td>
<td>.31</td>
<td>.22</td>
<td>2.99***</td>
</tr>
<tr>
<td></td>
<td>Cuddliness</td>
<td>-.33</td>
<td></td>
<td>-2.46*</td>
</tr>
<tr>
<td></td>
<td>Model 3: Low Intensity Pleasure</td>
<td>.30</td>
<td>.30</td>
<td>3.03***</td>
</tr>
<tr>
<td></td>
<td>Cuddliness</td>
<td>-.33</td>
<td></td>
<td>-2.58**</td>
</tr>
<tr>
<td></td>
<td>Fear</td>
<td>.24</td>
<td></td>
<td>2.14*</td>
</tr>
<tr>
<td></td>
<td>Model 4: Low Intensity Pleasure</td>
<td>.37</td>
<td>.36</td>
<td>3.63***</td>
</tr>
<tr>
<td></td>
<td>Cuddliness</td>
<td>-.48</td>
<td></td>
<td>-3.37***</td>
</tr>
<tr>
<td></td>
<td>Fear</td>
<td>.28</td>
<td></td>
<td>2.56**</td>
</tr>
<tr>
<td></td>
<td>Activity Level</td>
<td>-.21</td>
<td></td>
<td>-2.09*</td>
</tr>
</tbody>
</table>

Note. *$p < .05$. **$p < .01$. ***$p < .001$. ****$p < .0005$.

At 9 and 12 months, parents rated separately their infant’s ability to recognize when their vocalizations and movements were being copied. Low Intensity Pleasure and Perceptual Sensitivity emerged as significant predictors of sensitivity to sounds being imitated at 9 months ($F(2,68) = 11.34, p < .0005$) and accounted for 25% of the variance in parent ratings, while Vocal Reactivity and Perceptual Sensitivity predicted sensitivity
to movements being imitated \((F(2,68) = 7.36, p < .001\): accounting for 18% of variance). At 12 months, a different pattern of predictors emerged. Vocal Reactivity was the sole predictor of noticing when vocalizations were being copied \((F(1,46) = 4.55, p < .04\), accounting for 9% of the variance in parent ratings. A number of predictors however emerged for sensitivity to movements being imitated. Low Pleasure, Cuddliness, Fear, and Activity Level \((F(4,42) = 5.96, p < .001\), together accounted for 36% of the variance in parent ratings.

The direction of the relationships between the 4 month IBQ-R subscale scores and parent ratings of sensitivity to being imitated at 9 and 12 months are as follows:

1. Infants who were more vocal at 4 months (Vocal Reactivity) were rated as more sensitive to being imitated at 9 and 12 months.

2. Infants who were rated as enjoying low stimulus intensity (Low Intensity Pleasure) were also rated as more sensitive to being imitated at 9 and 12 months.

3. Infants who were rated as being more sensitive to slight, low intensity stimuli from the environment (Perceptual Sensitivity) were rated as more sensitive to being imitated at 9 months (movements and sounds).

4. Infants who were rated as being more cuddly (Cuddliness) were rated at 12 months as less sensitive to their movements being imitated.

5. Infants who were rated as being very active (Activity Level) were also rated as less sensitive to their movements being imitated at 12 months.

6. Infants who were rated as more fearful (Fear) were rated as more sensitive to their movements being copied at 12 months.
In summary, imitation at 9 and 12 months was predicted by parent report of infant temperament at 4 months. Of note, different relationships emerged for imitation performance than for sensitivity to being imitated and between full imitation and approximations. Characteristics of infants at 4 months who imitated well at 9 months included being vocal, recovering more slowly from distress, enjoying high intensity stimulation, and being less inclined to approach novel toys or situations. As expected, sensitivity to being imitated was predicted by enjoyment of low intensity stimulation and perceptual sensitivity. Vocal reactivity again predicted sensitivity to noticing movements being copied.

*Imitation and Mother-Infant Play at 4 Months*

Measures derived from the play session at 4 months included maternal and infant behaviors during initial free play and the imitation segment that followed (see Table 28). A series of separate step-wise multiple regression analyses predicting imitation ability at 9 months were run with free play behavior (mother and infant) and imitation segment behavior (mother and infant) as predictors. Findings from these sets of analyses examining prediction of imitation will be presented.
Table 28

4-Month Play Session Measures Included in the Prediction of Imitation at 9 and 12 Months

<table>
<thead>
<tr>
<th>Analysis Set</th>
<th>Play Session Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Play Measures</td>
<td>Proportion of time infants spent watching their parent’s actions</td>
</tr>
<tr>
<td></td>
<td>Proportion of time infants spent watching their parent’s facial expressions</td>
</tr>
<tr>
<td></td>
<td>Proportion of time infants spent vocalizing</td>
</tr>
<tr>
<td></td>
<td>Proportion of frequency of infants’ actions</td>
</tr>
<tr>
<td></td>
<td>Rating of infants’ engagement</td>
</tr>
<tr>
<td></td>
<td>Proportion of time parents spent touching their infant</td>
</tr>
<tr>
<td></td>
<td>Proportion of time parents spent vocalizing</td>
</tr>
<tr>
<td></td>
<td>Number of spontaneous imitations of infants’ vocalizations</td>
</tr>
<tr>
<td></td>
<td>Number of spontaneous imitations of infants’ actions</td>
</tr>
<tr>
<td></td>
<td>Number of spontaneous imitations of infants’ facial expressions</td>
</tr>
<tr>
<td></td>
<td>Rating of parents’ engagement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Imitation Segment Measures</th>
<th>Proportion of time infants spent watching their parent’s actions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proportion of time infants spent watching their parent’s facial expressions</td>
</tr>
<tr>
<td></td>
<td>Proportion of time infants spent vocalizing</td>
</tr>
<tr>
<td></td>
<td>Proportion of frequency of infants’ movements</td>
</tr>
<tr>
<td></td>
<td>Rating of infants’ engagement</td>
</tr>
<tr>
<td></td>
<td>Rating of infants’ “testing”</td>
</tr>
<tr>
<td></td>
<td>Rating of how well mother imitates infants’ vocalizations</td>
</tr>
<tr>
<td></td>
<td>Rating of how well mother imitates infants’ actions</td>
</tr>
<tr>
<td></td>
<td>Rating of how well mother imitates infants’ facial expressions</td>
</tr>
</tbody>
</table>

Prediction of imitation task performance

Six regression equations were calculated between the predictor 4-month variables and measures of imitation production from the elicited imitation task. No 4 month play measures predicted either 0-9 imitation (overall best score) at 9 months \( F(11,46) = .76, p > .05 \) or 0-27 imitation (overall best score) \( F(11,46) = .72, p > .05 \). The same was true
for 4 month play imitation segment measures (0-9 imitation: $F(9,47) = .69, p > .05$; 0-27 imitation: $F(9,47) = .83, p > .05$).

**Prediction of spontaneous imitation during free play**

Four month play session measures also did not predict infant spontaneous imitation during the 9 month mother-infant play session (4-month free play measures: $F(11,43) = .46, p > .05$; 4-month imitation segment measures: $F(9,44) = .34, p > .05$).

**Prediction of parent report of infants starting to copy (at 9 and 12 months)**

Four regression equations were calculated between the 2 sets of 4-month play session predictor variables and parent report measures of imitation performance at 9 and 12 months. For each of the following analyses, see Table 29 for $t$-values and beta weights for individual predictors.

No 4-month play session measures predicted parent report of starting to copy at 9 months (free play measures: $F(11,43) = .69, p > .05$, imitation segment measures: $F(9,44) = 1.23, p > .05$). Proportion of time infants spent watching their parent’s actions during free play emerged as the sole predictor of KIDS Advanced Imitation scores ($F(1,50) = 4.14, p < .05$), and accounted for 8% of the variance. KIDS Advanced Imitation was not predicted by measures from the 4-month imitation segment ($F(9,41) = .70, p > .05$).

Parent report of infant imitation abilities at 12 months was predicted by a number of 4 month play session measures. Maternal spontaneous imitation of infants’ facial expressions and actions during free play emerged as significant predictors of starting to copy ratings at 12 months ($F(2,33) = 6.38, p < .005$), accounting for 28% of the variance in parent ratings. Mothers who more often copied their infants’ facial expressions and less often copied their infants’ actions rated their infants as having started to copy more at 12 months. Ratings at 12 months were also predicted by the proportion of time infants
spent watching their parent’s actions during the imitation segment of the 4 month play
session \((F(1,33) = 6.31, p < .02)\), which accounted for 16% of the variance in parent
ratings. Infants who spent less time watching their parent’s actions were rated as copying
more at 12 months.

Table 29

*Summary of Regression Analyses for 4-Month Play Session Variables Predicting Parent
Report of Infants Starting to Copy at 9 and 12 Months*

<table>
<thead>
<tr>
<th>Parent Report Score</th>
<th>4-Month Play Model</th>
<th>(\beta)</th>
<th>(R^2)</th>
<th>(T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Starting to Copy</td>
<td>Free Play Measures N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Imitation Segment Measures N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Months KIDS Advanced</td>
<td>Model 1: Proportion of time watching parent’s actions during free play</td>
<td>2.05</td>
<td>.08</td>
<td>2.04*</td>
</tr>
<tr>
<td></td>
<td>Imitation Segment Measures N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Months Starting to Copy</td>
<td>Model 1: Spontaneous imitation of infant’s facial expressions during free play</td>
<td>.14</td>
<td>.14</td>
<td>2.38*</td>
</tr>
<tr>
<td></td>
<td>Model 2: Spontaneous imitation of infant’s facial expressions during free play</td>
<td>.15</td>
<td>.28</td>
<td>2.65**</td>
</tr>
<tr>
<td></td>
<td>Spontaneous imitation of infant’s actions during free play</td>
<td>-.21</td>
<td></td>
<td>-2.50**</td>
</tr>
<tr>
<td></td>
<td>Model 1: Proportion of time watching parent’s actions during imitation</td>
<td>-1.72</td>
<td>.16</td>
<td>-2.51**</td>
</tr>
</tbody>
</table>

*Note. *p < .05. **p < .01. ***p < .001.*

*Prediction of parent report of sensitivity to being imitated (at 9 and 12 months)*

Four regression equations were calculated between the 2 sets of 4-month play
session predictor variables and parent report measures of infant sensitivity to being
imitated at 9 and 12 months (Table 30). The sole predictor of sensitivity to being imitated
at 9 months was ratings of parent engagement during free play at 4 months, which predicted infants’ sensitivity to sounds being imitated at 9 months ($F(1,54) = 4.97, p < .03$). Imitation segment measures did not predict infants’ sensitivity to their vocalizations being copied ($F(9,45) = .36, p > .05$). No predictors emerged from the 4 month play session for sensitivity to movements being copied at 9 months (free play: $F(11,25) = .89, p > .05$); imitation segment: $F(9,26) = .86, p > .05$).

Four month play measures also did not predict either 12 month sensitivity ratings (noticing sounds: free play $F(11,26) = 1.08, p > .05$, imitation segment $F(9,27) = .63, p > .05$; noticing movements: free play $F(11,44) = .47, p > .05$, imitation segment $F(9,45) = .86, p > .05$).

Table 30

*Summary of Regression Analyses for 4-Month Play Session Variables Predicting Parent Report of Sensitivity to Imitation at 9 and 12 months*

<table>
<thead>
<tr>
<th>Parent Report Score</th>
<th>4-month Play Session Model</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Noticing Sounds</td>
<td>Model 1: Rating of parent engagement during free play</td>
<td>.28</td>
<td>.08</td>
<td>2.23*</td>
</tr>
<tr>
<td></td>
<td>Imitation Segment Measures</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Months Noticing Movements</td>
<td>Free Play Measures</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Imitation Segment Measures</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Months Noticing Sounds</td>
<td>Free Play Measures</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Imitation Segment Measures</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Months Noticing Movements</td>
<td>Free Play Measures</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Imitation Segment Measures</td>
<td>N.S.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.  *$p < .05$.  **$p < .01$.  ***$p < .001$.  

In summary, performance on the imitation task was not predicted by 4-month play session measures, nor was spontaneous imitation during free play. Some relationships
were noted for parent report of infants starting to copy, particularly at 12 months. For sensitivity to being imitated, only parent engagement during free play predicted sensitivity to sounds being imitated at 9 months.

*Imitation and Visual-Spatial Attention at 4 Months*

VSAT latency to shift and disengage scores at 4 months were entered into a series of step-wise multiple regression analyses predicting imitation at 9 and 12 months. Findings from two sets of analyses examining prediction of imitation will be presented (imitation performance and sensitivity to being imitated).

*Prediction of imitation performance at 9 and 12 months*

Five regression equations were calculated between the 2 predictor visual-spatial attention (VSAT) variables and measures of imitation performance (scores on the elicited imitation task, spontaneous imitation during free play, and parent report of imitation skill). No significant findings emerged from these analyses. Neither VSAT measure predicted 0-9 imitation (overall best score) at 9 months ($F(2,60) = .84, p > .05$) or 0-27 imitation (overall best score) ($F(2,60) = .41, p > .05$). The same was true for spontaneous imitation during free play ($F(2,59) = 2.01, p > .05$).

Parent report of starting to copy at 9 months was also not predicted by VSAT latency measures ($F(2,60) = 1.49, p > .05$), however the simple correlation between latency to shift and starting to copy was significant ($r(63) = -.22, p < .04$). Infants who were quicker to shift attention at 4 months were rated by parents as starting to copy more at 9 months. The VSAT measures did not predict KIDS Advanced Imitation scores at 9 months ($F(2,56) = .27, p > .05$). At 12 months, parent report of starting to copy was also not predicted by VSAT latency scores ($F(2,39) = .36, p > .05$).
Prediction of parent report of sensitivity to being imitated at 9 and 12 months

Four regression equations were calculated between the 4-month VSAT predictor variables and parent report measures of infant sensitivity to being imitated at 9 and 12 months. Neither latency measure predicted sensitivity to being imitated at 9 months (sensitivity to vocalizations being imitated: $F(2,61) = .02, p > .05$, sensitivity to movements being copied: $F(2,61) = .13, p > .05$). At 12 months, a similar lack of relationship was noted (sensitivity to vocalizations being imitated: $F(2,39) = 1.09, p > .05$, sensitivity to movements being copied: $F(2,39) = .93, p > .05$).

Imitation and VPIP 4 months

To correct for side bias, z-scores were used for all of the following analyses (see the 4 month VPIP results section for an explanation of these scores).

VPIP measures at 4 months (proportion of time spent viewing the preferred display, z-score for proportion of time spent viewing the non-contingent display, rating of “testing” the displays, and rating of interest in the displays) were entered into a series of step-wise multiple regression analyses predicting imitation at 9 and 12 months. Findings from two sets of analyses examining prediction of imitation will be presented (imitation performance and sensitivity to being imitated).

Prediction of imitation performance at 9 and 12 months

Seven regression equations were calculated between the 4 predictor VPIP variables and measures of imitation production at 9 and 12 months: (1) imitation task performance (0-9 all-or-none, 0-27 approximations), (2) spontaneous imitation during free play, and (3) parent report of imitation (starting to copy at 9 and 12 months and
KIDS Advanced Imitation. For each of the following analyses, see Table 31 for t-values and beta weights for individual predictors.

Table 31

Summary of Regression Analyses for 4-Month VPIP Variables Predicting Imitation Production at 9 and 12 months

<table>
<thead>
<tr>
<th>Imitation Performance Score</th>
<th>VPIP Model</th>
<th>β</th>
<th>R²</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 Best</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All-or-None</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-9 Best</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneous Imitation</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During Free Play</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Months Parent Report</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting to Copy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KIDS Advanced</td>
<td>Model 1: “Testing” the Displays</td>
<td>1.10</td>
<td>.23</td>
<td>3.37***</td>
</tr>
<tr>
<td>12 Months Parent Report</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting to Copy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. ***p < .001.

No VPIP scores emerged as significant predictors of imitation task performance:

0-9 all-or-none $F(4,40) = .74, p > .05$; 0-27 approximations $F(4,40) = .35, p > .05$. In a stepwise analysis, spontaneous imitation during free play was also not predicted by 4 month VPIP scores ($F(4,38) = .37, p > .05$).

Parent report of infants starting to copy was also not predicted by VPIP scores at either 9 months ($F(4,38) = .33, p > .05$) or 12 months of age ($F(4,24) = 1.34, p > .05$). KIDS Advanced Imitation scores however, were predicted by ratings of “testing” the
displays \(F(1,38) = 11.35, p < .002\). Infants who engaged in more testing behaviour received higher parent-report scores for Advanced Imitation from the KIDS.

*Prediction of parent report of sensitivity to being imitated (at 9 and 12 months)*

No VPIP predictors emerged for Noticing Movements \(F(4,39) = .34, p > .05\) or Sounds Being Copied \(F(4,39) = 1.08, p > .05\) at 9 months. At 12 months, the same was true; VPIP measures did not predict Noticing Movements Being Copied \(F(4,25) = .80, p > .05\) or Noticing Sounds \(F(4,25) = 1.53, p > .05\).

*Concurrent Relationships with Imitation Ability at 9 and 12 Months*

The following section presents a series of analyses examining concurrent relationships between imitation abilities at 9 and 12 months and the 9-month measures. Data will be presented first for prediction of imitation performance. Measures included task performance, spontaneous imitation during free play, and parent report of infants starting to imitate. Analyses regarding sensitivity to being imitated will follow imitation performance data.

*Imitation and Temperament at 9 Months*

As at 4 months, 9-month IBQ-R subscale scores were entered into a series of stepwise multiple regression analyses predicting imitation (performance and sensitivity) at 9 months. Findings from five sets of analyses examining prediction of imitation with be presented.

*Prediction of imitation task performance*

Four regression equations were calculated between the 14 predictor temperament variables and measures of imitation performance from the elicited imitation task. For
each of the following analyses, see Table 32 for \( t \)-values and beta weights for individual predictors.

Table 32

*Summary of Regression Analyses for 9-Month Temperament Variables Predicting Performance on the Imitation Task*

<table>
<thead>
<tr>
<th>Imitation Task Score</th>
<th>Temperament Model</th>
<th>( \beta )</th>
<th>( R^2 )</th>
<th>( T )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 Best</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-9 Trial 1</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-9 Trial 3</td>
<td>Model 1: Distress to Limitations</td>
<td>-.45</td>
<td>.09</td>
<td>-2.16*</td>
</tr>
<tr>
<td>0-27 Best</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-27 Trial 1</td>
<td>Model 1: Vocal Reactivity</td>
<td>1.40</td>
<td>.12</td>
<td>2.78***</td>
</tr>
<tr>
<td></td>
<td>Model 2: Vocal Reactivity Approach</td>
<td>1.09</td>
<td>.17</td>
<td>2.11*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.38</td>
<td></td>
<td>2.02*</td>
</tr>
<tr>
<td>0-27 Trial 3</td>
<td>Model 1: Distress to Limitations</td>
<td>-1.48</td>
<td>.09</td>
<td>-2.11*</td>
</tr>
</tbody>
</table>

*Note. *\( p < .05. **p < .01. ***p < .001.*

No IBQ-R subscale scores from 9 months predicted 0-9 imitation (overall all-or-none best score) at 9 months (\( F(14,53) = .74, p > .05 \)), though a significant simple correlation was found between Vocal Reactivity and 0-9 imitation scores (\( r(68) = .20, p < .05 \)). A similar result emerged for Trial 1 0-9. Though the regression analysis was not significant (\( F(14,47) = .78, p > .05 \)), significant simple correlations were found for Sadness (\( r(62) = -.22, p < .04 \)), Approach (\( r(62) = .22, p < .04 \)), and Vocal Reactivity (\( r(62) = .24, p < .03 \)). For Trial 3 scores with parents, Distress to Limitations emerged as the sole predictor of imitation performance, accounting for 9% of the variance in scores (\( F(1,45) = 4.67, p < .04 \)).
For approximations to imitation (0-27), no IBQ-R subscale predicted the overall best score \( (F(14,43) = .96, p > .05) \), though significant simple correlations were found for Fear \( (r(68) = -.23, p < .03) \), Approach \( (r(68) = .22, p < .04) \), and Vocal Reactivity \( (r(68) = .23, p < .03) \). Performance on Trial 1 (0-27) however was predicted by scores on Vocal Reactivity and Approach \( (F(1,59) = 6.12, p < .004) \), together accounting for 17% of the variance in imitation scores. Distress to Limitations was the sole predictor for Trial 3 (0-27) with parents \( (F(1,45) = 4.48, p < .04) \), and accounted for 9% of the variance in Trial 3 scores.

For the above regression analyses, the direction of the relationships between the 9 month IBQ-R subscale scores and performance on the imitation measures at 9 months were consistent:

1. Infants who were rated as being more vocal (Vocal Reactivity) performed better on the imitation task.

2. Infants who were rated as becoming more distressed when unable to perform a desired action (Distress to Limitations) received lower scores on the parent trial.

3. Infants who were rated as enjoying novel toys and environments (Approach) performed better on the imitation task.

*Prediction of infant engagement during the imitation task*

A single regression equation was calculated between the 14 predictor temperament variables and infant engagement during the elicited imitation task. The following 9-month IBQ-R subscale scores predicted engagement ratings: Fear \( (\beta = -.36, t = -2.63) \), Soothability \( (\beta = -.49, t = -2.83) \), and Low Pleasure \( (\beta = .39, t = 2.64) \) \( (F(5,62) = 5.62, p < .001) \), and together accounted for 21% of the variance in engagement ratings. Infants who were rated by parents as being more fearful, more easily soothed, and less
interested in engaging with novel toys and environments imitated less on the elicited imitation task.

*Prediction of spontaneous imitation during free play*

As with infant engagement, a single regression equation was calculated. No IBQ-R subscales predicted spontaneous imitation during free play (F(14,50) = .32, p > .05).

*Prediction of parent report of infants starting to copy (at 9 and 12 months)*

Four regression equations were calculated between the 14 predictor temperament variables and parent report measures of imitation performance at 9 and 12 months. See Table 33 for the *t*-values and beta weights for individual predictors from the following analyses.

Table 33

*Summary of Regression Analyses for 9-Month Temperament Variables Predicting Parent Report of Infants Starting to Copy at 9 and 12 Months*

<table>
<thead>
<tr>
<th>Parent Report Score</th>
<th>Temperament Model</th>
<th>β</th>
<th>R²</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Starting to Copy</td>
<td>Model 1: Vocal Reactivity</td>
<td>.61</td>
<td>.20</td>
<td>4.13****</td>
</tr>
<tr>
<td>9 Months KIDS Advanced</td>
<td>Model 1: Duration of Orienting</td>
<td>.53</td>
<td>.14</td>
<td>3.14***</td>
</tr>
<tr>
<td>12 Months Starting to Copy</td>
<td>Model 1: Distress to Limitations</td>
<td>-.34</td>
<td>.16</td>
<td>-2.79***</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001. ****p < .0005.

Scores on the Vocal Reactivity subscale at 9 months predicted parent ratings of infants “starting to copy” at 9 months (F(1,69) = 17.05, p < .0005), and accounted for 20% of the variance in the ratings. For the KIDS Advanced Imitation score, Duration of Orienting emerged as a predictor (F(1,63) = 9.90, p < .003), accounting for 14% of the variance in the KIDS imitation score. At 12 months, the Distress to Limitations subscale
score was the sole predictor of parent ratings of “starting to copy” (F(1,42) = 7.79, p < .008: 16% of variance accounted for).

For each of the above regression analyses, the direction of the relationships between the 9 month IBQ-R subscale scores and performance on the parent ratings of imitation at 9 and 12 months were as follows:

1. Infants who were more vocal (Vocal Reactivity) received higher imitation ratings at 9 months.

2. Infants who were rated as becoming more distressed when limits were placed on them (Distress to Limitations) received lower imitation ratings at 9 months.

3. Infants who were rated as attending to or interacting with a single object for extended periods of time (Duration of Orienting) received higher imitation ratings/scores at 9 and 12 months.

*Prediction of parent report of sensitivity to being imitated (at 9 and 12 months)*

Four regression equations were calculated between the 14 predictor temperament variables and parent report measures of infants’ sensitivity to being imitated at 9 and 12 months. For each of the following analyses, see Table 34 for t-values and beta weights for individual predictors.
Table 34

Summary of Regression Analyses for 9-Month Temperament Variables Predicting Parent Report of Sensitivity to Being Imitated at 9 and 12 months

<table>
<thead>
<tr>
<th>Parent Report Score</th>
<th>Temperament Model</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Noticing Sounds</td>
<td>Model 1: Low Intensity Pleasure</td>
<td>.44</td>
<td>.23</td>
<td>4.51****</td>
</tr>
<tr>
<td></td>
<td>Model 2: Low Intensity Pleasure</td>
<td>.39</td>
<td>.35</td>
<td>4.29****</td>
</tr>
<tr>
<td></td>
<td>Perceptual Sensitivity</td>
<td>.26</td>
<td></td>
<td>3.69****</td>
</tr>
<tr>
<td></td>
<td>Model 3: Low Intensity Pleasure</td>
<td>.29</td>
<td>.39</td>
<td>2.84**</td>
</tr>
<tr>
<td></td>
<td>Perceptual Sensitivity</td>
<td>.26</td>
<td></td>
<td>3.74****</td>
</tr>
<tr>
<td></td>
<td>High Intensity Pleasure</td>
<td>.25</td>
<td></td>
<td>2.01*</td>
</tr>
<tr>
<td>9 Months Noticing Movements</td>
<td>Model 1: Low Intensity Pleasure</td>
<td>.35</td>
<td>.14</td>
<td>3.35***</td>
</tr>
<tr>
<td>12 Months Noticing Sounds</td>
<td>Model 1: Soothability</td>
<td>.40</td>
<td>.21</td>
<td>3.43***</td>
</tr>
<tr>
<td>12 Months Noticing Movements</td>
<td>Model 1: Low Intensity Pleasure</td>
<td>.40</td>
<td>.32</td>
<td>4.44****</td>
</tr>
<tr>
<td></td>
<td>Model 2: Low Intensity Pleasure</td>
<td>.40</td>
<td>.42</td>
<td>4.78****</td>
</tr>
<tr>
<td></td>
<td>Perceptual Sensitivity</td>
<td>.19</td>
<td></td>
<td>2.79***</td>
</tr>
<tr>
<td></td>
<td>Model 3: Low Intensity Pleasure</td>
<td>.44</td>
<td>.57</td>
<td>5.96****</td>
</tr>
<tr>
<td></td>
<td>Perceptual Sensitivity</td>
<td>.25</td>
<td></td>
<td>4.10****</td>
</tr>
<tr>
<td></td>
<td>Approach</td>
<td>-.38</td>
<td></td>
<td>-3.79****</td>
</tr>
<tr>
<td></td>
<td>Model 4: Low Intensity Pleasure</td>
<td>.42</td>
<td>.61</td>
<td>5.85****</td>
</tr>
<tr>
<td></td>
<td>Perceptual Sensitivity</td>
<td>.23</td>
<td></td>
<td>3.87****</td>
</tr>
<tr>
<td></td>
<td>Approach</td>
<td>-.36</td>
<td></td>
<td>-3.67***</td>
</tr>
<tr>
<td></td>
<td>Soothability</td>
<td>.19</td>
<td></td>
<td>2.09*</td>
</tr>
</tbody>
</table>

Note. *$p < .05$. **$p < .01$. ***$p < .001$. ****$p < .0005$.

Low Intensity Pleasure, Perceptual Sensitivity, and High Pleasure emerged as significant predictors of sensitivity to vocalizations being imitated at 9 months ($F(3, 68) = 14.42, p < .0005$), together accounting for 39% of the variance in parent ratings, while Low Intensity Pleasure was the sole predictor of sensitivity to movements being imitated
at 9 months ($F(1,70) = 11.23, p < .001$: 14% of the variance accounted for). At 12 months, a different pattern of predictors emerged. Soothability was the sole predictor of noticing when vocalizations were being copied ($F(1,44) = 11.74, p < .001$) and accounted for 21% of the variance in parent ratings. In contrast to the 9 month findings, a number of predictors emerged for sensitivity to movements being imitated: Low Intensity Pleasure, Perceptual Sensitivity, Approach, and Soothability ($F(4,40) = 15.90, p < .0005$), together accounting for 61% of the variance in ratings.

The direction of the relationships between the 9 month IBQ-R subscale scores and parent ratings of sensitivity to being imitated at 9 and 12 months are as follows:

1. Infants who were rated as enjoying low stimulus intensity (Low Intensity Pleasure) were also rated as more sensitive to being imitated at 9 and 12 months.

2. Infants who were rated as enjoying high stimulus intensity (High Intensity Pleasure) were also rated as more sensitive to being imitated at 9 months.

3. Infants who were rated as being more sensitive to slight, low intensity stimuli from the environment (Perceptual Sensitivity) were rated as more sensitive to being imitated at 9 and 12 months.

4. Infants who were rated as more easily soothed (Soothability) were also rated as more sensitive to being imitated at 12 months.

5. Infants who were rated as more interested in approaching novel toys and environments (Approach) were rated as being less sensitive to being imitated at 12 months.

In summary, parent ratings of infant temperament at 9 months were related to some of the imitation measures. As at 4 months, different relationships were found for
full imitation versus approximations or parent report. Sensitivity to being imitated was related to similar temperament constructs at 9 months as at 4 months. Overall, more relationships emerged for 4 month than for 9 month IBQ-R parent ratings.

**Imitation and Play at 9 Months**

Maternal and infant measures were derived from the play session at 9 months. Maternal measures included verbal (e.g., calling infant’s name) and non-verbal behaviors (e.g., pointing at toy) and ratings of mothers’ following and scaffolding of their infants’ play. Infant measures during free play were time spent seated, number of toys played with, and ratings of infants’ enjoyment of the play session and level of engagement with their mother. One of the maternal measures, providing physical assistance, was not included in the analyses as it occurred infrequently during the play session.

A series of stepwise multiple regression analyses were performed to examine concurrent relationships between maternal and infant play behaviours at 9 months and imitation at 9 and 12 months.

**Prediction of imitation performance at 9 and 12 months**

Seven regression equations were calculated between the predictor 9 month play behaviors/ratings and measures of imitation performance at 9 and 12 months: (1) imitation task performance (0-9 all-or-none, 0-27 approximations), (2) spontaneous imitation during free play, and (3) parent report of imitation (starting to copy at 9 and 12 months and KIDS Advanced Imitation). Table 35 presents the t-values and beta weights for individual predictors in the following analyses.
Table 35

*Summary of Regression Analyses for 9-Month Play Measures Predicting Imitation Performance at 9 and 12 months*

<table>
<thead>
<tr>
<th>Imitation Performance Score</th>
<th>9-Month Play Model</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 Best All-or-None</td>
<td>Model 1: Number of times mother positions her infant</td>
<td>.33</td>
<td>.09</td>
<td>2.45**</td>
</tr>
<tr>
<td></td>
<td>Model 2: Number of times mother positions her infant</td>
<td>.29</td>
<td>.15</td>
<td>2.16*</td>
</tr>
<tr>
<td></td>
<td>Number of times mother creates an opportunity for her infant to imitate her</td>
<td>-.11</td>
<td></td>
<td>-2.07*</td>
</tr>
<tr>
<td>0-27 Best Approximations</td>
<td>Model 1: Number of times mother positions her infant</td>
<td>1.15</td>
<td>.10</td>
<td>2.63**</td>
</tr>
<tr>
<td>Spontaneous Imitation</td>
<td>Model 1: Rating of mother’s scaffolding of infant play</td>
<td>1.12</td>
<td>.13</td>
<td>3.12***</td>
</tr>
<tr>
<td>During Free Play</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Months Parent Report</td>
<td>Model 1: Number of mother’s sound effects and exclamations</td>
<td>-.006</td>
<td>.09</td>
<td>-2.37*</td>
</tr>
<tr>
<td>Starting to Copy</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KIDS Advanced</td>
<td>Model 1: Number of mother’s sound effects and exclamations</td>
<td>-.006</td>
<td>.09</td>
<td>-2.37*</td>
</tr>
<tr>
<td>12 Months Parent Report</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting to Copy</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.  *$p < .05$.  **$p < .01$.  ***$p < .001$.  

The number of times a mother positioned her infant during play, and created an opportunity for her infant to imitate her, emerged as significant predictors of 0-9 all-or-none imitation task performance ($F(2,62) = 5.29, p < .008$), accounting for 15% of the variance in imitation performance. The number of times a mother positioned her infant during play also predicted 0-27 approximations to imitation ($F(1,63) = 6.91, p < .01$: 10%
of variance accounted for). Infants of mothers who positioned them more often during play received higher imitation task scores, while infants of mothers who created more opportunities to imitate, received lower imitation scores.

Spontaneous imitation during free play was predicted by ratings of mothers’ scaffolding of their infants’ play \((F(5,58) = .73, p > .05; 13\% \text{ of variance accounted for})\). Infants of mothers who scaffolded their play more frequently imitated them more often during play.

In contrast to imitation task performance, parent ratings of infants starting to copy at 9 \((F(19,42) = .78, p > .05)\) and 12 months \((F(19,21) = .86, p > .05)\) were not predicted by play session measures. KIDS Advanced Imitation scores, however, were predicted by number of mothers’ sound effects and exclamations during play \((F(1,54) = 5.60, p < .02)\), which accounted for 9\% of the variance in KIDS scores.

Prediction of parent report of sensitivity to being imitated (at 9 and 12 months)

At 9 months, two predictors emerged for Noticing Sounds being imitated, which together accounted for 15\% of the variance in parent ratings (see Table 36). Infants whose mothers pointed to toys less and said “look” more during play were rated as being more likely to notice when their vocalizations are copied by others \((F(2,60) = 9.14, p < .0005)\). Number of times mothers made bids for joint engagement predicted infants’ sensitivity to having their movements copied \((F(1,61) = 4.46, p < .04)\), accounting for 7\% of the variance in parent ratings.
Table 36

Summary of Regression Analyses for 9-Month Play Scores Predicting Sensitivity to Being Imitated at 9 and 12 months

<table>
<thead>
<tr>
<th>Parent Report Score</th>
<th>Temperament Model</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Noticing Sounds</td>
<td>Model 1: Number of times mother points to toys during play</td>
<td>-.09</td>
<td>.12</td>
<td>-2.94***</td>
</tr>
<tr>
<td></td>
<td>Model 2: Number of times mother points to toys during play</td>
<td>-.11</td>
<td>.23</td>
<td>-3.64***</td>
</tr>
<tr>
<td></td>
<td>Number of times mother says “look” during play</td>
<td>.07</td>
<td></td>
<td>2.96***</td>
</tr>
<tr>
<td>9 Months Noticing Movements</td>
<td>Model 1: Number of mother’s bids for joint engagement during play</td>
<td>-.03</td>
<td>.07</td>
<td>-2.11*</td>
</tr>
<tr>
<td>12 Months Noticing Sounds</td>
<td>Model 1: Number of times mother says “look” during play</td>
<td>.05</td>
<td>.14</td>
<td>2.53**</td>
</tr>
<tr>
<td></td>
<td>Model 2: Number of times mother says “look” during play</td>
<td>.05</td>
<td>.24</td>
<td>2.68**</td>
</tr>
<tr>
<td></td>
<td>Time infant spends seated during play</td>
<td>.005</td>
<td></td>
<td>2.27*</td>
</tr>
<tr>
<td>12 Months Noticing Movements</td>
<td>Model 1: Number of mother’s spontaneous imitations during play</td>
<td>-.20</td>
<td>.13</td>
<td>-2.43*</td>
</tr>
</tbody>
</table>

Note. *$p < .05$. **$p < .01$. ***$p < .001$.

At 12 months, number of times mothers said “look” during play also predicted ratings of infants’ sensitivity to when their vocalizations are being copied, along with the amount of time infants spent seated during the play session ($F(2,38) = 6.14, p < .005$: 24% of variance accounted for). Infants of mothers who said “look” more, and who themselves spent more time seated during play, were rated as more likely to notice when their vocalizations are copied by others. The Number of times mothers spontaneously imitated their infants during play predicted sensitivity to movements being copied

199
\( F(1,39) = 5.91, p < .02 \) and accounted for 13\% of the variance in parent ratings. Infants of mothers who imitated them during free play were rated as less sensitive to having their actions copied.

Maternal play behaviours were related to infant imitation. Mothers of infants who received higher imitation task scores were more likely to position their infants during play and were less likely to create opportunities for their infants to imitate them.

Spontaneous imitation during free play was related to ratings of maternal scaffolding. A number of maternal play behaviours were related to parent ratings of sensitivity to being imitated at both 9 and 12 months (e.g., pointing at toys and saying “look”).

*Imitation and Visual-Spatial Attention at 9 Months*

VSAT latencies to shift and disengage at 9 months were entered into a series of step-wise multiple regression analyses examining relationships with imitation at 9 and 12 months. Findings from two sets of analyses (imitation production and sensitivity to being imitated) examining prediction of imitation will be presented.

*Prediction of imitation performance at 9 and 12 months*

Five regression equations were calculated between the 2 predictor visual-spatial attention (VSAT) variables and measures of imitation production (performance on the elicited imitation task, spontaneous imitation during free play, and parent report). No significant findings emerged from the analyses.

Neither VSAT measure predicted 0-9 imitation (overall best score) at 9 months \( F(2,59) = .01, p > .05 \) or 0-27 imitation (overall best score) \( F(2,59) = .22, p > .05 \). The same was true for spontaneous imitation during free play \( F(2,56) = .02, p > .05 \).
Parent report of starting to copy at 9 months was also not predicted by VSAT latency measures \( F(2,57) = .16, p > .05 \). Neither VSAT measure predicted KIDS Advanced Imitation scores at 9 months \( F(2,53) = .71, p > .05 \). At 12 months, parent report of starting to copy was also not predicted by VSAT latency scores \( F(2,36) = 2.11, p > .05 \), though the simple correlations for both latency to shift \( r(39) = -.24, p < .06 \) and disengage \( r(39) = -.24, p < .07 \) suggest a trend towards infants who took longer to shift and disengage at 9 months having been rated by their parents as copying less at 12 months.

**Prediction of parent report of sensitivity to being imitated at 9 and 12 months**

Four regression equations were calculated between the 9-month VSAT predictor variables and parent report measures of infant sensitivity to being imitated at 9 and 12 months. For each of the following analyses, see Table 37 for \( t \)-values and beta weights for individual predictors.

Table 37

*Summary of Regression Analyses for 9-Month VSAT Latency Scores Predicting Sensitivity to Being Imitated at 9 and 12 months*

<table>
<thead>
<tr>
<th>Parent Report Score</th>
<th>9-Month VSAT Model</th>
<th>( \beta )</th>
<th>( R^2 )</th>
<th>( T )</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Noticing Sounds</td>
<td>Model 1: Latency to shift attention</td>
<td>-.002</td>
<td>.07</td>
<td>-2.03*</td>
</tr>
<tr>
<td>9 Months Noticing Movements</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Months Noticing Sounds</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Months Noticing Movements</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. *\( p < .05 \).*
Neither latency measure predicted sensitivity to movements being imitated at 9 months \((F(2,58) = .47, p > .05)\), however latency to shift predicted sensitivity to vocalizations being copied \((F(1,59) = 4.12, p < .04)\), accounting for 7% of the variance in parent ratings. Infants who were quicker to shift attention at 9 months were rated by parents as more sensitive to having their vocalizations imitated. At 12 months, a similar lack of relationship was noted for sensitivity to movements being copied \((F(2,37) = .14, p > .05)\). Unlike at 9 months, latency measures did not predict sensitivity to vocalizations being copied \((F(2,38) = .97, p > .05)\).

**Imitation and Joint Attention at 9 Months**

A series of stepwise multiple regression analyses were performed to examine concurrent relationships between joint attention and imitation at 9 and 12 months. Seven regression equations were calculated between the 6 predictor joint attention variables from the gaze following task (0-4 gaze follow difference score, 0-4 locating target score, 0-4 checking back with experimenter score) and the object exploration task (number of looks to experimenter, number of looks to parent, number of show/give toy to experimenter or parent) and measures of imitation at 9 and 12 months.

**Prediction of imitation performance at 9 and 12 months**

No joint attention scores emerged as significant predictors of imitation task performance: 0-9 all-or-none \((F(6,50) = .50, p > .05)\); 0-27 approximations \((F(6,50) = .60, p > .05)\). Spontaneous imitation during free play was also not predicted by joint attention measures \((F(6,49) = .35, p > .05)\).

Similar to imitation task performance, joint attention scores also did not predict parent report of infant imitation abilities at 9 or 12 months: KIDS Advanced Imitation
(F(6,43) = .64, p > .05), Starting to Copy at 9 Months (F(6,47) = .35, p > .05), and
Starting to Copy at 12 Months (F(6,29) = .60, p > .05).

*Prediction of parent report of sensitivity to being imitated at 9 and 12 months*

At 9 months, no predictors emerged for Noticing Sounds being imitated (F(6,48)
= .37, p > .05), or Noticing Movements being copied (F(6,48) = 1.21, p > .05). Twelve-
month ratings of Noticing Sounds being copied were also not predicted by joint attention
scores (F(6,29) = 1.26, p > .05), nor were ratings of Noticing Movements being imitated
(F(6,29) = .27, p > .05).

*Imitation and VPIP at 9 Months*

VPIP measures at 9 months were entered into a series of step-wise multiple
regression analyses examining relationships with imitation at 9 and 12 months. The 6
VPIP measures included:

1. proportion of time spent viewing preferred display
2. z-score for proportion of time spent viewing the non-contingent display
3. proportion of time spent reaching/pointing while viewing the non-contingent
display
4. proportion of time spent rocking/leaning while viewing the non-contingent
display
5. rating of “testing” the displays
6. rating of interest in the displays

Findings from two sets of analyses (imitation production and sensitivity to being
imitated) examining prediction of imitation will be presented.
Prediction of imitation performance at 9 and 12 months

To correct for side bias, z-scores were used for all of the following analyses (see the 4 month VPIP results section for an explanation of these scores).

Seven regression equations were calculated between the predictor VPIP scores and measures of imitation performance at 9 and 12 months: (1) imitation task performance (0-9 all-or-none, 0-27 approximations), (2) spontaneous imitation during free play, and (3) parent report of imitation (starting to copy at 9 and 12 months and KIDS Advanced Imitation). Table 38 presents the t-values and beta weights for individual predictors in the following analyses.

Table 38

<table>
<thead>
<tr>
<th>Imitation Performance Score</th>
<th>VPIP Model</th>
<th>β</th>
<th>R²</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 Best All-or-None</td>
<td>Model 1: Proportion of Time Reaching/Pointing</td>
<td>1.40</td>
<td>.14</td>
<td>3.03**</td>
</tr>
<tr>
<td>0-27 Best Approximations</td>
<td>Model 1: Proportion of Time Reaching/Pointing</td>
<td>4.31</td>
<td>.13</td>
<td>2.91**</td>
</tr>
<tr>
<td>Spontaneous Imitation</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During Free Play</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Months Parent Report</td>
<td>Model 1: Proportion of Time Reaching/Pointing</td>
<td>.99</td>
<td>.08</td>
<td>2.17*</td>
</tr>
<tr>
<td>Starting to Copy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KIDS Advanced</td>
<td>Model 1: “Testing” the Displays</td>
<td>.43</td>
<td>.09</td>
<td>2.22*</td>
</tr>
<tr>
<td>12 Months Parent Report</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting to Copy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .005.
The proportion of time spent reaching/pointing emerged as a significant predictor of imitation task performance: 0-9 all-or-none \(F(1,57) = 8.44, p < .005\); 0-27 approximations \(F(1,57) = 9.18, p < .004\). Infants who reached/pointed more while viewing the non-contingent display received higher scores on the imitation task. In contrast to task performance, spontaneous imitation during free play was not predicted by VPIP scores \(F(6,50) = .70, p > .05\).

Parent report of infants starting to copy at 9 months was also predicted by VPIP scores. Proportion of time spent reaching/pointing predicted parent ratings for Starting to Copy at 9 months \(F(1,58) = 4.71, p < .03\) while KIDS Advanced Imitation was predicted by ratings of “testing” the displays \(F(1,53) = 4.93, p < .03\). At 12 months, Starting to Copy was not predicted by VPIP measures \(F(6,33) = .58, p > .05\).

**Prediction of parent report of sensitivity to being imitated at 9 and 12 months**

At 9 months, two predictors emerged for Noticing Movements being imitated (see Table 39). Infants with high ratings for interest in the displays and those who engaged in more reaching/pointing while viewing the non-contingent display were rated by parents as being more likely to notice when their movements were copied by others \(F(2,58) = 6.09, p < .004\). Though not included in the regression model, a significant simple correlation was also found between noticing movements and ratings of “testing” the displays \(r(61) = .30, p < .009\). Noticing Sounds being copied was not predicted by VPIP scores \(F(6,54) = .68, p > .05\).

Twelve-month ratings of sensitivity to being imitated were not predicted by VPIP scores: Noticing Movements \(F(6,34) = .72, p > .05\), Noticing Sounds \(F(6,34) = 1.29, p > .05\), though two significant simple correlations were found between Noticing Movements being copied and the z-score for proportion of time spent viewing the non-
contingent display \((r(41) = .26, p < .05)\), and the proportion of time spent viewing the preferred display \((r(41) = -.29, p < .03)\).

In summary, performance on VVIP measures was related to imitation performance. Infants who reached/pointed more while viewing the non-contingent display received higher imitation task scores and were rated by their parents as starting to copy more. Testing the displays was also related to KIDS Advanced Imitation ratings. As expected, sensitivity ratings for noticing movements were also associated with more reaching/pointing while viewing the non-contingent display.

Table 39

*Summary of Regression Analyses for 9-Month VVIP Variables Predicting Sensitivity to Being Imitated at 9 and 12 months*

<table>
<thead>
<tr>
<th>Parent Report Score</th>
<th>VVIP Model</th>
<th>(\beta)</th>
<th>(R^2)</th>
<th>(T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Months Noticing Sounds</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Months Noticing Movements</td>
<td>Model 1: Proportion of Time</td>
<td>.81</td>
<td>.09</td>
<td>2.47*</td>
</tr>
<tr>
<td></td>
<td>Reaching/Pointing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model 2: Proportion of Time</td>
<td>.83</td>
<td>.17</td>
<td>2.62**</td>
</tr>
<tr>
<td></td>
<td>Reaching/Pointing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interest in the Displays</td>
<td>.35</td>
<td></td>
<td>2.37*</td>
</tr>
</tbody>
</table>

12 Months Noticing Sounds    | N.S.                              |           |         |         |

12 Months Noticing Movements | N.S.                              |           |         |         |

*Note. *\(p < .05. **p < .01. *\)
Summary of Prediction and Concurrent Relationships Findings

In summary, scores on the IBQ were related to the most imitation measures at both 4 and 9 months (see Figure 23). Other 4-month measures that predicted imitation performance included the play session, visual propioceptive inter-modal processing, and visual-spatial attention, though these measures only predicted a single imitation score each, and were not related to task performance. Of the 9-month measures, maternal variables from the play session were also associated with a number of imitation scores, including parent report, spontaneous imitation, and task performance. Visual-proprioceptive inter-modal processing at 9 months was related to both task performance and parent report, and importantly was associated with parent report of infants’ sensitivity to their actions being imitated. Visual-spatial attention at 9 months was only related to one parent report score, noticing when sounds are being imitated. Of note, joint attention measures were not associated with a single imitation score.
Figure 23. Summary of 4-month predictors and concurrent relationships with 9-month imitation ability measures.
DISCUSSION

The results of this research extend our knowledge of imitation at the end of the first year and of the psychological processes that underlie infants’ ability to imitate at this age. While the study of neonatal matching and imitation in the second year of life has been of particular interest to investigators, little recent work has examined imitation in infants just before their first birthday. Given the body of research indicating that the 9-month period is a critical turning point in cognitive and social-cognitive development, the relative neglect of infants’ imitative abilities at this age is surprising. Developmental theories of imitation discuss processes argued to underlie infants’ ability to imitate and highlight the importance of early contingent social experiences. However, direct tests of these ideas have not been undertaken. A major goal of this investigation was to examine the prediction of imitation abilities at 9 months from performance on both social and non-social tasks at 4 months. The role of temperament as an individual difference variable was also explored, as were concurrent correlates of imitation at 9 months.

This discussion will be organized as follows: methodological considerations and limitations will be addressed first, followed by consideration of the findings from the imitation measures. Next, results of the analyses examining the predictor measures will be discussed briefly, independent of their relationships with imitation. Lastly, the focus of the discussion will shift to the main findings, from the analyses predicting imitation from the 4-month measures and exploration of concurrent relationships among the measures at 9 months. Directions for future research will be suggested throughout the discussion, and implications of the current research for the study of imitation in autism will be addressed.
Methodological Considerations and Limitations

Research on imitation within the first year has provided a description of age-related changes in imitative accuracy and an account of what actions infants are capable of imitating (e.g., gestures, actions on objects) at various ages. Though informative, these studies tell us little about the processes involved in imitation and what precursor skills and correlates contribute to imitative ability during infancy. Developmental theories of the mechanisms involved in imitation have been formulated but not tested. Careful examination of infant imitation studies also reveals a number of gaps in the description of matching behaviour and imitation from birth through the first year, particularly at transitional periods (e.g., 3-4 months, 6 months, 9 months). Little is known about relationships between early matching behaviour and imitation in the second half of the first year, and whether similar processes and developmental functions are involved. Few longitudinal data are available that address whether later forms of imitation develop continuously from early forms. By providing a first description of some of the processes that may contribute to imitation at 9 months, the current research contributes important information for refining approaches to the study of mechanisms of imitation during infancy.

Choice of Constructs and Tasks

As discussed above, no previous study has examined relationships between imitative skill and performance on measures that assess constructs considered important for imitation. As such, there are no established measures in the literature that have demonstrated relationships with imitation performance in infancy, thus posing a challenge for making evidence-based choices regarding constructs and tasks. In the
current study, we drew on theories in the typical developmental literature and findings related to imitation impairments in autism to make two measurement choices: (a) selection of constructs expected to be important for imitation development, and (b) selection of tasks to provide indices of those constructs. Design decisions and choices regarding constructs to measure were primarily theory-driven, within pragmatic constraints. An important factor in the choice of constructs to measure was our interest in examining relationships with both social and non-social processes. Examination of individual differences (temperament) enabled us to look at what infants themselves bring to an imitative situation. Review of both modern and classical theories of imitation highlighted constructs considered by most investigators to be critical to imitation development (e.g., visual-proprioceptive intermodal processing, detection of contingencies within dyadic social interactions). Other constructs were chosen based on recent ideas concerning the imitation deficit in autism (Barresi & Moore, 1996; Smith & Bryson, 1994), though some of these constructs do not figure prominently in most typical developmental theories (e.g., visual-spatial attention, but see Mataric, 2002). Further choices were made in order to explore possible variables associated with imitation that have not been the focus of much attention in the literature, including temperament. Although others may be deserving of future study, we focus on a broad set of constructs relevant to current theories of imitation in both typical and atypical development. Selection of tasks was based on a review of experimental approaches to our constructs of interest. Considerations included whether tasks have demonstrated sufficient variability in performance in infants at 4 and 9 months, and could be adapted to our laboratory.
Sample Size

The current study examined imitation abilities in the largest sample of 9-month-olds to date (N = 77). All efforts were made to be flexible and to accommodate the needs of the infants during testing sessions (e.g., providing breaks when necessary). Nonetheless, considerable demands were placed on infants to participate in five experimental tasks at 4 months and seven experimental tasks at 9 months. Therefore, the number of infants able to complete all of the tasks at either age (n’s ranged from ~45 to 93), and especially at both ages, was somewhat reduced. In the present study, analyses of prediction of imitative ability and concurrent relationships were conducted individually for each task. Measures from different tasks were not entered together into regression analyses as originally planned, as the ratio of cases to independent variables became too small.

Interpretation of Null Findings

Design of this study was such that we relied on relationships among measures being evident through observed correlations. Although literature review, pilot testing, and examination of the descriptive data ensured sufficient variability in performance on each of the tasks, not all expected relationships were observed. Perhaps in a typical developmental sample, despite individual differences, performance of all infants was above a critical threshold sufficient to support imitation. Variability for a group of infants whose scores fall below and above the threshold might be predictive of differences in imitative abilities.

For this reason, it is possible that relationships between imitative ability and the constructs measured in the current study might be more evident in an atypical sample.
For example, individual differences in imitation might be associated with level of impairment in disengaging attention in a group of children with autism, for whom both difficulties have been reported. While some investigations in autism have begun to look at relationships among such abilities, these have primarily focused on correlations between imitation performance and levels of language and play behaviours (e.g., Stone, Ousley, & Littleford, 1997). However, Rogers, Hepburn, Stackhouse, and Wehner (2003) recently examined correlations between oral-facial, manual, and object imitation in children with autism and scores for initiating joint attention and for executive function (indexed by a spatial reversal task). In contrast to the findings from the current study, initiating joint attention was related to scores for object and facial-oral imitation, suggesting that different relationships might be evident in an atypical sample. The need for parallel studies of prediction of imitative abilities in typical infants and children with autism was a major impetus for the present research.

Bates and colleagues (1979) wrote of the limitations of correlational methods and the challenge of interpreting lack of relationships among developmental variables. They assert that if a relationship is not observed, it cannot be concluded that the variables in question do not share a common structure. It may be that shared underlying mechanisms between domains contribute to individual variability at certain ages but not at others. Hence, relationships which were not observed in the current study may be observed in a group of infants older than 9 months.

The Descriptive Nature of the Current Study

The current research is largely a descriptive study of imitation and its correlates. Despite the inherent limitations of descriptive studies, the preceding literature review
strongly suggests the need for more such studies, especially using longitudinal designs. Little is currently known about predictors and correlates, about the relationship between earlier and later forms of imitation, and whether mechanisms underlying imitation at one age are similar to those that contribute to imitation at another age. Descriptive studies provide important information for refining approaches and posing questions that can be addressed in more experimental designs to study imitation in this age range. Findings from the current study raise numerous questions about imitation during the first year and the processes involved that we hope will launch more hypothesis-driven studies.

*Imitation at the End of the First Year*

*The “Picture” of Imitation at the End of the First Year*

The current study is the first to provide a comprehensive description of imitation in a large sample of 9-month-olds. Three different approaches to measuring imitation enabled exploration of different aspects of imitative abilities at this age. Performance on an *elicited imitation task* permitted examination of imitation of different actions (gestures, vocalizations, and actions on objects), infants’ readiness to imitate, and imitation with different models (experimenter and parent). Our comprehensive approach to scoring infants’ performance on the imitation task involved capturing approximations to imitation, in addition to all-or-none performance. This method contributes to a fuller understanding of individual differences and precursor behaviours that may occur during an imitative context before an infant is able to fully imitate an action. *Parent report* of infants’ imitation abilities provided an opportunity to assess parents’ perceptions of their infants’ imitation abilities as seen outside the laboratory, and also to explore the relationship between infants’ awareness of being imitated and actual imitation skill. The
free play *spontaneous imitation* measure was expected to capture infant imitative behaviour with the parent during a situation that more closely resembled day-to-day imitative contexts.

In the following sections, findings from the imitation measures will be discussed, first independently for each measure and then together within the context of understanding relationships among imitative behaviours in different situations and between imitation skill and sensitivity to being imitated.

*Elicited imitation.*

The pattern of results observed for the elicited imitation task was consistent with previous literature describing imitation abilities in infants at 9 months of age. As found in previous investigations examining rates of imitation across different actions (Abravanel et al., 1976; McCall et al., 1977; Rodgon & Kurdek, 1977, Masur & Ritz, 1984), infants in the current study imitated actions on objects most readily, followed by vocalizations and gestures. Also consistent with previous research, infants’ performance improved across trials. Post-hoc analysis revealed a significant difference in scores across trials for “mama/dada” \( F(2,45) = 8.17, p < .001 \) and a trend towards a difference across trials for “clapping” \( F(2,45) = 2.69, p < .07 \). Mean scores for these two actions were significantly higher on trial 3. These findings differ from those of McCabe and Uzgiris (1983) who found no difference in imitation scores between actions modeled by a female experimenter and those modeled by an infant’s mother. Two possible explanations for the improved performance on trial 3 are that they had previous exposure to the actions during trials 1 and 2, or that the social-communicative history they have with their mothers influenced imitation of two actions one might expect would be most familiar in mother-infant routines. In either case, our findings suggest that a single trial for an action
underestimates infants’ imitation abilities, as does a design in which interaction with an experimenter is the only opportunity for infants to demonstrate their skills.

*Approximations to imitation.*

A unique contribution of the present research is the dual approach taken to scoring infants’ imitative skills. Though it is known that infants’ reproductions of a model’s demonstrations become more accurate over time and that infants “correct” imitative responses (Meltzoff & Moore, 1994, 1997; Uzgiris, 1972), little attention has been paid to approximations to imitation in the experimental literature (Kaye & Marcus, 1978, 1981). Kaye and Marcus conducted the only investigations of partial imitations for which an explicit coding system was designed to capture such differences in infants’ behaviour. Sample sizes for their studies were small: 34 infants seen at 6 months (1978), and 9 infants seen longitudinally from 6 to 12 months (1981). In the current study, approximations to imitation were coded for a large sample of 77 infants at 9 months, providing the first rich description of partial imitative behaviour at this age.

Our findings indicate that there is marked regularity in the behaviours that precede accurate action-copying in 9-month-olds, beginning with attempts directed to the model’s body, and in particular, towards effectors of the modeled actions (e.g., hands during clapping, mouth during “mama”/”dada” or kissing). Infants also engaged in relevant responses directed elsewhere (e.g., hitting the table repeatedly when the experimenter clapped). Though Piaget (1962) described instances of such early attempts to imitate that involved comparable responses with different body parts (e.g., opening and closing hands in response to a model’s eye blinks) in a single infant (J), ours is the first study to document this behaviour in a sample of infants.
These data provide support for Kaye and Marcus' (1981) original categories of partial imitative behaviours, and add to our understanding of the development of imitation in the second half of the first year. Imprecise responses related to the modeled action (e.g., touching hands together lightly after the experimenter models clapping) fit within a Piagetian sequence of accommodations (Piaget, 1964). Other precursor behaviours, such as directing an action towards the model, may be attempts to recreate an interesting event and may occur developmentally before infants are able to translate actions of others into actions of self. Infants may also be responding to the reciprocal social nature of the interaction. Imitation of a partner is a socially engaging activity, particularly during a play context. Data with young infants indicate that they are highly sensitive to turn-taking inherent in dyadic play (Brazelton, Koslowski & Main, 1974; Stern, 1985). Infants who were unable to imitate an action were nevertheless frequently observed to respond in a relevant manner following the experimenter’s demonstration (e.g., banging the table after the experimenter tapped her cheek). This is consistent with an interpretation of infants’ behaviour as being prompted by their understanding of the turn-taking nature of the “imitative game”: you do something, then I do something.

Infants’ earliest pre-imitative behaviours may reflect interest in the actions of their social partners, and a desire for the interesting actions to continue. This hypothesis is supported to some extent by our finding that “imitative state”—our rating of interest/engagement in the elicited imitation task—was significantly correlated with performance. Later pre-imitative behaviours may be indicative of infants’ emerging understanding that they are taking part in a back-and-forth interaction and that there is an expectation for them to respond in turn. Though not yet able to imitate, infants who
engage in such pre-imitative behaviours are perhaps in a state of “readiness”: interest in
the actions of a social partner and understanding of reciprocal behavioural exchanges set
the stage for imitation to follow, which proceeds from imperfect, partial imitations to the
ability to make correct matches. Kaye and Marcus’ (1978, 1981) findings indicate that
infants “work up” to closer approximations of a modeled action, yet do not address issues
related to readiness to imitate and how infants make the transition from an initial state of
interest in an imitative exchange to being responsive themselves. Data from the current
study document that, prior to being able to imitate, infants become engaged in imitative
interactions in a number of ways. Whether these pre-imitative behaviours reliably occur
on an individual basis before infants begin to imitate is not known and is deserving of
further study.

Spontaneous imitation

Most of the literature on imitation in infancy is based on performance during
laboratory tasks. While informative, it is not known whether these findings generalize
outside the experimental context. Imitative behaviour during contrived situations in
which infants’ imitative behaviours are delivered on command may not tell us much
about what infants do during naturally occurring imitative interactions at home. The
current findings that infants at 9 months are beginning to imitate social partners are
consistent with the few studies that have examined spontaneous imitation at this age
(Pawlby, 1977; Power & Parke, 1982). Pawlby (1977) reported that only 21% of
imitations during mother-infant interaction are of the mother initiate – infant imitate type
of sequence. These data were for 8 mother-infant pairs seen longitudinally from 4 to 11
months, and were collapsed across age. It is not known what the percentage of infant
IMITATIONS was for infants at 9 months. In the current study, there was considerable
variability in the frequencies of imitative responses; over one-third of the infants did not imitate a single action by their mother, while another third imitated one or two actions. The data suggest that 9 months may be an important transition period in mother-infant play, with infants beginning to imitate their social partner more frequently.

**Parent report of imitation: Performance and perception**

In this section, findings from the parent report measure of imitation are discussed. In particular, we address the validity of the parent questionnaire as a measure of infants’ imitation skills, and discuss parent ratings of imitative skill and sensitivity to being imitated.

Parent report provided measures of both imitative skill and sensitivity to being imitated. It is important to note that the parent report ratings of sensitivity discussed here and in subsequent sections probably measure infant’s general sensitivity to temporal contingencies in social interactions, rather than specific sensitivity to the spatial similarities between their actions and those of adults. Qualitative examples provided by parents as to how they judge that their infant has noticed they have been imitated support this hypothesis. While the infants at 9 months reportedly smiled, stopped their behaviour, and looked at their parents when being imitated, parents did not provide examples of the sorts of behaviours that Meltzoff (1990) observed in older infants such as changing the tempo of their action or altering the action while looking at the adult. It has been proposed that these actions test the spatial parameters of the interaction and indicate a more specific awareness of being imitated (Meltzoff, 1990; Nadel, 2002).

Within the area of infant developmental psychology, parent-based measures of temperament and language are common. However, outside of the context of standardized early language and communication assessments (e.g., the MacArthur Communicative
Development Inventory), there are no parent report measures specifically designed to assess infants’ emerging imitation abilities. Samples of infants’ behaviour obtained during laboratory studies provide important information about developmental skills but may not represent typical or reliable behaviour (Bodnarchuk & Eaton, 2004; Epstein, 1979, 1980), or, perhaps, emerging skills. Parents have a wealth of knowledge about their infant’s development on a day-to-day basis, and may contribute insight into particular aspects of their infant’s behaviour that cannot be captured in a laboratory context. Complementary data from parent measures may be useful during investigations of imitation in infancy, provided it can be determined that parents are able to report accurately regarding their infant’s imitative skills.

The validity of parental reports of their child’s behaviours and abilities has been addressed in both the clinical and developmental literature. Parent ratings are frequently used to assess children’s psychosocial adjustment, and a solid body of research demonstrates their validity and diagnostic utility (e.g., Achenbach, McConaughy, & Howell, 1987). Less work has examined the accuracy of parent reports of young children’s cognitive abilities. Recent research supports parents’ ratings of some aspects of their children’s skills such as general cognitive ability and fluid reasoning (Oliver, Dale, Saudino, Petrill, Pike, & Plomin, 2002; Saudino et al., 1998; Waschbusch, Daleiden, & Drabman, 2000). Critics of parent measures have argued that parents cannot be objective observers of their infant’s behaviour (Wallace, Franklin, & Keegan, 1994, cited in Bodnarchuk & Eaton, 2004). Reznick and Schwartz (2001), however, found that inconsistencies and inaccuracies are less likely to occur when parents are asked simply to report on behaviours that are observable, familiar, and salient (e.g., words, gestures),
rather than to interpret their infant's behaviour (e.g., judge intentionality). In the current study, we were interested in convergent evidence that could provide support for the validity of our parent report measure: (a) sufficient variability in ratings, (b) findings consistent with the literature, and (c) relationships with parent report from standardized questionnaires.

A number of expected findings emerged from the parent questionnaire. Descriptive data indicated that parent ratings demonstrated sufficient variability and captured individual differences in infants' imitative skills. Ratings for recognition of imitation at 9 and 12 months were higher than ratings for imitation performance, which is consistent with the literature demonstrating that infants are sensitive to the contingencies inherent in being imitated from an early age yet do not themselves begin to imitate until the second half of the first year. Parent report was also sensitive to developmental change. As anticipated, ratings for all three questions were significantly higher at 12 months than at 9 months, and average ratings of delayed imitation at 12 months were significantly lower than ratings for immediate imitation. Parents also rated their infants as being more aware of imitation of their vocalizations, versus movements. This is also consistent with findings that indicate that infants are more attentive to actions involving sounds within an imitative context (Abravanel et al., 1976). We see that, in addition to demonstrating sufficient variability, our parent report findings are consistent with existing literature.

Further to the aim of validating our parent report questionnaire, we examined relationships between imitation scores on the KIDS, the MacArthur, and parent ratings on our questionnaire. We expected to find a relationship between the 9-month rating of
starting to imitate and the simple KIDS score (imitation of simple familiar actions and sounds), whereas associations were not expected with the complex KIDS score (deferred imitation, imitation of words) or the MacArthur. Consistent with these hypotheses, parent ratings for starting to imitate at 9 months were moderately associated with KIDS simple, but not complex imitation, nor the MacArthur score. Also as expected, given that the items on the KIDS complex imitation scale and the MacArthur capture more sophisticated imitation, ratings of imitation performance at 12 months were related to the KIDS complex imitation score, and the rating for delayed imitation was associated with the MacArthur imitation score. Thus, our parent report correlates with standardized questionnaires, and so all three of our parent report validity criteria are satisfied. Though the differential pattern of correlations rules out a simplistic shared methods variance explanation of the findings, consideration of shared method variance through maternal report is important.

*Relationships between the imitation measures.*

Three issues are relevant to the discussion of relationships among the imitation measures in the current study. The first addresses the relationship between imitative ability and sensitivity to being imitated. The second concerns the importance of taking a broad approach to the study of imitation during infancy. Third, findings from the 9-month measures and parent report at 12 months also permitted an examination of the continuity of imitation abilities at the end of the first year.

*Associations between performance and perception.*

The current findings suggest that the ability to imitate during infancy is related to sensitivity to being imitated. Relationships were found across parent ratings at 9 months
and, importantly, between parent report and performance on the imitation task. These data provide preliminary evidence that imitation perception and performance share some of the same underlying mechanisms, of which the most likely candidate process is the ability to detect correspondences between actions seen in others and self-produced movements. In addition to simply establishing a relationship, our parent report data indicate that the developmental emergence of sensitivity to being imitated precedes the development of imitative skill. Infants receiving low skill ratings achieved a wide range of recognition scores, whereas high skill ratings were in all cases associated with high recognition scores. In particular, of the 30 infants rated at least 3 out of 4 for noticing movements being imitated, all but one were also rated at least 3 out of 4 for imitation ability. Longitudinal data regarding infants’ responses to being imitated and imitative abilities are needed to more fully address the developmental inter-relationship of these two aspects of imitation.

The developmental course of the transition from being sensitive to temporal contingencies in social interactions to being able to detect imitation in a social partner is also not known and will be important to delineate in future investigations. Nine months may be a transition period between responding primarily to temporal contingencies and being able to recognize structural similarities between self-produced and others’ movements.

In the current study different relationships emerged between imitation skill and infants’ sensitivity to when their sounds and their actions were copied by others (indicating stronger relationships with actions). To date, no studies have looked at whether infants “test” adults’ imitations of their vocalizations. It is not known whether
different processes underlie infants’ perceptions of when their vocalizations, actions, and facial expressions are imitated and how differences might translate into behavioural responses to being imitated. A comprehensive approach to studying imitation perception and performance would need to include demonstrations of a variety of actions, and measures of infants’ sensitivity to having these actions copied by the experimenter (or parent). Studies that look explicitly at the factors known to be relevant to imitative abilities during infancy (e.g., visible and non-visible actions, gestures and actions with objects, novelty, familiarity, and meaningfulness) will be critical in determining the specificity of relationships between imitation perception and performance.

*Imitative skill in different contexts.*

We examined relationships between the three different measures of imitative ability at 9 months. Parent report for starting to imitate was not related to spontaneous imitation of the parent during free play, and was only weakly associated with performance on the first trial of the imitation task. As expected, spontaneous imitation during free play was related to infants’ score on trial 3 (the parent-led trial) during the elicited imitation task. The data indicate that infants who are good imitators in one context are not necessarily the same infants who are skilled in other contexts. Findings from the cluster analysis suggest that there may be patterns of imitation performance across situations. Two groups distinguished themselves from infants who generally received lower scores across all measures: one small group of infants appeared to receive higher imitation scores during free play and on the parent rating, while a larger group performed better on the imitation task. It was thought that developmental skills, communicative development, or temperament might distinguish the three groups; however, no differences were noted.
Longitudinal Relationships.

Parent report of imitation abilities was also measured at 12 months, thus providing data addressing the issue of continuity of imitation skills throughout the first year. Parent ratings demonstrated longitudinal relationships; parent report of starting to imitate at 9 months was related to ratings on the same question at 12 months and ratings for the emergence of delayed imitation. The simple and complex KIDS scores at 9 months were also associated with parent report of immediate and delayed imitation at 12 months. Relationships were also noted between full imitation scores on the elicited imitation task at 9 months and parent ratings for immediate imitation at 12 months. Spontaneous imitation, however, was not associated with parent report of either immediate or delayed imitation at 12 months.

Although based solely on relationships with parent report, these findings provide some support for the continuity of imitative abilities at the end of the first year. Only one other study has examined relationships between imitative skills in first year. Heimann and Ullstadius (1999) reported that, in their longitudinal study, individual differences in imitative ability at 12 months were related to those at 3 months. Longitudinal studies of imitation in infants from the neonatal period into the second year are necessary to answer questions about the nature of early and later forms of imitation, and whether similar or different processes underlie the ability to imitate at various ages (cf. Gattis & Perra, 2004).

Variability in Imitative Skill at 9 Months

This study provides a rich description of individual differences in imitative behaviour at 9 months. As discussed above, variability across infants, and within
individuals, was reflected differently in the various measures of imitation. Not all infants demonstrated imitation on the laboratory task, or spontaneously imitated their mother during play, while other infants imitated quite readily in all contexts. With the exception of work in the area of motor development (e.g., Adolph, 1997), little attention has been paid to such variability in the infant developmental literature. In a recent special issue on variability in the journal *Infant Behavior and Development*, Siegler (2002) argued that the emphasis on the "age of emergence" of developmental skills has created a narrowly focused approach to research, resulting in little understanding of the psychological mechanisms underlying emerging competencies during the infancy period. Origins of individual differences are not often explored, nor have intra-individual differences.

Most developmental studies of imitation aim to determine that age at which infants are capable of imitating particular types of actions. In this context, individual differences between infants at a particular age are of little interest and can be problematic given that they increase within-group variability. What few studies have addressed individual differences in levels of imitation note these merely as interesting observations. We adopt a different focus, in which understanding contributions to variability in imitative skills of same-aged infants, including both early and concurrent influences, is critical. Investigations have begun to examine correlates of imitation. However, in these studies 9 months is commonly the youngest age (Carpenter, Nagell, & Tomasello, 1998; Slaughter & McConnell, 2003). More work that is directed toward individual differences and associated mechanisms in imitative skills within the first year might contribute to a greater understanding of psychopathology as well as normal development.
Measurement Issues in the Study of Infant Imitation

Measurement issues are seldom addressed in the literature on imitation development, and yet are critical (cf. Smith, Nichols, & Lowe-Pearce, in press). The current study explored a number of these issues, to be discussed here in brief.

A major implication of this study is that performance on imitation tasks depends heavily on what infants themselves bring to the interaction. As will be discussed in sections that follow, temperament is related to imitation in a variety of contexts and may affect infants' propensity to demonstrate their skills, or may influence how readily infants acquire imitative ability. Consideration of infant attentiveness and their engagement in the task is important in order to maximize the chance that an infant will imitate, given that they have the capacity to do so.

How actions are modeled is also an important issue. Using bursts rather than a single demonstration of an action increases its salience, attracts attention, and provides the infant with multiple opportunities to perceive the action. Kaye and Marcus (1978, 1981) demonstrated that infants "work up" to more precise imitations over trials. Ensuring that infants have more than one opportunity to imitate a particular action is critical. These kinds of designs are also essential in testing hypotheses regarding the nature of imitation development.

"Imitation on demand" is a defining feature of most laboratory imitation studies. In Kaye and Marcus' (1978) paradigm, however, the experimenter responded to infants' behaviour indicating that they were ready for the next trial (e.g., re-establishing eye contact), thus allowing the infant to control the presentation of the demonstrated actions. The study of spontaneous imitation during free play is another example in which there are reduced demands on infants to perform. As the findings from the current study suggest,
information about different aspects of infant imitation is likely to be acquired when skills are measured in an elicited context versus in a more naturalistic, infant-led situation.

Scoring of infants’ responses to a demonstrated action is critical, and yet few studies have moved beyond the traditional all-or-none approach. Kaye and Marcus demonstrated in the late 70s and early 80s the importance of taking a more fine-grained approach to scoring imitative responses, and yet the current study is the first since then to follow their suggestions. The study of infants’ pre-imitative responses and partial imitations provides valuable information about individual differences and if investigated systematically, may illuminate developmental changes in the ability to imitate during infancy. The current study also suggests the value of more investigation of infant imitation across contexts, especially in more naturalistic conditions, and of parent report as a complement to direct observational measures.

Validation of 4 and 9 Month Measures

In the following section, we discuss findings pertaining to the predictor and correlate measures, independent of their relationships with imitation, the purpose being to support the validity of our battery.

Temperament: IBQ-R (4 and 9 months)

Our data on the Revised Infant Behavior Questionnaire replicate those of Gartstein and Rothbart’s (2003). Longitudinal age effects for the 14 subscales and for the 3 broad temperament factors mapped exactly onto those of the previous research. One of three sex effects noted by Gartstein and Rothbart (higher scores for males on High Intensity Pleasure) was replicated. Findings of concurrent and longitudinal relationships in the present study are also similar to those reported by Gartstein and Rothbart (2003).
Visual-Spatial Attention Task (4 and 9 months)

Data from the visual-spatial attention task extend the longitudinal findings of McConnell and Bryson (2004) regarding the development of disengage and shift mechanisms in infants within the first year. In their study, latencies to shift and disengage decreased between 4 and 6 months and at both ages, infants were quicker to shift than disengage. Latencies to shift and disengage also decreased significantly from 4 to 9 months in the current study, with a stronger age effect noted for shift trials.

Visual-Proprioceptive Intermodal Perception (4 and 9 months)

4-month VPIP findings.

Bahrick and Watson’s (1985) original study of visual-proprioceptive intermodal processing in infancy was conducted with 3- and 5-month-old infants, and demonstrated that by 5 months, infants demonstrate a preference for imperfect contingencies. Little is known about the transition period in infants’ emerging preferences for temporally non-contingent stimuli. The current findings regarding infants’ abilities on the same task at 4 months address the question of whether preference for viewing non-contingent stimuli is in transition at this age. Looking times by the 4-month-olds more closely resembled those of the 3-month-olds in Bahrick and Watson’s study; there was no difference between times spent viewing the contingent and the non-contingent display. Other data, including attention to the displays, time spent viewing the preferred display, and gaze switches were comparable to those reported by Bahrick and Watson.

No previous studies of visual-proprioceptive intermodal perception in infancy have investigated behavioural measures other than looking times. In addition, the current study also examined whether infants engaged in active exploration of the displays. One-
third of the infants demonstrated exploratory behaviours consistent with a strategy of “testing” what was happening on the screens (sequences of looking intently, kicking rapidly, pausing, looking intently). Importantly, ratings of testing were strongly associated with time infants spent viewing the non-contingent display. Testing might reflect infants’ awareness that their behaviour is somehow related to what they see on the displays. In Rochat and Striano’s (1999) theory of social-cognitive development within the first year, infants at approximately 2 months begin to take a “contemplative stance” and systematically explore the effects of their actions. Infants in the current study may have developed an expectation regarding the non-contingent display based on the temporal match that they experienced while viewing the contingent display. Testing behaviour may indicate infants’ active exploration of whether the non-contingent display would “respond” in the same manner as the contingent display.

Bahrick and Watson’s (1985) interpretation of their findings was that the imperfect contingencies inherent in the non-contingent display may specify “other” (vs. “self”), and that infants’ preference for viewing non-contingent displays reflects their developing social orientation. Rochat (1999) has presented a similar argument regarding infants’ developing social-cognitive abilities. An alternative explanation, however, is that the 5-month-olds’ preferential looking towards the non-contingent display may merely reflected their interest in information that is not redundant across sources of information (as in the contingent display). This suggests that young infants’ behaviour in a visual-proprioceptive intermodal processing task does not reflect emerging social awareness. If Bahrick and Watson’s and Rochat’s theory regarding infants’ preferences were correct,
we would expect to see clear evidence of a shift towards preference for the non-contingent visual feedback from 4 to 9 months in our sample of infants.

7-month VPIP findings.

At 9 months, a visual-preference paradigm was used in which infants viewed on-line (i.e., contingent) and non-contingent displays of their own faces. In contrast to their performance when they were younger, infants as a group spent more time viewing the contingent display. Also unlike at 4 months, testing was not associated with preference for viewing either display. Other specific behavioural measures were, however, related to time spent viewing the contingent display. Infants were more emotionally expressive (both positive and negative) when viewing the on-line display. They also engaged in more rocking and leaning behaviour, and marginally more reaching and pointing toward the contingent display. These behaviours are similar to those reported in studies of infant interactions with mirrors (e.g., Amsterdam, 1972). This finding stands in direct contrast to that at 4 months when infants engaged in more active exploration when viewing the non-contingent display.

According to Bahrick and Watson’s (1985) and Rochat’s (1999) proposals, infants older than 5 months should prefer non-contingent visual feedback. The current data indicate that 9-month-old infants do not demonstrate this preference, nor do they engage in more active exploration of the non-contingent display, as they did at 4 months. In the only other study to examine 4- and 9-month-olds’ looking towards on-line and non-contingent displays of their own images, Rochat and Striano (2002) examined infants’ looking times in 4 conditions: self contingent (online), self delayed contingency, other contingent (online), other delayed contingent. Across age (between subjects), condition (between subjects, self or other) and episode (within-subjects, still-face and
normal interaction), infants spent more time looking at the on-line contingent display, as was found in the current study. However, Rochat and Striano did not examine differences at either age between time spent viewing the on-line and delayed images of self.

Few studies have examined visual-proprioceptive intermodal processing in infancy. Those that have demonstrate that by approximately 5 months infants can discriminate differences in temporal contingencies, spatial calibration, and presence or absence of eye contact. Little is known, however, about the nature of infants’ preferences for types of feedback, and how infants explore and respond to contingent and non-contingent visual displays. More work is needed to understand both cognitive and social processes underlying infants’ behaviour during visual-proprioceptive intermodal processing tasks. At both 4 and 9 months, the current findings complement previous work on visual-proprioceptive intermodal processing and support the validity of the measures used in our study.

Mother-Infant Play (4 and 9 months)

4-month play session findings.

The literature indicates that mothers differ in their level of contingent responding to their infant’s behaviour during early dyadic interactions, and that these individual differences are stable within pairs (Bigelow, 1998; Legerstee & Varghese, 2001; Nadel, 2000; Stern et al., 1985). Data from the current study support previous research: 3 mothers did not imitate their infants’ behaviour at all during the imitation segment despite explicit instructions to do so, and of those who did, there was considerable variability in accuracy across mothers. Ratings were highest for copying infants’ vocalizations, which is consistent with Pawlby’s (1977) work on naturally occurring
mother-infant imitation sequences. Of the total instances of mothers copying their infants in Pawlby’s study, over half were imitations of speech sounds while only 18% were imitations of manual gestures or facial expressions (the remaining 30% were imitations of object-directed actions or non-speech sounds). The current data were inconsistent with Pawlby’s findings, however, with respect to frequency of maternal imitations of infant behaviour. During free play segment, mothers in the current study more frequently copied their infants’ facial expressions than vocalizations or actions. A possible explanation for this finding is that the play session occurred near the end of the overall laboratory session, and mothers may have been attempting to respond to and regulate their infants’ emotional state.

Quality of mothers’ responding is reflected in infants’ early emotional, social, and self development (see Introduction). Few studies have examined direct effects on infants’ behaviour of levels of maternal contingent responsiveness. Watson (1985) suggested that infants who experience different degrees of contingency in their early interactions would orient more towards adults who demonstrate similar levels of contingency. Testing this hypothesis, Bigelow (1998) found that 4- and 5-month-old infants were more responsive to an experimenter whose degree of contingent responsiveness was similar to that of their mother. They further demonstrated that infants at this age maintain their preferences up to a week after an initial social encounter (Bigelow & Birch, 2000). These findings indicate that individual differences in infants’ responsiveness to social contingencies in interactions are in part a function of variability in their mothers’ behaviour.

Legerstee and Varghese (2001) also found that 3-month-old infants of mothers who were ranked as “high” on social affect mirroring (attention maintenance, warm
sensitivity, and social responsiveness) responded in turn with more smiling, cooing, and gazing than infants of mothers ranked "low". These infants also demonstrated a greater ability to discriminate between live and replay videos of their mothers, and demonstrated social expectancies as evidenced by reduced smiling, gazing, and vocalizing during the replay condition.

The present study provides further evidence of the effect of individual differences in mothers’ contingent responding on infants’ behaviour. Mothers’ ability to imitate their infant’s facial expressions and actions predicted time infants spent watching their mother’s face and actions, and ratings of infants’ engagement. When mothers were classified as “high” (HMI) and “low” maternal imitators (LMI), further differences emerged. The behaviour of infants of HMI mothers changed very little from play to imitation, while infants of LMI mothers became less engaged, moved more, and vocalized more during the imitation than the play phase. These findings may be interpreted within the context of the infants’ “state”. The play episode occurred near the end of the experimental session and infants were likely tired at this time. Change in behaviour of infants of LMI mothers may have reflected increased fussiness and less interest, whereas the contingent imitative responding of HMI mothers likely maintained their infants’ interest and engagement in the interaction.

One fourth of the infants “tested” the imitative behaviour of their mothers (pause, look, repeat action). While we do not interpret these infants’ behaviour as evidence that they are aware of the spatial similarities between their actions and those of their mothers (cf. Meltzoff, 1990), testing is considered a strong demonstration of awareness of the contingencies inherent in the interaction. It is noteworthy that mothers of infants who
tested were more likely to be classified as skilled imitators. These data provide further support for the effect of maternal behaviour on infants’ ability to detect and respond to contingencies in social interactions.

9-month play session findings.

With the exception of infants’ spontaneous imitations and activity level, the focus of the 9-month play session was on maternal behaviours. Relationships between infant and maternal imitation will be discussed in the upcoming section on prediction of imitation.

Mothers engaged in both physical and verbal behaviours to direct their infants’ attention and to respond to infants’ actions with the toys. Expected and logical relationships emerged between mothers’ play behaviours, and between maternal and infant behaviours during exploratory bouts with the toys (e.g., mothers made more bids for joint engagement to infants who changed position frequently). As reported in other descriptive studies of mother-infant play at the end of the first year, mothers named and described toys, presented them to their infants, demonstrated how they worked, and commented on their infants’ play (Power & Parke, 1982). Maternal sensitivity during play was assessed by ratings of following (following infant’s lead rather than directing the play) and scaffolding (supporting and structuring infants’ self-initiated play behaviours). Infants of mothers who received higher ratings for scaffolding were themselves rated as enjoying the interaction more, and as being more engaged.

Mothers also engaged in two behaviours specific to imitation: spontaneous imitation of their infant, and creation of opportunities for their infant to imitate them. Over half of the mothers did not imitate their infant during play; more often, they set up imitation opportunities. Flynn, Masur, and Eichorst (2004) conducted a longitudinal
study of opportunities provided by mothers for their infants to imitate from 10-21 months of age. Using a broad definition of "opportunity" to mean object-directed action that was not unintentional (e.g., fumble) or static (e.g., holding), Flynn and colleagues demonstrated that mothers differ in their rates of providing opportunities for imitation during free play with their infant, similar to what was found in the current study.

Overall, as with the 4-month play sessions, considerable individual differences were noted in mothers’ play behaviours. Relationships between rates of these behaviours and infants’ imitative abilities will be discussed in the section examining prediction of imitation. Data from the current study support previous findings in the literature on mother-infant play behaviours and thus validate the use of our play measures in our battery.

Initiating and Responding to Joint Attention (9 months)

Considerable research conducted on infants’ joint attention abilities within the first two years has documented the age at which infants follow another’s gaze to targets at various locations in the environment (e.g., within or outside the infant’s visual field) and initiate triadic interactions with objects themselves (e.g., looking at a social partner while holding an object, showing/giving an object). It is generally accepted that while infants may follow gaze by 4 months when the target is in the visual field (D’Entremont, Hains, & Muir, 1997), following gaze to targets outside the visual field emerges in the second half of the first year, with reliable and consistent demonstrations evident between 10 and 12 months (Corkum & Moore, 1998; Moore & Corkum, 1998; Morales, Mundy, & Rojas, 1998).
In the current study, responding to and initiating joint attention were measured via a standard gaze following task and an object exploration task. Using a difference score method, approximately 20% of infants did not follow the experimenter’s gaze on any of the 4 trials. Another third of infants followed gaze on 1 or 2 trials, while approximately 40% followed the experimenter’s gaze on at least 3 trials. Similar findings were noted for locating the target and checking back with the experimenter. Not all infants who followed the experimenter’s gaze were able to locate the target, and of those who did, not all looked back at the experimenter. These findings are consistent with other studies reporting individual differences in joint attention behaviours during the second half of the first year and in the second year (e.g., Mundy & Gomes, 1998; Vaughan et al., 2003), with 9-month-olds demonstrating a wide range of joint attention skills. We also observed relationships between responding to joint attention (gaze following and locating the target) and initiating joint attention (giving/showing during object exploration). Vaughan and colleagues (2003), however, reported no relationship between initiating and responding to joint attention as measured in the context of a structured interaction. They interpreted their null findings as evidence that responding and initiating to joint attention demonstrate somewhat distinct processes. It is also possible that particular measures subsumed under the conceptual categories of “responding” and “initiating” may reflect different aspects of the overall skill. For example, in the current study, a stronger relationship was found between locating the target and showing objects than for gaze following, though both scores measure aspects of responding to joint attention. Further studies are needed that examine relationships between specific measures of initiating and responding to joint attention rather than aggregate scores.
Prediction of Imitation and Correlates at 9 Months

In the following sections, findings related to the prediction of imitation abilities and to its correlates will be discussed. Non-social mechanisms are addressed first, followed by processes evident in maternal-infant social interactions. Within each section, findings related to correlates at 9 months follow a discussion of the prediction of imitation from the 4-month measures.

Visual-Proprioceptive Intermodal Processing

Four measures were derived from the VPIP task at 4 months: time spent viewing the preferred display; time spent viewing the non-contingent display; rating of "testing" the displays; and rating of interest in the displays. Contrary to our expectations, no scores predicted infants' performance on the elicited imitation task, spontaneous imitation during free play, or parent report of starting to copy. Most surprisingly, VPIP scores were not predictive of ratings of sensitivity to being imitated. Of the mechanisms thought to be involved in imitation, coordination of visual and proprioceptive information is considered by all investigators to be a necessary underlying competency. The VPIP task originally developed by Bahrick and Watson (1985) is the only experimental measure in the literature that assesses visual-proprioceptive intermodal processing in infancy. Based on findings with this task, and arguments posed in the literature concerning the meaning of infants' behaviour, we expected to see relationships with imitation. However, the sole finding that emerged was that testing predicted parent report for KIDS Advanced Imitation (imitation after a delay and imitation of words). If, as we suggested, testing at 4 months involves active exploration of temporal parameters and self-agency, the relationship between testing and advanced imitation may reflect individual differences in
infants’ sophistication of interacting with their environment (both social and non-social). In the context of Want and Harris’ (2002) characterization of levels of imitative behaviour, simple imitation, as assessed by our elicited imitation task and parent report of starting to copy at 9 months, may reflect mimicry, or emulation; infants attended to the model’s actions and responded in a like manner. The advanced imitation scale items, however, captured what could be considered more deliberate, intentional imitative behaviours (e.g., deferred imitation; see Appendix G). In support of this suggestion, 4-month testing behaviour also marginally predicted parent ratings at 12 months of their infants’ emerging deferred imitation skills ($F(1,30) = 3.22, p < .08; \beta = .73, R^2 = .10$).

Imitative competencies measured by the KIDS Advanced score likely serve different functions, and therefore may reflect different underlying mechanisms, than those required for simple imitative skill. We suggest that the KIDS Advanced score may have captured imitation reflecting a beginning understanding of people. Further studies investigating the relationship between active exploration of the displays during the VPIP task at 4 months and later imitative abilities will contribute to our understanding of the role of visual-proprioceptive intermodal processing in imitation. It may be that the ability simply to detect correspondences across modalities is a necessary and sufficient ability for the emergence of imitation, but that individual differences in this skill will not be associated with imitation performance. In contrast, behavioural measures tapping active exploration of displays may be a fruitful avenue for further investigation, and as found in the current study, may be related to different levels of imitative skill.

At 9 months, two additional behavioural indices were derived from the VPIP task: proportion of time spent reaching/pointing and proportion of time spent rocking/leaning
while viewing the non-contingent display. As at 4 months, time spent viewing the preferred display and time spent viewing the non-contingent display were not related to either imitation skill or sensitivity to being imitated. However, proportion of time engaging in reaching/pointing was related to both 9-month elicited imitation scores and to parent report of starting to copy. Parent report of infants’ sensitivity to being imitated was also associated with time spent reaching/pointing, and as expected, was specific to noticing when movements were being imitated. Interestingly, a similar finding emerged at 9 months as at 4 months: ratings of testing the VPIP displays were related to KIDS Advanced Imitation scores. This further supports the suggestion above, that sophistication of interacting with one’s social and non-social environment might underlie this relationship. Interpretation of these findings however, is complicated by the lack of a relationship between testing at 4 and 9 months. Infants who engaged in testing behaviour at 4 months were not the same infants who tested more at 9 months. Nonetheless, at both 4 and 9 months, behavioural measures of exploration of the displays were associated with both imitation scores and sensitivity to one’s movements being copied.

Unexpected was the lack of a relationship between imitative skill and time spent viewing the preferred display and the non-contingent display. We initially considered time spent viewing the preferred display as a measure of the degree of infants’ ability to discriminate between the displays. As such, we thought that infants’ discrimination between the displays would be associated with imitation performance. However, the difficulty is that even infants who can discriminate may spend equal time looking at each display, and a given infant who is poor at discriminating between the displays may show a preference simply by chance. Infants may also demonstrate extreme looking times and
side biases (as noted in the current study). Fisher-Thompson, Romagnola, Marolf, Pettapiece, and Moorhead (2002a, 2002b) demonstrated that 3- and 4-month-old infants displayed strong side biases during a side-by-side visual preference task, and that on consecutive visits, infants did not always display the same side bias. Looks were influenced by where infants had looked previously, and by what appeared in that location. In the current study, there was wide variability in infants’ gaze switching, with the lowest number of switches ranging from 6-10 times during the presentation of the displays (4 minutes at 4 months and 2 minutes at 9 months). At both 4 and 9 months, fifteen percent of infants switched their gaze between the displays 10 or fewer times during the total task time, suggesting that a subset of infants in the current study demonstrated more extreme looking than the other infants.

The current study raises important questions about how to measure visual-proprioceptive intermodal processing in infancy, how to interpret performance on a VPIP task, conceptualization of this skill as a unitary or multi-dimensional ability, and conceptualization of how visual-proprioceptive intermodal processing abilities are related to imitation. Seemingly minor methodological factors influence infant performance and contribute to the difficulty in establishing a clear developmental picture. The sole method that has been used to assess visual-proprioceptive intermodal processing in infants is a preferential looking paradigm where one screen presents on-line information specifying self. Studies are needed that investigate other paradigms and that capture infants’ responses other than looking time.
Visual-Auditory intermodal processing.

Both visual-proprioceptive and visual-auditory tasks were included in the current study in order to test whether any intermodal relationship, if observed, was attributable to a general (supramodal) or specific (visual-proprioceptive) process. However, we were unable to examine relationships between imitation and visual-auditory intermodal processing in the current study, and between the two different types of intermodal processing (VPIP and VAIP) as infants failed to demonstrate sensitivity to the displays in the VAIP task. This issue remains critical to understanding the role intermodal processing plays in imitation. Future studies of imitation and different types of intermodal processing are needed to explore the specificity of relationships. As few relationships were observed in the current study between VPIP and imitation, investigations directed at understanding the influence of general versus specific intermodal processes may be need to be conducted with individuals with autism, for whom impaired imitation and intermodal processing have been noted.

Visual-Spatial Attention

The current study is the first to examine relationships between visual-spatial attention abilities (shift and disengage mechanisms) and imitative skill in infants at the end of the first year. At 4 months, latencies to shift and disengage were entered together into a regression analysis predicting imitation at 9 months. Neither VSAT measure predicted performance on the elicited imitation task or spontaneous imitation during free play. Though the correlation between latency to shift and parent report of starting to copy at 9 months was significant (infants who took longer to shift at 4 months were received lower parent ratings for starting to copy at 9 months), the regression analysis was not.
Other parent report measures of imitative skill (KIDS Advanced Imitation, 12-month ratings of starting to imitate) were also not predicted by VSAT scores, nor were ratings of sensitivity to being imitated at 9 or 12 months.

As at 4 months, 9-month VSAT measures were not associated with performance on the imitation task, spontaneous imitation during free play, or parent report of starting to imitate at 9 months. Twelve-month parent ratings of starting to copy were marginally related to latency to shift and disengage at 9 months; infants with longer latencies were rated by their parents as copying less. Again, however, the regression analysis was not significant. With respect to sensitivity to being imitated, latency to shift attention was associated with parent report of awareness of sounds being copied at 9 months; infants who took longer to shift were rated as being less sensitive. No predictive relationships were found for parent ratings at 12 months.

Though the current study observed few and relatively weak relationships between imitation and visual-spatial attention, it is without question that some form of attention plays a role in imitation. Infants cannot imitate actions or vocalizations that they don’t notice or don’t attend to. A number of possibilities could explain the lack of findings with our sample of infants:

1) Shift and disengage attentional mechanisms and imitation are associated during infancy, but we were unable to detect the relationship. Simple correlations were in the correct direction (longer latencies associated with lower imitation scores or ratings), and some were marginally significant, suggesting that we may not have had sufficient power to detect a small effect if present. Other studies using visual-spatial attention paradigms in infancy (e.g., McConnell & Bryson, 2004) have calculated average latency
scores for each infant across 10 trials, yet no investigations have examined within-infant variability.

(2) A second possibility is that despite individual differences in latencies, performance of all most infants on the VSAT task was above a critical threshold. Perhaps infants who are able to shift and disengage at all, regardless of how quickly, performed at a level that was sufficient to support the emergence of imitation. If the performance of typically developing infants on the VSAT task is above a critical threshold, detection of relationships between visual-spatial attention and imitation may best be achieved by studying an atypical sample for which deficits have been noted in both skills. Using the same visual-spatial attention task as employed in the current study, Landry and Bryson (2004) reported striking difficulties with disengagement in a sample of young children with autism (mean age 5.6 years), compared to typically developing toddlers/preschoolers, and to children with Down syndrome. These children were unable to disengage from the competing stimulus on 20% of trials, which is comparable to the performance of typically developing 2-month-old infants (Hood & Atkinson, 1993; Johnson et al., 1991; 1994). Studies that assess both imitation and visual-spatial attention in children with autism will be important in addressing the question of whether deficits in non-social information processing are directly related to the difficulties observed in copying the actions of others. If relationships between the two skills are found, further study will be needed in order to determine whether an underlying deficit causes difficulties with both disengagement and imitation, or whether persistent problems disengaging attention early in infancy and childhood leads to later difficulties with imitation (among other skills), as in a cascade model (Smith & Bryson, 1994). To date,
research has not identified the mechanisms involved in the development of visual disengagement, and what might contribute to its dysfunction in autism (Landry & Bryson, in press).

(3) A third possibility is that attentional mechanisms are related to imitation ability but exert their effects indirectly through related temperament constructs. Relationships between attention and aspects of temperament have been studied in typically developing infants. Johnson, Posner, and Rothbart (1991) found that 4-month-old infants who disengaged more easily were the same infants who were rated by their parents on the IBQ as more easily soothed (Soothability) and less prone to being distressed (Fear). McConnell and Bryson (2004) did not replicate Johnson et al.’s (1991) finding that ease of disengagement was related to soothability. However, they noted that at 6 months, infants who took longer to disengage were rated as more easily frustrated (Distress to Limitations) and less inclined to smile. In the current study, concurrent and longitudinal relationships between attentional mechanisms and temperament were found. Similar to Johnson et al.’s (1991) findings, we observed a trend towards easily soothed 4-month-olds being somewhat quicker to disengage, perhaps concurrently ($r = -.19, p < .10$), but, interestingly, significantly at 9 months ($r = -.24, p < .05$). We also found that soothability at 4 months was related to ease of shifting attention at the same age ($r = -.25, p < .04$). Infants who at 9 months were rated as high in frustration and distress to limitations ($r = .26, p < .03$), and fear ($r = .29, p < .02$) were slower to disengage at 9 months, as McConnell and Bryson reported for 6-month-olds.

Relationships between temperament and attention such as those reported above have been considered to reflect dimensions of infants’ self-regulatory capacities and
possibly early face-to-face social interaction (Johnson et al., 1991). If visual-spatial
attention were related to imitation through temperament, two possible avenues could
exist: through regulatory processes that affect an infants’ tendency to imitate, or through
temperament dimensions that more directly tap attentional mechanisms. In the current
study, two such relationships were found: infants who took longer to disengage attention
at 4 months were rated by their parents as orienting for longer \( r = .26, p < .04 \), and as
less sensitive to stimuli in the environment \( r = -.27, p < .03 \) at 9 months. It is not known
whether aspects of infants’ attention that are assessed by experimental paradigms and
temperament questionnaires are distinguishable from each other, perhaps measuring
ability versus tendency, or whether they are tapping conceptually similar processes (W.
Dixon and R. Brand, personal communication, September 24, 2004). In the following
section, associations between temperament and imitation will be discussed and
considered in the context of attentional processes.

(4) Other attentional mechanisms underlie imitative abilities. Performance on the
visual-spatial attention task in the current study was only marginally related to aspects of
infants’ imitation skills. Nonetheless, other forms of visual attention may be associated
with imitative capacities. For example, studies of how infants distribute their attention
have noted differences between “short” and “long” lookers, whereby shorter looking has
been found to be associated with better information processing (Colombo, Mitchell,
Coldren, & Freeseman, 1991) and novelty preference (Jankowski & Rose, 1997). Other
developmental attentional mechanisms include selective attention (inhibitory and
excitatory processes) and distractibility (Tellinghsuisen & Oakes, 1997; Tipper, Bourque,
Selective attentional processes related to the perception of biological movement may also be particularly relevant. In the current study, attentional mechanisms were assessed within the context of infants’ perception of abstract stimuli (brightly coloured moving shapes). In Mataric’s (2002) model of imitation, selective attention directed towards the effectors of actions is considered a primary mechanism. Woodward’s work (1998, 1999; Woodward & Sommerville, 2000) on how infants represent and understand human actions is consistent with Mataric’s approach. Attention to biological movements and action effectors, and subsequent representation of those actions are likely important processes that contribute to the development of imitation. Woodward (1999) reported that by 6 months, as imitative skill is emerging, infants show some understanding of the object directedness of actions. Interestingly, recent research with children with autism has demonstrated that recognition of biological movement is impaired. Blake, Turner, Smoski, Pozdol and Stone (2003) found that children with autism aged 8-10 years had significantly more difficulty than typical peers on a task involving perception of point-light animations depicting human activity versus elements grouped to form a global figure. If individuals with autism have difficulty integrating components of human actions, selective attention to and representation of actions may also be similarly impaired and contribute to difficulties with imitation. Studies examining the relationship between action perception and imitative skill in children with autism are warranted.

Temperament

Temperament emerged as the strongest predictor of imitative abilities in the current study. Four-month temperament subscale scores predicted performance on all imitation measures at 9 months across task (elicited performance, spontaneous imitation
during free play, and parent report) and sensitivity to being imitated (parent report). Infants who imitated more on demand were those who, at 4 months, reportedly recovered more slowly from distress (Falling Reactivity) and who were less excited in anticipation of pleasurable activities, in addition to showing positive temperamental features of Surgency / Extraversion (e.g., vocal reactivity, enjoyment of high intensity pleasure, perceptual sensitivity) and Orienting/Regulation (e.g., smiling and laughter). The negative relationships between imitation and both distress recovery and approach were unexpected, yet slow recovery from distress at 4 months was also related to higher levels of spontaneous imitation during free play, suggesting that these were not spurious findings. These relationships pose a challenge for interpretation. Positive relationships have been noted, however, between early negative emotion and later cognitive function (e.g., IQ scores and language: Dixon & Smith, 2000; Karass & Braungart-Ricker, 2004). Karass and Braungart-Ricker (2004) found that infants who were rated by their parents as higher in distress to novelty at 4 months had higher IQs when assessed at 3 years. Distress to novelty at 12 months also predicted higher IQ scores at 3 years, but only for infants who were insecurely attached. Karass and Braungart-Ricker suggested that heightened emotionality early in infancy creates a context in which both one’s own and others’ behaviours are regulated, and it may in fact elicit more caretaking behaviours that foster cognitive growth. In work aimed towards understanding externalizing difficulties in preschoolers, Campbell (1995) emphasized the importance of maternal factors in moderating outcomes associated with infant negativity. When mothers of distressed infants are sensitive and responsive, and carefully manage their infant’s interactions with the environment, these conditions can promote cognitive development. On the other
hand, the combination of insensitive parenting and a highly distressed infant may result in a negative outcome. As support for this assertion, Karrass and Braungart-Ricker (2004) found that maternal responsiveness moderated the relationship between distress to novelty at 12 months and language at 16 months. In the current study, slow recovery from distress at 4 months may be related to later imitative skill due to mothers’ careful structuring of their infant’s interactions with the environment and support for their infant’s regulatory abilities, which in turn fosters cognitive and social development.

Scores on the Approach subscale at 4 months also demonstrated a negative relationship with performance on the imitation task at 9 months. This finding is somewhat counterintuitive as one might expect that infants who from an early age rapidly approached toys, people, and new surroundings would engage in more imitation. We propose two possibilities that may account for the observed relationship. First, low scores on the Approach subscale may reflect behaviourally inhibited tendencies. Behavioural inhibition during infancy has been conceptualized as withdrawal from, and long latencies to interact with, novel and intense toys, sounds, and people (Putnam & Stifler, 2002; Rothbart, 1988). Negative reactivity to novel stimuli during infancy is also an antecedent of behavioural inhibition during the preschool period (Kagan & Snidman, 1991). Similar to the negative relationship found between imitation and Rate of Falling Reactivity, parents of behaviourally inhibited infants may be highly attuned and sensitive to their infant’s style of interacting with their environment and carefully structure opportunities to explore novel situations that best suit their infants’ needs. Alternatively, the relationship between imitative ability and negative reactivity to novel stimuli in early infancy may reflect cognitive sophistication. As is seen with the “stranger effect”
observed around 9 to 12 months, infants must recognize that stimuli are novel and thus
deserving of apprehension. Infants who do not demonstrate some degree of tentativeness
or negativity when faced with novel stimuli may not yet realize the novelty of the stimuli
(J. Barresi, personal communication, November 24, 2004).

A further explanation for the association between behavioural inhibition and
performance on the elicited imitation task can be generated based on the view that
imitation of an adult reflects child responsiveness and compliance. Provided infants are
cognitively and motorically capable of imitating a given action, whether or not they do so
is likely related in part to the quality of their responses to the model and compliance with
directives. Forman and Kochanska (2001) found relationships between imitation of
pretend play sequences with a parent at 14 months and responsiveness to maternal control
at 22 months. The authors interpreted elicited imitative behaviour as reflecting
“committed compliance” (Kochanska, Aksan, & Koenig, 1995); that is, a disposition
towards responsiveness and willingness to be socialized. Kochanska and colleagues have
explored the antecedents of committed compliance during the second year. Infants who
demonstrated spontaneous restraint (ignoring or not touching a forbidden object) during
an interaction with their mother at 8-10 months evidenced more committed compliance
(enthusiastic and sustained clean-up of toys; acceptance of a directive to not touch a
forbidden toy) between 13 and 15 months (Kochanska, Tjebbkes & Forman, 1998).
These findings suggest that inhibition and self-regulatory abilities at the end of the first
year are associated with committed compliance. Imitative behaviour during our elicited
imitation task might reflect in part infants’ willingness to comply with an adult’s request.
If inhibition at 8 months is associated with later committed compliance, earlier
manifestations of inhibition (at 4 months) might demonstrate similar relationships. We acknowledge that it is unclear whether behavioural inhibition and self-regulatory inhibition share underlying mechanisms. In Kochanska's (1997) model of emergent internalization, temperamental fearfulness promotes adherence to parental guidelines and requests. Behavioural inhibition may also influence elicited imitation through a similar route: sensitive mothers of fearful and inhibited infants may elicit responsiveness and compliance. In support of this, committed compliance has been observed in fearful, inhibited children whose mothers used gentle, low-power discipline (Kochanska, 1995).

Further support for conceptualizing elicited imitation as reflecting committed compliance comes from the findings in the current study that Approach was only negatively associated with scores on the elicited imitation task, not with spontaneous imitation or parent-reported imitation. Additionally, the Approach score only emerged as a predictor of full imitation for the parent trial. Strongest relationships were found for the approximations to imitation score, suggesting that that association between imitation and behavioural inhibition is less about capacity to imitate, and more to do with infants' willingness to respond in a turn-taking manner during an imitative exchange.

Few studies have examined origins of committed compliance within the first year. Findings from the current study suggest that it may be fruitful to consider relationships between infant temperament and elicited imitation performance within a framework of committed compliance. Thinking of imitation from the perspective of child responsiveness to adult direction provides an important direction for understanding the processes involved in the development of imitation during infancy.
The parent-reported imitation results suggest that different predictive relationships with temperament may underlie levels of sophistication of imitative skill, and may change developmentally as infants’ imitation skills mature. Infants who were reported by their parents at 4 months as being both very vocal and enjoying high stimulus intensity activities received higher ratings of starting to copy at 9 months. In contrast, ratings of advanced imitation at 9 months, imitation at 12 months, and spontaneous imitation during free play were all associated with infants’ earlier enjoyment of low intensity activities. These data suggest that early imitative skill is associated with an outgoing, playful nature and interest in highly active interactions. The relationship between more sophisticated imitation at 9 months and at the end of the first year and interest in low intensity activities may be due to infants’ focused attention to the substance of interactions and more subtle relationships in their environment. The temperamental dimension of Duration of Orienting on the IBQ-R was much more strongly related to Low Intensity Pleasure than to High Intensity Pleasure. Advanced imitative skills require attention to details and close monitoring of the interaction. Infants who have demonstrated an early temperamental preference for low intensity activities may be more sensitive in ways that promote imitative skill, as contrasted with the propensity to engage in an imitative interaction.

In addition to contributing to imitative ability, early temperament characteristics were also strongly associated with sensitivity to being imitated at the end of the first year. Infants whose parents reported them to be very aware of being imitated at 9 months were those who, at 4 months, obtained high scores on scales from the Surgency/Extraversion (Vocal Reactivity, Perceptual Sensitivity) and Orienting/Regulation (Low Intensity Pleasure) Factors. That is, infants who were responsive to being imitated were more
sensitive to changes in their surroundings and vocalized more in response to environmental events at 4 months. At 12 months, additional predictive relationships emerged. Very active, cuddly infants at 4 months were rated by their parents as less likely to notice when their movements were being copied, whereas fearfulness was associated with greater sensitivity. Few data in the literature address sensitivity to being imitated, and none concern relationships with temperament. Forms of imitation that are evident at different ages might be associated with different underlying processes, one of which may be temperament. Constructs related to early imitation (e.g., at 9 months) may not be those that predict later-developing imitative ability (e.g., at 12 months and beyond).

9-month temperament relationships

In contrast to the many predictive relationships observed with the 4-month temperament subscale scores, fewer were noted between imitation and concurrent 9-month temperament scores. Performance on the elicited imitation task was associated with two aspects of temperament, one directly related to imitation and the other that reflected individual differences in how infants coped with the task demands. For both all-or-none and approximations to imitation scores, infants who were rated by their parents as likely to become distressed when in a confining place received lower scores on Trial 3. Given that Trial 3 began 10-12 minutes into the imitation task, it is not surprising that infants who were easily distressed by being confined imitated less during the last trial with their parent. Trial 1 approximations to imitation scores were predicted by two temperament subscale scores, both from the Surgency/Extraversion composite: Vocal Reactivity and Approach. Vocal infants, and those who were rated by parents as being excited about pleasurable activities, made more attempts to copy during the first trial with the experimenter. These findings suggest that during a novel interaction with a stranger,
outgoing, friendly infants are more likely to respond and engage in a turn-taking exchange. While these infants were not more likely to achieve higher all-or-none imitation scores, sociability appears to facilitate responsiveness during an imitative interaction. It is also possible that the relationships between vocal reactivity, approach, and approximations to imitation are in part associated with individual differences in “committed compliance” (Forman & Kochanska, 2001). As discussed in the foregoing 4-month section, committed compliance reflects a dispositional readiness and willingness to be socialized. Vocal and engaging infants may be more responsive to the requests of adults, which is reflected in individual differences in imitative attempts. The relative contributions of temperamental factors and parent-child interactional variables to the developmental origins of committed compliance warrant further exploration. It is also interesting to note that while Approach scores at 4 months were negatively related to imitation, 9-month scores demonstrated a positive association. Though clearly speculative, the development of imitation during infancy may be maximized by an early phase during which infants are somewhat more inhibited and closely tuned in to their mothers’ sensitive parenting, followed by a later phase characterized by increasing awareness of and interest in engaging with the external social world. Longitudinal studies examining imitative skills of infants from different subgroups of mother-infant dyads that vary on dimensions of parenting sensitivity and infant temperament (e.g., behaviourally inhibited and low sensitivity versus behaviourally inhibited and high sensitivity) are needed in order address the viability of this hypothesis.

In contrast to the 4-month findings, no temperament subscale scores were associated with spontaneous imitation during free play. Early individual differences in
temperament may interact with parental factors and contribute to learning experiences that are particularly relevant for imitation at the end of the first year. Concurrent individual differences in temperament, in contrast, may have less of an influence on whether infants imitate their mothers during free play, perhaps because mothers have become skilled at matching their infants’ disposition and style of interacting.

Parent report of infants starting to copy at 9 and 12 months demonstrated expected relationships with temperament scores. As found with the elicited imitation task, vocal infants were reported by parents as imitating more frequently, supporting our suggestion that sociability plays an important role in imitativeness. It is not known whether vocal infants are more likely to imitate an adult’s sounds. Studies that include separate measures of vocal, gestural, and object-directed imitation can address the specificity of temperamental “ chattiness” in relation to imitation. Duration of Orienting was related to the KIDS Advanced Imitation Score. Together with the findings at 4 months, this suggests that temperamental differences in the Orienting/Regulation domains influence sophistication of imitation, and is consistent with research that has demonstrated that relationships between early attention and self-regulatory abilities during infancy and later cognitive skills (e.g., IQ, Bono & Stifter, 2003; Lawson & Ruff, 2004).

Similar relationships were noted at 9 months as at 4 between infants’ sensitivity to changes in their environment, enjoyment of low stimulus intensity activities, and awareness of when they are being imitated. Twelve-month imitation ratings were also strongly associated with 9-month temperament scores reflecting orienting and self-regulatory skills. Of note, the Approach subscale score was negatively associated with
sensitivity to being imitated. While sociability and eager interest in activities at 9 months
are positively associated with imitativeness during an elicited imitation task at the same
age, this temperament trait has a negative effect on infants’ ability to notice when they
are being imitated. Perhaps a less inhibited style of interacting with the environment
interferes with the attention to detail that is necessary in order to detect subtleties in
interactions, such as what happens when a social partner matches one’s behaviour or
expressions.

Summary

The current findings are the first to demonstrate longitudinal relationships
between early individual differences in temperament and imitation at the end of the first
year. We expected to see relationships with the orienting/regulation dimension of
temperament. Those with surgency/extraversion were not anticipated, yet provide a
number of interesting directions for future research on how temperament influences
imitation during infancy, and potentially interacts with maternal variables during
imitative play contexts.

Mother-Infant Play

4-month findings

The current study is only the second to examine predictive relationships among
maternal and infant behaviours during dyadic play and infants’ imitation abilities at the
end of the first year. Contrary to our expectations, individual differences in mothers’
contingent responding to their infants at 4 months were not associated with infants’
imitation skills at 9 months. Theories that emphasize social processes in the development
of imitation underscore the importance of parental social “mirroring”. Nonetheless, how
well mothers were able to imitate their infant’s behaviour when asked to do so, and how often they spontaneously imitated their infant during free play, did not predict either imitative ability or infants’ sensitivity to being imitated at 9 months. However, relationships were found between mothers’ spontaneous imitation of their infants during the free play period and parent ratings of starting to copy at 12 months. Maternal imitation of facial expressions predicted higher imitation ratings, while imitation of actions predicted lower imitation ratings. Why were relationships found between maternal behaviour at 4 months and infant imitation at 12 months, but not at 9? As we expected, our data suggest that forms of imitation at different ages rely on different underlying mechanisms. As imitation near the end of the first year moves beyond mimicry or emulation learning (Want & Harris, 2002), a strong history of emotionally-attuned social interactions with parents may facilitate more sophisticated social imitation at 12 months. Mothers’ matching of their infants’ emotional states at 4 months may also be related to later imitation through effects on infants’ self-regulatory capacities.

Though our data demonstrated predictive relationships between maternal behaviours and imitation only at 12 months, it seems unreasonable to accept that mothers have no influence on their infants’ emerging imitation abilities before this point. Our play-imitation task at 4 months may not have captured the individual differences in mothers’ behaviour that are important for imitation at 9 months. We asked mothers to imitate their infants in order to amplify highly contingent responding, but perhaps differences in maternal behaviour that manifest in other ways may better capture relationships with infants’ imitative abilities. Alternatively, imposing an artificial requirement on mothers’ behaviour may have disrupted natural interactional styles and
obscured the effects we were hoping to enhance. As discussed in the context of other measures, individual differences in mothers’ contingent responding may also have been above a critical threshold that precluded detection of relationships with imitation at 9 months. Studying an atypical sample for which disruptions in contingent responding have been noted may reveal such relationships. Interactions of mothers experiencing post-natal depression have been observed to be less contingent and less emotionally attuned to their infant’s behaviour (Field, Sandberg, Garcia, Vega-Lahr, Goldstein, & Guy, 1985; Herrera, Reissland, & Shepherd, 2004; Murray, Fiori-Cowley, Hooper, & Cooper, 1996; Stanley, Murray, & Stein, 2004). Effects of disruptions of early contingent mother-infant interactions may be evident in the early imitation skills of infants of depressed mothers.

As with the maternal measures, few predictive relationships were observed between infant behaviour at 4 months and their imitative abilities at 9 months. Consistent with our interpretation that forms of imitation at 9 and 12 months differ, infant watching of mothers’ actions at 4 months differentially predicted later imitative abilities. Infants who spent more time watching their mothers’ actions during free play at 4 months were reported by parents to engage in more complex imitation (e.g., deferred imitation) at 9 months. The opposite finding emerged for prediction of imitation at 12 months: infants who watched their mother’s actions more while being imitated at 4 months received lower ratings for starting to copy at 12 months. If social mechanisms exert the most influence in driving imitation at the end of the first year, individual differences early in development in infants’ interest in observing faces and emotional displays versus actions may underlie imitative abilities at 12 months. Needless to say, this interpretation is speculative and deserving of further exploration. In the only other study that has
examined the prediction of later imitation abilities from infant behaviour during early dyadic interactions, Heimann (1989) also observed few significant relationships. In his study, fewer instances of brief gaze aversion by infants at 3 months were associated with higher vocal imitation scores at 12 months, suggesting that perhaps infants who manifest self-regulatory skills are more socially oriented and sensitive to changes within social interactions. Though maternal behaviours were not examined as part of their study, mothers' contingent responding may have indirectly facilitated infants' imitative behaviour through promotion of regulatory capacities.

Surprisingly, in the present study no relationships were found between maternal or infant behaviour at 4 months and infants' sensitivity to being imitated at 9 or 12 months. Given that sensitivity to imperfect temporal contingencies early in development may be a precursor to later detection of imitation, strongest relationships were expected to emerge for our imitation recognition ratings. Again, limitations of correlational research, and issues of threshold may be associated with the observed lack of relationship.

9-month findings

The present study also examined maternal and infant factors during play that are associated concurrently with infants' imitation abilities at the end of the first year. As one of the only investigations to address individual differences in maternal behaviours that may promote imitation, the current findings contribute to our understanding of the effects of maternal play strategies on infants' imitative behaviour in a variety of contexts. Overall, the results indicate that infants of mothers who structured triadic play episodes and supported their infant's interactions with the environment imitated more, both during

259
an elicited imitation task and during free play. Infants’ sensitivity to being imitated was also associated with individual differences in maternal play behaviours.

Ratings of mothers’ scaffolding of their infants’ play were strongly associated with the frequency of spontaneous infant imitations during the play session, while ratings for following play showed no relationship. In what ways does maternal scaffolding exert its influence on the imitative abilities of 9-month-olds? It is likely that the effects are both direct and indirect and may arise from general enrichment of infants’ overall cognitive and motor functioning and self-regulatory abilities (Rogoff, 1990), in addition to specific facilitation of imitation skills. While considerable work on scaffolding and tutoring styles has been conducted with older toddlers and preschoolers in problem-solving tasks, and school-aged children learning academic skills (e.g., math, reading, Clarke-Stewart, 1998; Pratt & Savoy-Levine, 1998; Rogoff, Mistry, Goncu, & Mosier, 1993), less work has examined structuring opportunities in early mother-infant play with toys, and no studies have investigated scaffolding specific to imitation in infancy. Hodapp, Goldfield and Boyatzis (1984) examined a number of maternal helping behaviours in the context of mother-infant games from 8 to 16 months. Across different games (e.g., ball rolling, peek-a-boo), similarities were noted in the types of assistance mothers used, including attention-getting, stage-setting, scaffolding and reinforcement, and it was observed that attention-getting and stage-setting tended to occur early in the interaction. Hodapp et al. suggested that patterns of maternal helping behaviours may be generalizable to other mother-infant interactions. Other studies have suggested that directing, focusing, and maintaining attention may be one of the earliest forms of scaffolding in mother-infant object play (Bono & Stifter, 2003). Regulating attention during toy play may be an
extension of mothers’ earlier contingent responding during dyadic interactions, and may reflect mothers’ sensitivity to their infant’s skill levels and engagement in joint play. Regulating attention has been observed to be associated with vocabulary development in 13-month-olds (Akhtar, Dunham & Dunham, 1991) and may be associated with infant behaviours during imitative interactions when infants are first demonstrating imitative skill. Scaffolding of turn-taking has also been observed in mothers of 6-month-olds (Vandell & Wilson, 1987), which may be particularly relevant for imitative interactions.

We used a global rating of scaffolding, and no distinctions were made between scaffolding of play in general and helping behaviours specific to infants’ imitation. However, while the global rating was only weakly associated with general maternal play behaviours coded during the play session (sound effects and exclamations, demonstrations, and pointing), there was a strong relationship between scaffolding and creating opportunities to imitate. Ratings of scaffolding were thus likely based on a combination of maternal behaviours that contribute to a general style of interacting with their infant, with an emphasis on mothers’ structuring play interactions to create imitation opportunities. No studies have investigated mothers’ responses to their infant’s imitative attempts and how individual differences in maternal responding may influence the development of imitation. Studies are needed that examine more specifically how scaffolding is related to imitation during infancy, how mothers support imitative attempts by their infants in the context of social play, and how they respond to partial imitations. Intervention programs for children with autism target teaching of imitation and emphasize the importance of prompting and using physical support to facilitate motor imitation (e.g., Leaf & McEachin, 1999; Lovaas, 2003; Lovaas & Smith, 1989). Others
however, have suggested that these structured teaching techniques are contrived and unnatural (Ingersoll & Schreibman, in press), yet we know very little about how mothers of typically developing infants respond during imitative play.

In the current study, infants of mothers who positioned them more often during play achieved higher scores on the elicited imitation task. Positioning may be a physical “stage setting” behaviour that mothers use to structure interactions and create a state of optimal readiness and focus for their infant. Infants for whom physical positioning is a familiar component of object play with their mother may have found that the structure of the elicited imitation task fit with their expectations for object play with an adult. Positioning was also strongly related to the time infants spent seated during the play session. Mothers of highly active infants positioned them much more frequently during free play. Individual differences in infant temperament may underlie the relationship between maternal positioning and imitation scores on the elicited task; infants who needed positioning may be more active, outgoing and sociable, and for these reasons scored higher on the imitation task.

A further finding related to infants’ performance on the imitation task was noted for imitation-specific maternal behaviour: mothers of infants who received lower imitation scores were more likely to set up opportunities for their infant to imitate them during play. One possible explanation for this finding is that it reflects an order effect – mothers who noticed that their infant did not engage in much imitation during the imitation task attempted to elicit copying behaviour during free play. It is also possible that structuring opportunities for imitation is a natural response of mothers when their infant is not yet engaging in much spontaneous imitation. Maternal solicitations of
imitation during infancy have been studied recently, demonstrating that they account for less than a quarter of infants’ increasing imitation of actions on objects during play situations (Masur & Rodemaker, 1999). Flynn, Masur and Eichorst (in press) also found that opportunities provided by mothers for their infants to imitate were not associated with rates of imitative behaviour. Opportunities in this context were defined as engaging in “imitable” actions with the objects. In the current study, the relationship was weak between mothers’ imitation “set-ups” and infants’ imitation during free play. When infant imitation was considered dichotomously (yes or no), mothers of infants who imitated them at least once during free play had created more opportunities for their infant to imitate. However, as previously discussed, scaffolding was strongly associated with “set-ups” and spontaneous imitation, suggesting that the relationships between soliciting imitation and infants’ imitative behaviour are complex and deserving of further exploration.

Partner modeling of imitation has also been studied and while relationships have been found between verbal imitation rates of mothers and infants (Masur 1987; Masur & Rodemaker, 1999, Snow, 1989), correspondences have not been noted for object-directed imitation. The current findings support previous work; no relationships were noted between mothers’ imitations and rates of spontaneous imitation in their infants.

Ratings of infants’ sensitivity to being imitated were also associated with maternal behaviours during free play. Mothers’ verbal and non-verbal play strategies were differentially associated with infants’ sensitivity to their vocalizations being imitated. Mothers who used more non-verbal play strategies (pointing) had previously reported that their infants were less sensitive to when their vocalizations were being
imitated. In contrast, infants of mothers who used more verbal play strategies (saying “look”) were reported at both 9 and 12 months to be more sensitive to when their vocalizations were being imitated. These findings suggest that individual differences in maternal approaches to play are not only related to infants’ imitative abilities, but are also strongly associated with their sensitivity to being imitated. In particular, a verbal or non-verbal maternal interactive style affects infants’ awareness of when others are copying them.

*Summary (4 and 9 months)*

While interpersonal variables figure prominently in theories of infants’ developing imitation skills, it is not known what specific interpersonal factors are associated with imitative skill in infancy. The current study is the first to demonstrate concurrent relationships between maternal play behaviours and imitative skill. We require more information to understand how mothers support their infants’ emerging imitation abilities, and how verbal and non-verbal interactive styles contribute to imitative skill and sensitivity to being imitated. While the study of “scaffolding” (Wood, Bruner, & Ross, 1976) and the socio-cultural approach to learning and development (Vygotsky, 1978) has been highly influential in work with toddlers and preschoolers, little is known about the origins of scaffolding in interactions with infants. The current findings suggest that early individual differences in how caregivers support their infants’ interactions with the world are important for the development of imitative skill.

*Joint Attention*

No relationships were found in the current study between initiating and responding to joint attention and any of the measures of imitative skill or sensitivity to
being imitated. The lack of such relationships is interesting given several previous reports of correlations between joint attention and imitation in both typical (Carpenter, Nagell, & Tomasello, 1998; Charman, Baron-Cohen, Swettenham, Baird, Cox, & Drew, 2000) and atypical development (Carpenter, Pennington & Rogers, 2002; Rogers, Hepburn, Stackhouse, & Weiner, 2003). However, data from other recent studies also suggest that imitation and gaze following are not linked developmentally, either at the early age of 4 months (Gattis & Perra, 2004), or at the beginning of the second year (Slaughter & McConnell, 2003).

These findings, together with those of the current study, support a “lean”, as opposed to a “rich” theoretical account of the emergence of social-cognitive abilities during the triadic period (Moore, 2004; Slaughter & McConnell, 2003). If a lean interpretation were correct, one would expect to not observe relationships earlier in development when skills are first emerging. For example, Moore’s (2004) “intentional islands” account suggests that the underlying mechanisms thought to give rise to developmental changes in each joint attention behaviour are related specifically to that behaviour, and do not reflect a general conceptual process that accounts for change across all behaviours (e.g., an abstract concept of an intentional agent: Tomasello, & Carpenter, 2004; Uzgiris & Kruper, 1992). Correlations between skills would be expected to emerge over time as a result of limiting factors. Arguably, more than one underlying ability or process contributes to early performance on gaze following and imitation tasks. These basic skills and processes such as learning mechanisms, innate releasing mechanisms, emulation learning, mood contagion, reinforcement contingencies, and perceptual and motor processes limit infants’ accomplishments (Moore, 2004; Slaughter & McConnell,
While some of the processes involved in the development of each skill may be similar, others may be skill-specific. Performance on a task will in general be limited by multiple factors, and scores determined by the “weakest link” factor. If imitation and gaze following have different “weakest links”, they will not be correlated initially. If, over time, basic skills are acquired and the same underlying process becomes the limiting factor for both gaze following and object-directed imitation, then a correlation will be found. For example, consider the relationship between how much weight an individual can “leg press” and how fast they can run. The limiting factor in leg press is strength, but for younger children, the limiting factor in running speed is leg coordination. As a result, there is no relationship between weight pressed and speed in young children. As children get older, however, strength takes over as the limiting factor and a correlation develops between leg press (strength) and running speed. Social-cognitive developmental theorists would suggest that this shared limiting factor is the emerging understanding of intentionality. The question then becomes when in development does this conceptual ability become the shared limiting factor for joint-attentional skills such as gaze following and object-directed imitation?

Five studies, including this one, provide data as to when gaze following and imitative abilities are related developmentally. Three published studies have examined relationships among imitation and other joint attentional abilities (Carpenter et al., 1998; Charman et al., 2001; Slaughter & McConnell, 2003). Though Carpenter and colleagues (1998) reported a sequence from 9 to 15 months in which ability to follow attention appeared before imitative learning, Slaughter and McConnell (2003) did not replicate this order of emergence. They also did not find a significant relationship between individual
differences in gaze following, social referencing, and imitation abilities in a cross-sectional sample of infants 8 to 14 months old, after age had been partialled out. This is inconsistent with correlations reported by Carpenter, Pennington, and Rogers (2002) that indicated a positive association at 12 months between gaze following and imitation scores in their original longitudinal sample (Carpenter et al., 1998). Charman and colleagues (2000) found relationships between imitative learning and gaze switching between a toy and an experimenter at 20 months, after non-verbal IQ had been partialled out. The sample size (N = 13) was quite small, however. These three studies provide conflicting evidence of relationships among joint attentional abilities in the second year.

Only the current study and one other have examined relationships between imitation and gaze following in the first year. Gattis and Perra (2004) postulated that if early imitation plays a role in establishing joint attention, relationships between individual differences in neonatal facial imitation should be associated with the ability to follow the direction of an adult’s gaze at 4 months. As in the current study, no relationships were found. Thus, the only studies to have investigated associations between imitation and gaze following in the first year suggest that these skills are likely serving different functions, and that different underlying processes underlie developmental change in each ability.

Two issues are important to note related to the above findings: first, matching of facial gestures in Gattis and Perra’s (2004) study, and imitation of manual gestures and vocalizations in the current study, differ from imitation as defined in the other studies cited above in that they are not triadic. Gaze following as evident at 4 months is also not integrated into triadic interactions (Moore, 1999). Relationships between elicited
imitation, gaze following, and showing in the current study were examined using the summary imitation scores that combined object-directed, gestural, and vocal imitation. In order to more specifically address associations among joint attention behaviours, regression analyses were re-run using an object-directed imitation score (full imitation performance on trials 1-3, summed across the 3 object actions). These analyses produced the same findings as those for the overall imitation scores: no relationships were found among gaze following, showing, and object imitation.

A second important issue is related to the form of copying behaviour at various ages. Though longitudinal data addressing the continuity of imitation skills during the first two years is limited, “imitation” at 4 months is different from that at 9 months, and the processes underlying 9-month imitation are presumably also different from those contributing to imitation in the second year (Want & Harris, 2002). The same is likely true for manifestations of gaze following abilities; forms seen at earlier ages differ from later developments (Corkum & Moore, 1995; 1998, Moore, 1999). Understanding of the mechanisms involved in the development of these specific skills (e.g., gaze following, imitation) will be critical to understanding the relationships between skills.

The current data suggest that within the first year, even at the beginning of the triadic period of development (9 months), individual differences in gaze following and imitative abilities are not related (see Figure 24). It is unclear at what point these skills begin to share a common limiting factor, such as the developing understanding of minds. Slaughter and McConnell (2003) suggested that by 8-14 months, these skills remain unrelated. That this is inconsistent with Carpenter and colleagues (1998) finding of an observed relationship at 12 months means that the issue remains to be resolved. Much
research has supported 18 months as the time at which infants first begin to understand the mental states of others (e.g., that a person turns her head because she is looking at something interesting in the environment, or that a person imitates to reach a goal; Corkum & Moore, 1995; Meltzoff, 1995). This view is supported by Charman and colleagues’ (2000) finding of relationships among joint attentional behaviours at 20 months. Longitudinal studies are needed that examine associations among individual differences in imitation and other joint attention skills from the second half of the first year into the latter half of the second year. If the lean interpretation of infant behaviour were correct, one would not expect to see relationships between object imitation and joint attention skills in a group of infants until the second year.
Figure 24. Relationships among imitation, gaze following, and other joint behaviours
Conclusions

The current study is the first to undertake a comprehensive examination of imitative abilities at the end of the first year. With a large sample of infants, and a fine-grained approach to understanding the emergence of imitation, we have provided a detailed description of the imitative experiences and abilities of 9-month-olds. A thorough understanding of these experiences is critical to appreciating how infants make the transition towards intentional understanding, and to delineating what psychological processes are involved in different aspects of imitation at this age (e.g., elicited and spontaneous, skill and sensitivity to being imitated). Our data indicate that whereas, as a group, 9-month-olds do imitate the actions of others, and in particular actions on objects, there is considerable variability in imitative skill at this age. Importantly, infants who are not fully imitating actions nonetheless engage in systematic behaviours that precede accurate copying. These approximations occurred with marked regularity and provide insight into the developmental emergence of imitative skills. Observations of imitation across contexts revealed that while 9-month-old infants as a group imitated more frequently during an elicited imitation task than during free play with a parent, the same infants did not necessarily imitate well on both tasks. The data suggest that scores from elicited tasks, free play, and parent report reflect different facets of an infants’ imitative repertoire that are deserving of further study, particularly in the same group of infants. Our data are also the first to demonstrate relationships between imitative skill and sensitivity to being imitated at the end of the first year. Having demonstrated empirically that imitation perception and performance in 9-month-olds share some of the same underlying mechanisms, and that sensitivity to being imitated precedes the development
of imitative skill, future longitudinal studies are needed that document the developmental relationships between these two aspects of imitative skill.

In addition to providing a detailed description of the imitative abilities of 9-month-olds, a primary goal of this research was to investigate predictors of imitation at the end of the first year. As such, the current study provides a first description of both social and non-social processes involved in imitation at 9 months. While a number of 4-month measures emerged as predictors of imitation, they were not those that we expected to demonstrate the strongest relationships. Based on developmental theory, we anticipated that visual-proprioceptive intermodal processing and early maternal-infant social interactions might be most predictive of imitative ability at the end of the first year. However, of all the constructs assessed at 4 months, temperament was the most predictive of imitation scores across contexts, thus highlighting the need for further research concerning both the meaning of temperamental constructs, and the role of individual differences in the development of imitation. It is important to note that prediction of imitation was assessed in the current study by separately examining relationships with individual predictors. We know that aspects of temperament are associated with attentional processes, self-regulation, and maternal-infant interaction. Relationships among the predictors themselves were not systematically explored, yet they likely do not reflect completely independent constructs. Establishing relationships among precursor skills and interpersonal processes will be important in future investigations of mechanisms of imitation.

Though a number of expected relationships with imitation were not found, it cannot be concluded that these skills (e.g., attentional processes) are not important
for the development of imitative abilities. As discussed, performance of our group of infants may have been above a critical threshold for detecting relationships. Alternatively, the tasks chosen may not have captured variability in aspects of performance that were relevant for imitation. Replication of the current findings and studies that investigate these constructs in different ways are needed to better understand the processes involved in imitation.

It is important to note that the current study examined a relatively narrow window in the developmental progression of imitative skills during infancy. Imitative processes revealed at different ages and in different contexts will likely have different underlying mechanisms (Barr, 2002; Want & Harris, 2002). What predicts imitation at one age (e.g., 9 months) may not necessarily be associated with imitation at another age. For example in the present research, some measures that predicted imitation at 9 months did not predict parent reported imitation at 12 months. One might expect in particular that different underlying processes would be related to imitation at transitional periods during development. A different set of predictors would be expected to be associated with intentional imitation during the second year than at 9 months. Longitudinal studies that examine imitation and predictors are needed to address these questions. Based on findings from the current research, we would expect that longitudinal studies of visual-proproceptive intermodal processing would demonstrate stronger relationships between active exploration of displays and imitative abilities in the second year than during the first year. Different relationships with temperamental dimensions would also be expected during the second year, such as stronger associations with aspects of temperament that influence an infant’s ability to detect and respond to subtle changes in social interactions.
Findings from the play sessions also suggest that different relationships may be found between maternal and infant interaction variables and imitation at different ages. Our data suggest that imitative performance in the second year would be more strongly related to earlier social interaction measures because imitation at this age is thought to involve more sophisticated social understanding (Want & Harris, 2002). A strong history of emotionally attuned social interactions with parents may facilitate these later-emerging imitative capacities.

With respect to concurrent processes, an important finding of the present study was the lack of relationship between imitation and joint attention abilities at 9 months. Object-directed imitative behaviour at this age is pre-intentional, and not connected with other supposed triadic behaviours via an underlying abstract concept of an intentional agent. Imitation of 9-month-olds represents an early stage of mutual engagement with objects, and such imitative experiences lead to intentional understanding during the second year. Research describing imitation at the end of the first year and its predictors and correlates will contribute to our appreciation of how infants get to the next level of social-cognitive awareness.

As a first attempt at studying processes involved in imitation during infancy, the current research sets the stage for future hypothesis-driven empirical approaches to a critical question that has not yet been answered: how do typically-developing infants come to imitate others so readily? Importantly, new lines of research were addressed in this dissertation that been given little consideration in the literature such as the role of individual differences in the development of imitation, the emergence of pre-imitative
behaviours and partial imitation, and relationships between imitation perception and performance.

Implications for the Study of Imitation and Autism

Research on imitation and autism has grown substantially within the last decade and has provided important insights regarding possible mechanisms of imitation and what might underlie the imitation impairment in individuals with autism (Rogers et al., 2003; Williams, Whiten & Singh, 2004). Findings from the current study suggest a number of avenues that are deserving of investigation with children with autism.

Our data from typically developing infants indicate that pre-imitative behaviours and approximations to imitation occur with marked regularity. It is currently not known how children with autism begin to imitate and whether a similar hierarchy of responses to a demonstrated action might be seen in a group of young children with autism (e.g., use of an adult’s body preceding object-directed imitation). Pass/fail scores, or ratings of the quality of imitation performance are often used in studies of imitation and autism (Smith, Lowe-Pearce, & Nichols, in press) without a comprehensive accounting of how children with autism respond to an adult’s action. A detailed approach to scoring approximate responses will provide rich data concerning the development of imitation in children with autism. This information will also be critical in best understanding how to facilitate teaching of imitation.

It has been demonstrated that children with autism are sensitive to some extent to being imitated by others (e.g., increase in positive attention to an imitating experimenter, (Dawson & Galpert, 1990; Tiegeman & Primavera, 1984), and yet as with studies of typical development, relationships between imitation perception and skill have not been
investigated in children with autism (yet see Nadel, 2000). The current study demonstrated that sensitivity to being imitated is associated with imitative abilities in typically developing infants. Further research is needed documenting how these two aspects of imitation are related in children with autism.

An important application of the current findings to research in developmental psychopathology is to understanding whether individual variation in imitative behaviour in typical infants (e.g., precursor abilities and patterns of association with social and nonsocial skills) can shed light on the imitation problems in autism. For example, are impaired attentional and joint attention skills related to imitation deficits in autism? Do observed relationships noted in the present research map onto how skills are associated in children with autism? Carpenter and colleagues (2002) found that imitation was related in different ways with other social-cognitive abilities in children with autism than typically developing infants. As discussed in the present study, perhaps some relationships between skills may be best examined in an atypical population. The current research provides direction for looking at predictors and correlates of imitation in children with autism. In particular, the strong relationships observed with aspects of temperament suggest that this may be a promising course of study in understanding the role of individual differences in the imitative abilities of individuals with autism. Theoretical links between temperament, attention, and self-regulation have been explored in typical developing infants and have begun to be investigated in children with autism (Hepburn & Stone, 2004; Landry & Bryson, 2004). Documented difficulties with attention, adaptability, emotion regulation and interest in approaching novel situations may be
associated with impaired imitative skills. Research examining the relationships among these constructs is needed.

Reciprocal approaches to understanding typical and pathological developmental processes further our understanding of cognitive and social development during infancy and childhood. Appreciation of deficits in imitation in individuals with autism, and of typical developmental pathways permits a view of imitation that is more comprehensive and integrated. By straddling the boundary between clinical and developmental research we hope to inform both typical developmental theory and understanding of imitation impairments in autism.
REFERENCES


293


APPENDIX A

Screening Phone Call and Interest Check

Mother’s Name: ___________________ Father’s Name: ___________________

Child’s Name: _______________ Child’s Sex: ___

Child’s Birthday (D/M/Y) ______________

Phone Number: _______________ Letter sent out: (Date) ______________

- Introduce self and say calling from the Dalhousie Child Study Centre
  Date of call:
- Remind them of the letter that they would have received
- Ask if they would be interesting in hearing more about the study that is ongoing
- If yes, explain study Y _____ N ______
- If no, ask if they would be interested in participating at another time. Y _____ N ______
- If no, say thanks for their time.

After explaining study, ask if they would be interested in participating: Y _____ N ____

Screening Questions:

1. Was ________ born full term? Y _____ N _____ How far from due date? _______

2. Were there any complications during your pregnancy? Y ____ N _____
   If yes, explain: __________________________________________________________

3. Were there any complications during delivery? Y ____ N _____
   If yes, explain: __________________________________________________________

4. How much did _________ weigh at birth?

5. What was _________ Apgar score at birth? ____________

6. Does _________ have any visual, hearing, or motor problems? Y ____ N _____
   If yes, explain: __________________________________________________________

7. Does _________ have any serious medical conditions? Y ____ N _____
   If yes, explain: __________________________________________________________

Meet criteria: Y _____ N _____ Maybe _____
Appointment: ____________________________

299
APPENDIX B

4 Month Demographics Form

ID: ____

Demographics Form

Child's Name: ___________________________ Today's Date: _____________

Child's Age: _______ Child's Sex: _______

Date of Birth: _______________________

Person completing this form (circle one): Mother  Father  Other __________________________

MOTHER INFORMATION:

Mother's Name: ___________________________ Age: _________________

Occupation (please be as specific as possible): _____________________________

Education:  ( ) Did not complete highschool or GED
( ) Graduated from highschool or earned a GED
( ) Graduated from technical school
( ) Graduated from college
( ) Graduated from post college program (masters, Ph.D., M.D., J.D., etc.)

FATHER INFORMATION:

Father's Name: ___________________________ Age: _________________

Occupation (please be as specific as possible):

Education:  ( ) Did not complete highschool or GED
( ) Graduated from highschool or earned a GED
( ) Graduated from technical school
( ) Graduated from college
( ) Graduated from post college program (masters, Ph.D., M.D., J.D., etc.)
**FAMILY COMPOSITION:**

<table>
<thead>
<tr>
<th>SIBLING'S NAME</th>
<th>SEX</th>
<th>BIRTH DATE</th>
<th>AGE</th>
<th>LIVING AT HOME?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adults in child’s main household: Number of male adults____  Number of female adults____
Specify:


Does this child live in more than one household (e.g., joint custody)? Yes ____  No ____

**CHILD INFORMATION:**

Baby was born at: within two weeks of due date ______
early (specify) ________________________________
late (specify) ________________________________
Child’s weight at birth: ______________________
Child’s Apgar score at birth (if known): __________
Any complications during the pregnancy, labour, or delivery?  Yes _____  No _____
If yes, please explain:


Has your child ever received medication or other treatment for any medical problems / illness?
Yes _____  No _____
If yes, what medication / treatment and when?


If yes, for what condition / illness and when?


301
FAMILY HISTORY:
Do you have any medical / developmental / learning / language concerns about any of your child’s siblings?
Yes _______ No _______ If yes:

<table>
<thead>
<tr>
<th>SIBLING</th>
<th>CONCERN(S)</th>
<th>IDENTIFIED WHEN?</th>
<th>IDENTIFIED BY WHOM?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do either of your child’s parents, grandparents, or other first degree relatives (i.e. cousins, aunts) have any medical / developmental / learning / language problems? Yes _____ No _____
If yes: (please indicate father’s versus mother’s side of the family)

<table>
<thead>
<tr>
<th>WHO</th>
<th>PROBLEM(S)</th>
<th>SINCE WHEN?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SOCIALIZATION:
Does anyone else look after your child on a regular basis? Yes _____ No _____
Who?

If yes, how many hours / days per week?

Does your child attend any parent-baby social / learning activities? (i.e. parent-baby swimming lessons, parent-baby play groups)

---

302
THE CURRENT STUDY:

How did you hear about the study?

Would you like to receive a group summary of the results. Yes _______ No _______

Would you be willing to be contacted about participation in any future studies that our research group may be conducting? This does not entail a commitment to participate, only to contact you: Yes _______ No _______

Your mailing address: _____________________________________________
                                                                 _____________________________________________
                                                                 _____________________________________________
                                                                 _____________________________________________

Home Phone Number: __________________________
Best time to be contacted: _____________________

9 MONTH VISIT ONLY:

Please read the above information from your visit at 4 months. Are there any changes or additions to the information you provided previously? If yes, please note changes below, and any other relevant information you would like us to know.

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

Thank you for taking the time to complete this form! ☺
APPENDIX C

Infant Behavior Questionnaire - Revised

© 2000
Mary K. Rothbart
Maria A. Gartstein
All Rights Reserved

Infant Behavior Questionnaire - Revised

Subject No. ____________ Date of Baby’s Birth _______ _______ _______

Today’s Date ____________ Age of Child _______ _______ _______

Sex of Child ____________

INSTRUCTIONS:
Please read carefully before starting:

As you read each description of the baby’s behavior below, please indicate how often the baby
did this during the LAST WEEK (the past seven days) by circling one of the numbers in the left
column. These numbers indicate how often you observed the behavior described during the last
week.
The “Does Not Apply” (X) column is used when you did not see the baby in the situation described during the last week. For example, if the situation mentions the baby having to wait for food or liquids and there was no time during the last week when the baby had to wait, circle the (X) column. “Does Not Apply” is different from “Never” (1). “Never” is used when you saw the baby in the situation but the baby never engaged in the behavior listed during the last week. For example, if the baby did have to wait for food or liquids at least once but never cried loudly while waiting, circle the (1) column.

Please be sure to circle a number for every item.

**Feeding**

During feeding, how often did the baby:
- 1 2 3 4 5 6 7 X . . . (1) lie or sit quietly?
- 1 2 3 4 5 6 7 X . . . (2) squirm or kick?
- 1 2 3 4 5 6 7 X . . . (3) wave arms?
- 1 2 3 4 5 6 7 X . . . (4) notice lumpy texture in food (e.g., oatmeal)?

In the last week, while being fed in your lap, how often did the baby:
- 1 2 3 4 5 6 7 X . . . (5) seem to enjoy the closeness?
- 1 2 3 4 5 6 7 X . . . (6) snuggle even after she was done?
- 1 2 3 4 5 6 7 X . . . (7) seem eager to get away as soon as the feeding was over?

How often did your baby make talking sounds:
- 1 2 3 4 5 6 7 X . . . (8) while waiting in a high chair for food?
- 1 2 3 4 5 6 7 X . . . (9) when s/he was ready for more food?
- 1 2 3 4 5 6 7 X . . . (10) when s/he has had enough to eat?

**Sleeping**

Before falling asleep at night during the last week, how often did the baby:
- 1 2 3 4 5 6 7 X . . . (11) show no fussing or crying?

During sleep, how often did the baby:
- 1 2 3 4 5 6 7 X . . . (12) toss about in the crib?
- 1 2 3 4 5 6 7 X . . . (13) move from the middle to the end of the crib?
- 1 2 3 4 5 6 7 X . . . (14) sleep in one position only?

After sleeping, how often did the baby:
- 1 2 3 4 5 6 7 X . . . (15) fuss or cry immediately?
- 1 2 3 4 5 6 7 X . . . (16) play quietly in the crib?
- 1 2 3 4 5 6 7 X . . . (17) cry if someone doesn’t come within a few minutes?
How often did the baby:
1 2 3 4 5 6 7 X . . . (18) seem angry (crying and fussing) when you left
her/him in the crib?
1 2 3 4 5 6 7 X . . . (19) seem contented when left in the crib?
1 2 3 4 5 6 7 X . . . (20) cry or fuss before going to sleep for naps?

When going to sleep at night, how often did your baby:
1 2 3 4 5 6 7 X . . . (21) fall asleep within 10 minutes?
1 2 3 4 5 6 7 X . . . (22) have a hard time settling down to sleep?
1 2 3 4 5 6 7 X . . . (23) settle down to sleep easily?

When your baby awoke at night, how often did s/he:
1 2 3 4 5 6 7 X . . . (24) have a hard time going back to sleep?
1 2 3 4 5 6 7 X . . . (25) go back to sleep immediately?

When put down for a nap, how often did your baby:
1 2 3 4 5 6 7 X . . . (26) stay awake for a long time?
1 2 3 4 5 6 7 X . . . (27) go to sleep immediately?
1 2 3 4 5 6 7 X . . . (28) settle down quickly?
1 2 3 4 5 6 7 X . . . (29) have a hard time settling down?

When it was time for bed or a nap and your baby did not want to go, how often did s/he:
1 2 3 4 5 6 7 X . . . (30) whimper or sob?
1 2 3 4 5 6 7 X . . . (31) become tearful?

Bathing and Dressing

When being dressed or undressed during the last week, how often did the baby:
1 2 3 4 5 6 7 X . . . (32) wave her/his arms and kick?
1 2 3 4 5 6 7 X . . . (33) squirm and/or try to roll away?
1 2 3 4 5 6 7 X . . . (34) smile or laugh?
1 2 3 4 5 6 7 X . . . (35) coo or vocalize?

When put into the bath water, how often did the baby:
1 2 3 4 5 6 7 X . . . (36) smile?
1 2 3 4 5 6 7 X . . . (37) laugh?
1 2 3 4 5 6 7 X . . . (38) splash or kick?
1 2 3 4 5 6 7 X . . . (39) turn body and/or squirm?

When face was washed, how often did the baby:
1 2 3 4 5 6 7 X . . . (40) smile or laugh?
1 2 3 4 5 6 7 X . . . (41) fuss or cry?
1 2 3 4 5 6 7 X . . . (42) coo?

When hair was washed, how often did the baby:
1 2 3 4 5 6 7 X . . . (43) smile?
1 2 3 4 5 6 7 X . . . (44) fuss or cry?
1 2 3 4 5 6 7 X . . . (45) vocalize?
Play

How often during the last week did the baby:
1 2 3 4 5 6 7 X . . . (46) look at pictures in books and/or magazines for
2-5 minutes at a time?
1 2 3 4 5 6 7 X . . . (47) look at pictures in books and/or magazines for
5 minutes or longer at a time?
1 2 3 4 5 6 7 X . . . (48) stare at a mobile, crib bumper or picture for
5 minutes or longer?
1 2 3 4 5 6 7 X . . . (49) play with one toy or object for 5-10 minutes?
1 2 3 4 5 6 7 X . . . (50) play with one toy or object for 10 minutes or longer?
1 2 3 4 5 6 7 X . . . (51) spend time just looking at playthings?
1 2 3 4 5 6 7 X . . . (52) repeat the same sounds over and over again?
1 2 3 4 5 6 7 X . . . (53) laugh aloud in play?
1 2 3 4 5 6 7 X . . . (54) repeat the same movement with an object for 2
minutes or longer (e.g., putting a block in a cup, kicking
or hitting a mobile)?
1 2 3 4 5 6 7 X . . . (55) pay attention to your reading during most of the story
when looking at picture books?
1 2 3 4 5 6 7 X . . . (56) smile or laugh after accomplishing something (e.g.,
stacking blocks, etc.)?
1 2 3 4 5 6 7 X . . . (57) smile or laugh when given a toy?
1 2 3 4 5 6 7 X . . . (58) smile or laugh when tickled?

How often during the last week did the baby enjoy:
1 2 3 4 5 6 7 X . . . (59) being sung to?
1 2 3 4 5 6 7 X . . . (60) being read to?
1 2 3 4 5 6 7 X . . . (61) hearing the sound of words, as in nursery rhymes?
1 2 3 4 5 6 7 X . . . (62) looking at picture books?
1 2 3 4 5 6 7 X . . . (63) gentle rhythmic activities, such as rocking or swaying?
1 2 3 4 5 6 7 X . . . (64) lying quietly and examining his/her fingers or toes?
1 2 3 4 5 6 7 X . . . (65) being tickled by you or someone else in your family?
1 2 3 4 5 6 7 X . . . (66) being involved in rambunctious play?
1 2 3 4 5 6 7 X . . . (67) watching while you, or another adult, playfully
made faces?
1 2 3 4 5 6 7 X . . . (68) touching or lying next to stuffed animals?
1 2 3 4 5 6 7 X . . . (69) the feel of soft blankets?
1 2 3 4 5 6 7 X . . . (70) being rolled up in a warm blanket?
1 2 3 4 5 6 7 X . . . (71) listening to a musical toy in a crib?

When playing quietly with one of her/his favorite toys, how often did your baby:
1 2 3 4 5 6 7 X . . . (72) show pleasure?
1 2 3 4 5 6 7 X . . . (73) enjoy lying in the crib for more than 5 minutes?
1 2 3 4 5 6 7 X . . . (74) enjoy lying in the crib for more than 10 minutes?

When something the baby was playing with had to be removed, how often did s/he:
1 2 3 4 5 6 7 X . . . (75) cry or show distress for a time?
1 2 3 4 5 6 7 X . . . (76) seem not bothered?

307
When tossed around playfully how often did the baby:
1 2 3 4 5 6 7 X .... (77) smile?
1 2 3 4 5 6 7 X .... (78) laugh?

During a peekaboo game, how often did the baby:
1 2 3 4 5 6 7 X .... (79) smile?
1 2 3 4 5 6 7 X .... (80) laugh?

How often did your baby enjoy bouncing up and down:
1 2 3 4 5 6 7 X .... (81) while on your lap?
1 2 3 4 5 6 7 X .... (82) on an object, such as a bed, bouncer chair, or toy?

How often did the infant look up from playing:
1 2 3 4 5 6 7 X .... (83) when the telephone rang?
1 2 3 4 5 6 7 X .... (84) when s/he heard voices in the next room?

When your baby saw a toy s/he wanted, how often did s/he:
1 2 3 4 5 6 7 X .... (85) get very excited about getting it?
1 2 3 4 5 6 7 X .... (86) immediately go after it?

When given a new toy, how often did your baby:
1 2 3 4 5 6 7 X .... (87) get very excited about getting it?
1 2 3 4 5 6 7 X .... (88) immediately go after it?
1 2 3 4 5 6 7 X .... (89) seem not to get very excited about it?

**Daily Activities**

How often during the last week did the baby:
1 2 3 4 5 6 7 X .... (90) cry or show distress at a change in parents’
appearance, (glasses off, shower cap on, etc.)?
1 2 3 4 5 6 7 X .... (91) when in a position to see the television set,
look at it for 2 to 5 minutes at a time?

How often during the last week did the baby:
1 2 3 4 5 6 7 X .... (92) when in a position to see the television set,
look at it for 5 minutes or longer?
1 2 3 4 5 6 7 X .... (93) protest being placed in a confining place (infant
seat, play pen, car seat, etc)?
1 2 3 4 5 6 7 X .... (94) startle at a sudden change in body position (for
example, when moved suddenly)?
1 2 3 4 5 6 7 X .... (95) appear to listen to even very quiet sounds?
1 2 3 4 5 6 7 X .... (96) attend to sights or sounds when outdoors (for example, wind
chimes or water sprinklers)?
1 2 3 4 5 6 7 X .... (97) move quickly toward new objects?
1 2 3 4 5 6 7 X .... (98) show a strong desire for something s/he wanted?
1 2 3 4 5 6 7 X .... (99) startle to a loud or sudden noise?
1 2 3 4 5 6 7 X .... (100) look at children playing in the park or on the
playground for 5 minutes or longer?
1 2 3 4 5 6 7 X .... (101) watch adults performing household activities
(e.g., cooking, etc.) for more than 5 minutes?
1 2 3 4 5 6 7 X .... (102) squeal or shout when excited?
1 2 3 4 5 6 7 X . . . . (103) imitate the sounds you made?
1 2 3 4 5 6 7 X . . . . (104) seem excited when you or other adults acted in an excited manner around him/her?

**When being held, how often did the baby:**
1 2 3 4 5 6 7 X . . . . (105) pull away or kick?
1 2 3 4 5 6 7 X . . . . (106) seem to enjoy him/herself?
1 2 3 4 5 6 7 X . . . . (107) mold to your body?
1 2 3 4 5 6 7 X . . . . (108) squirm?

**When placed on his/her back, how often did the baby:**
1 2 3 4 5 6 7 X . . . . (109) fuss or protest?
1 2 3 4 5 6 7 X . . . . (110) smile or laugh?
1 2 3 4 5 6 7 X . . . . (111) wave arms and kick?
1 2 3 4 5 6 7 X . . . . (112) squirm and/or turn body?

**When the baby wanted something, how often did s/he:**
1 2 3 4 5 6 7 X . . . . (113) become upset when s/he could not get what s/he wanted?
1 2 3 4 5 6 7 X . . . . (114) have tantrums (crying, screaming, face red, etc.) when s/he did not get what s/he wanted?

**When placed in an infant seat or car seat, how often did the baby:**
1 2 3 4 5 6 7 X . . . . (115) wave arms and kick?
1 2 3 4 5 6 7 X . . . . (116) squirm and turn body?
1 2 3 4 5 6 7 X . . . . (117) lie or sit quietly?
1 2 3 4 5 6 7 X . . . . (118) show distress at first; then quiet down?

**When frustrated with something, how often did your baby:**
1 2 3 4 5 6 7 X . . . . (119) calm down within 5 minutes?

**When your baby was upset about something, how often did s/he:**
1 2 3 4 5 6 7 X . . . . (120) stay upset for up to 10 minutes or longer?
1 2 3 4 5 6 7 X . . . . (121) stay upset for up to 20 minutes or longer?
1 2 3 4 5 6 7 X . . . . (122) soothe her/himself with other things (such as a stuffed animal, or blanket)?

**When rocked or hugged in the last week, how often did your baby:**
1 2 3 4 5 6 7 X . . . . (123) seem to enjoy her/himself?
1 2 3 4 5 6 7 X . . . . (124) seemed eager to get away?
1 2 3 4 5 6 7 X . . . . (125) make protesting noises?

**When reuniting after having been away during the last week how often did the baby:**
1 2 3 4 5 6 7 X . . . . (126) seem to enjoy being held?
1 2 3 4 5 6 7 X . . . . (127) show interest in being close, but resisted being held?
1 2 3 4 5 6 7 X . . . . (128) show distress at being held?

**When being carried, in the last week, how often did your baby:**
1 2 3 4 5 6 7 X . . . . (129) seem to enjoy him/herself?
1 2 3 4 5 6 7 X . . . . (130) push against you until put down?
While sitting in your lap:
1 2 3 4 5 6 7 X... (131) how often did your baby seem to enjoy her/himself?
1 2 3 4 5 6 7 X... (132) how often would the baby not be content without moving around?

How often did your baby notice:
1 2 3 4 5 6 7 X... (133) low-pitched noises, air conditioner, heating system, or refrigerator running or starting up?
1 2 3 4 5 6 7 X... (134) sirens from fire trucks or ambulances at a distance?
1 2 3 4 5 6 7 X... (135) a change in room temperature?
1 2 3 4 5 6 7 X... (136) a change in light when a cloud passed over the sun?
1 2 3 4 5 6 7 X... (137) sound of an airplane passing overhead?
1 2 3 4 5 6 7 X... (138) a bird or a squirrel up in a tree?
1 2 3 4 5 6 7 X... (139) fabrics with scratchy texture (e.g., wool)?

When tired, how often was your baby:
1 2 3 4 5 6 7 X... (140) likely to cry?
1 2 3 4 5 6 7 X... (141) show distress?

At the end of an exciting day, how often did your baby:
1 2 3 4 5 6 7 X... (142) become tearful?
1 2 3 4 5 6 7 X... (143) show distress?

For no apparent reason, how often did your baby:
1 2 3 4 5 6 7 X... (144) appear sad?
1 2 3 4 5 6 7 X... (145) seem unresponsive?

How often did your baby make talking sounds when:
1 2 3 4 5 6 7 X... (146) riding in a car?
1 2 3 4 5 6 7 X... (147) riding in a shopping cart?
1 2 3 4 5 6 7 X... (148) you talked to her/him?

Two Week Time Span

When you returned from having been away and the baby was awake, how often did s/he:
1 2 3 4 5 6 7 X... (149) smile or laugh?

When introduced to an unfamiliar adult, how often did the baby:
1 2 3 4 5 6 7 X... (150) cling to a parent?
1 2 3 4 5 6 7 X... (151) refuse to go to the unfamiliar person?
1 2 3 4 5 6 7 X... (152) hang back from the adult?
1 2 3 4 5 6 7 X... (153) never “warm up” to the unfamiliar adult?

When in the presence of several unfamiliar adults, how often did the baby:
1 2 3 4 5 6 7 X... (154) cling to a parent?
1 2 3 4 5 6 7 X... (155) cry?
1 2 3 4 5 6 7 X... (156) continue to be upset for 10 minutes or longer?

When visiting a new place, how often did the baby:
1 2 3 4 5 6 7 X... (157) show distress for the first few minutes?
1 2 3 4 5 6 7 X... (158) continue to be upset for 10 minutes or more?
1 2 3 4 5 6 7 X . . . (159) get excited about exploring new surroundings?
1 2 3 4 5 6 7 X . . . (160) move about actively when s/he is exploring new surroundings?

When your baby was approached by an unfamiliar person when you and s/he were out (for example, shopping), how often did the baby:
1 2 3 4 5 6 7 X . . . (161) show distress?
1 2 3 4 5 6 7 X . . . (162) cry?

When an unfamiliar adult came to your home or apartment, how often did your baby:
1 2 3 4 5 6 7 X . . . (163) allow her/himself to be picked up without protest?
1 2 3 4 5 6 7 X . . . (164) cry when the visitor attempted to pick her/him up?

When in a crowd of people, how often did the baby:
1 2 3 4 5 6 7 X . . . (165) seem to enjoy him/herself?

Did the baby seem sad when:
1 2 3 4 5 6 7 X . . . (166) caregiver is gone for an unusually long period of time?
1 2 3 4 5 6 7 X . . . (167) left alone/unattended in a crib or a playpen for an extended period of time?

When you were busy with another activity, and your baby was not able to get your attention, how often did s/he:
1 2 3 4 5 6 7 X . . . (168) become sad?
1 2 3 4 5 6 7 X . . . (169) cry?

When your baby saw another baby crying, how often did s/he:
1 2 3 4 5 6 7 X . . . (170) become tearful?
1 2 3 4 5 6 7 X . . . (171) show distress?

When familiar relatives/friends came to visit, how often did your baby:
1 2 3 4 5 6 7 X . . . (172) get excited?
1 2 3 4 5 6 7 X . . . (173) seem indifferent?

Soothing Techniques

Have you tried any of the following soothing techniques in the last two weeks? If so, how quickly did your baby soothe using each of these techniques? Circle (X) if you did not try the technique during the LAST TWO WEEKS.

When rocking your baby, how often did s/he:
1 2 3 4 5 6 7 X . . . (174) soothe immediately?
1 2 3 4 5 6 7 X . . . (175) not soothe immediately, but in the first two minutes?
1 2 3 4 5 6 7 X . . . (176) take more than 10 minutes to soothe?

When singing or talking to your baby, how often did s/he:
1 2 3 4 5 6 7 X . . . (177) soothe immediately?
1 2 3 4 5 6 7 X . . . (178) not soothe immediately, but in the first two minutes?
1 2 3 4 5 6 7 X . . . (179) take more than 10 minutes to soothe?
When walking with the baby, how often did s/he:
1 2 3 4 5 6 7 X . . . . (180) soothe immediately?
1 2 3 4 5 6 7 X . . . . (181) not soothe immediately, but in the first two minutes?
1 2 3 4 5 6 7 X . . . . (182) take more than 10 minutes to soothe?

When giving him/her a toy, how often did the baby:
1 2 3 4 5 6 7 X . . . . (183) soothe immediately?
1 2 3 4 5 6 7 X . . . . (184) not soothe immediately, but in the first two minutes?
1 2 3 4 5 6 7 X . . . . (185) take more than 10 minutes to soothe?

When showing the baby something to look at, how often did s/he:
1 2 3 4 5 6 7 X . . . . (186) soothe immediately?
1 2 3 4 5 6 7 X . . . . (187) not soothe immediately, but in the first two minutes?
1 2 3 4 5 6 7 X . . . . (188) take more than 10 minutes to soothe?

When patting or gently rubbing some part of the baby’s body, how often did s/he:
1 2 3 4 5 6 7 X . . . . (189) soothe immediately?
1 2 3 4 5 6 7 X . . . . (190) not soothe immediately, but in the first two minutes?
1 2 3 4 5 6 7 X . . . . (191) take more than 10 minutes to soothe?
APPENDIX D

Imitation Questionnaires 9 and 12 Months

Imitation Questionnaire – 9 Months

ID: ______

1. Does your baby notice if you copy what he / she is doing (his/her movements)?

0 never 1 2 3 4 always

Does your baby notice if you copy what he / she says (sounds)?

0 never 1 2 3 4 always

2) How can you tell that he / she has noticed you copying him /her? (e.g. stops what she’s doing, looks at you, smiles more)

________________________________________________________________________

3) When you copy your baby, what kinds of things is he / she more likely to notice? (e.g. sounds, arms moving, playing with a toy)

________________________________________________________________________

4) Has your baby started to copy what other people are doing?

0 not yet 1 2 3 4 often

5) What kinds of things does your baby copy? (e.g. sounds, waving)

________________________________________________________________________

6) Is there a particular object your baby is most likely to copy the action associated with it?

________________________________________________________________________

**** IF SO, COULD YOU PLEASE BRING THIS OBJECT WITH YOU TO YOUR SESSION AT THE CHILD STUDY CENTRE? ****

7) Is there a particular action / movement / sound that DOES NOT use an object that your baby is most likely to copy?

________________________________________________________________________
8) Are there particular people (a person) your baby is more likely to copy? (e.g. mother, sister, grandfather)

___________________________________________________________________________

___________________________________________________________________________

Thank you for completing this form!

Dalhousie Centre for Child Studies 😊
12-month Imitation Questionnaire

ID: _____

IMITATION QUESTIONNAIRE!

Today’s Date (important to complete): __________________________

1. Does your baby notice if you copy what he/she is doing (his/her movements)?

   0  1  2  3  4
   never  always

2. Does your baby notice if you copy what he/she says (sounds)?

   0  1  2  3  4
   never  always

3) How can you tell that he/she has noticed you copying him/her?
(Please check all that apply)

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Yes, my baby does this</th>
<th>How often? (1 - 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>stops what he/she is doing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>looks at me</td>
<td></td>
<td></td>
</tr>
<tr>
<td>smiles more</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laughs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>repeats what he/she is doing and looks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>touches me</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4) When you copy your baby, what kinds of things is he/she more likely to notice?
(e.g. sounds, arms moving, playing with a toy)

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Yes, my baby notices this often</th>
<th>How often? (1 - 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sounds that I make give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>arms and body parts moving give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>playing with a toy give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>facial expressions give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5) Has your baby started to copy what other people are doing?

0  1  2  3  4  
not yet  often

6) What kinds of things does your baby copy?

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Yes, my baby copies this</th>
<th>How often? (1 - 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sounds that I make</td>
<td></td>
<td></td>
</tr>
<tr>
<td>give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clapping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sticking out tongue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>kissing sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>touching cheek</td>
<td></td>
<td></td>
</tr>
<tr>
<td>touching head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>touching nose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>touching ear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>putting hands over eyes (like in Peek-a-boo)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dancing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>throwing a ball</td>
<td></td>
<td></td>
</tr>
<tr>
<td>making a plane fly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pushing a toy car or truck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>playing with a toy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>playing with a toy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>knocking over blocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>kissing or hugging a doll</td>
<td></td>
<td></td>
</tr>
<tr>
<td>putting a doll to bed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>brushing / combing a doll's hair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>feeding a doll or stuffed animal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wiping a doll's face or hands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>talking to a doll or stuffed animal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>facial expressions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7) What kinds of activities around the home does your baby copy or try to copy?

<table>
<thead>
<tr>
<th>Activity (using real or toy implements)</th>
<th>Yes, my baby copies this often</th>
<th>How often? (1–4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sweeping with a broom or mop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>putting a key in a door or lock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pounding with a hammer or mallet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>attempting to use a saw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>typing at a typewriter or computer keyboard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>read (opens book, turns page)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>play musical instrument (i.e. piano, drum)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dry dishes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>clean with a cloth or duster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>write with a pen, pencil, marker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dig with a shovel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>raking the yard / mowing the yard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>putting on glasses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>feeding a family pet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>setting the table</td>
<td></td>
<td></td>
</tr>
<tr>
<td>putting away laundry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>talking on the phone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>stirring something in a bowl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>spreading jam/peanut butter on bread</td>
<td></td>
<td></td>
</tr>
<tr>
<td>serving food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>give example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>putting on make up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: (specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8) Is there a **particular object** your baby is most likely to copy the action associated with it?

9) Is there a **particular action/movement/sound** that **DOES NOT** use an object that
your baby is most likely to copy?

10) Are there particular people (a person) your baby is more likely to copy? (e.g. mother, sister, grandfather)

11) Has your baby started to do “delayed imitation” (after a delay of at least 10 minutes, your baby copies something he/she saw someone do)?

0 not yet 1 2 3 4 often

12) Has your baby shown “delayed imitation” after a period of (check all that apply):

10 minutes ______
30 minutes ______
one hour ______
a few hours ______
a day ______
a few days ______

13) What kinds of behaviours/actions/sounds has your baby copied after a delay of at least 10 minutes? (if your baby does delayed imitation, list some examples)


14) Is there anything else you have noticed about your baby’s imitation that we haven’t asked you about and you would like to comment on?


Thank you for completing this questionnaire! Enclosed you will find a return envelope to mail it back to the Dalhousie Centre for Child Studies. When we have group results from the study ready, we will mail you a summary of our findings. Thank you for participating… we’re very glad you could join us.

Shana Nichols, Teri Phillips, Nicolle Vincent, Dr. Isabel Smith, Dr. Chris Moore
### APPENDIX E

**Description of Measures Coded During the 9 Month Play Session**

<table>
<thead>
<tr>
<th>Category</th>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imitation</td>
<td>Number of times the infant spontaneously imitates her mother during play</td>
<td>Frequency of infant attempts to imitate her mother (sound or gesture or action on object) during the play session.</td>
</tr>
<tr>
<td></td>
<td>Number of times mother spontaneously imitates her infant during play</td>
<td>Frequency of mother’s imitations of her infant’s sounds, gestures, or actions on objects during the play session.</td>
</tr>
<tr>
<td></td>
<td>Number of times mother “sets up” a situation for her infant to imitate her during play</td>
<td>Mother sets up a situation for her infant to engage in imitation. May include: performing an action on a toy and handing the toy to her infant, doing an action and then pausing and looking at her infant (e.g. clapping).</td>
</tr>
<tr>
<td>Joint Engagement</td>
<td>Number of times mother makes a “bid” for joint engagement with her infant during play</td>
<td>Mother attempts a joint engagement bid with infant. She looks at a toy, then her infant, then back to the toy.</td>
</tr>
<tr>
<td>Physical Directing of Attention</td>
<td>Number of times mother moves a toy into her infant’s line of sight during play</td>
<td>Mother physically picks up / moves a toy in front of her infant.</td>
</tr>
<tr>
<td></td>
<td>Number of times mother points to a toy during play</td>
<td>Mother points to a toy during play</td>
</tr>
<tr>
<td></td>
<td>Number of times mother demonstrates how a toy works during play</td>
<td>Mother performs an action on a toy with the purpose of showing her infant how it works.</td>
</tr>
<tr>
<td></td>
<td>Number of times mother physically positions her infant to facilitate visual/tactual exploration during play</td>
<td>Mother physically moves her infant into a better position for playing with a toy.</td>
</tr>
<tr>
<td>Verbal Directing of Attention</td>
<td>Number of times mother calls her infant’s name during play</td>
<td>Mother calls her infant’s name during the play session.</td>
</tr>
<tr>
<td></td>
<td>Number of times mother says “look” during play</td>
<td>Mother says “look” during the play session.</td>
</tr>
<tr>
<td></td>
<td>Number of times mother names the toy during play</td>
<td>Mother names the toy during the play session.</td>
</tr>
<tr>
<td></td>
<td>Number of times mother makes sound effects or exclamatory comments during play</td>
<td>Mother makes sound effects or exclamatory comments during play.</td>
</tr>
<tr>
<td></td>
<td>Number of times mother describes the qualities/properties of the toy during play</td>
<td>Mother describes the toy’s qualities/properties during play.</td>
</tr>
<tr>
<td>Activity Level</td>
<td>Motoric activity level</td>
<td>Amount of time the infant spent seated during the 3-minute play session.</td>
</tr>
<tr>
<td></td>
<td>Number of times the infant moved from being</td>
<td>Number of times the infant moved from being.</td>
</tr>
<tr>
<td>Category</td>
<td>Measure</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Breadth of Play</td>
<td>Number of toys</td>
<td>The number of toys the infant played with during the play session</td>
</tr>
<tr>
<td>Infant Ratings</td>
<td>Rating of infant’s enjoyment (1-4)</td>
<td>Rating of how much infants appeared to enjoy the play session (e.g. smiles, plays with the toys, positive vocalizations)</td>
</tr>
<tr>
<td></td>
<td>Rating of infant’s engagement (0-2)</td>
<td>Rating of how much infants appeared engaged with their mother during the play session (e.g. makes eye contact with their mother, sense of a shared play experience)</td>
</tr>
<tr>
<td>Maternal Ratings</td>
<td>Rating of mother’s following of their infant’s play (1-3)</td>
<td>Rating of how well mothers were able to follow their infant’s play (e.g. intrusive and directive versus attentive to infant’s interests and adapts own activity to maintain focus with their infant).</td>
</tr>
<tr>
<td></td>
<td>Rating of mother’s scaffolding of their infant’s play (1-3)</td>
<td>Rating of how well mothers were able to scaffold their infant’s play (e.g. passive involvement versus active facilitation of infant’s play with verbal encouragement).</td>
</tr>
</tbody>
</table>
APPENDIX F

Informed Consent Documents at 4 and 9 Months

Consent Form – 4-Month Visit

Title – Information Processing Abilities and Parent-Child Interaction: Prediction of Imitative Ability in the First Year

Principal Investigator and Contact Person -  
Shana Nichols  
Ph.D. Student  
Clinical Psychology  
Dalhousie University  
Department of Psychology  
Halifax, Nova Scotia  
B3H 4J1  
(902) 494-3480 (lab)  
snichol2@is2.dal.ca

Supervisors -  
Isabel Smith, Ph.D  
Clinical Psychologist  
IWK Grace Health Centre  
and Dalhousie University  
Departments of Pediatrics and Psychology  
Halifax, Nova Scotia  
B3H 4J1  
(902) 428 3271  
isabel.smith@iwk.nshealth.ca

Chris Moore, Ph.D  
Dalhousie University  
Department of Psychology  
Halifax, Nova Scotia  
B3H 4J1  
(902) 494-3458  
moorec@is.dal.ca

Please feel free to use this contact information if, at any time, you require additional information or clarification about the procedure or other details of this study.

Thank you,

Shana Nichols
Title: Information Processing Abilities and Parent-Child Interaction: Prediction of Imitative Ability in the First Year

Dear Parents,

We invite you and your child to take part in a research study at the Dalhousie Centre for Child Studies here at Dalhousie University. Taking part in this study is voluntary and you may withdraw from the study at any time. The study is described below. This description tells you about what you will be asked to do, and any risks, inconvenience, or discomfort that you might experience. Participating in the study might not benefit you, but we might learn things that will benefit others. You should discuss any questions you have about this study with the people who explain it to you.

Purpose of the Study

The purpose of this study is to look at thinking abilities and interactions with parents in 4-month-olds. We want to see if the way babies think and how they play with and interact with their parents are important for how well they can copy people’s actions when they are 9 months old. Being able to copy another person’s actions, is an important skill babies use to learn about the world around them. For example, they discover what they can do with different kinds of objects such as spoons, blocks, cups, and squeaky toys. Typically, young children learn a great deal about the people and objects in the world around them by watching what others do and copying their actions. We think that a number of thinking abilities in babies and the way that parents interact with their baby are important contributors to a baby’s ability to watch others and copy what they do.

Study Design

This study is a longitudinal study. This means that we see the same seventy infants when they are 4 months of age and again when they are 9 months of age. It allows us to see if how they do on the tasks at 4 months predicts how well they will do on the tasks at 9 months, particularly the imitation task.

Who Can Participate in the Study? You and your child may participate if:
1. Your child had an Apgar score of 7 or higher at birth.
2. Your child was born full term and there were no serious medical complications at birth.
3. Your child was born with a birth weight of 2500 grams or more.
4. Your child has no known visual, hearing, or motor problems.
5. Your child does not have any serious medical conditions.

The principal investigator will determine whether you and your child are eligible to participate by conducting a short screening questionnaire with you over the telephone.

Who Will Be Conducting the Study?

The study will be conducted by Shana Nichols, a Ph.D. Student in Clinical Psychology at Dalhousie University. She is working under the supervision of Dr. Isabel Smith, Clinical Psychologist, from the IWK Grace Health Centre, and Dr. Chris Moore from Dalhousie University. You and your child will be interacting with Shana during the study. Shana will have an assistant who will be watching the session, controlling the video camera, and recording responses.
Title: Information Processing Abilities and Parent-Child Interaction: Prediction of Imitative Ability in the First Year

What You and Your Child Will Be Asked to Do

Participation in this study involves two visits to the Dalhousie Centre for Child Studies, one when your child is approximately 4 months old, the other when your child is approximately 9 months old. You and your child will be asked to take part in similar activities at both of these visits. Some tasks your child will be doing with Shana while you watch. Other tasks you will be doing with your child and with Shana. You will also have some questionnaires to complete on your own.

When you bring your child to the Centre for Child Studies, you will read this consent form and talk with Shana about what will happen during the session. After your questions have been answered, the session will take place in two parts.

Part One

Your child will first complete two tasks while seated in an infant seat. You will be able to sit near your child, but out of sight. In the first task, we will show patterns that appear in different areas of a slide projector screen. We will look to see when your child looks away from a pattern directly in front to one that appears off to one side.

For the next task, your child will be seated in an infant seat in front of two video monitors. On one screen there will be a live recording of your baby’s legs while he/she sits in the seat. The other will be the taped recording of another child who participated. We will videotape your child so that we can measure at which television screen your baby looks. The second set of pictures your baby will see on the television screen are of a clear glass jar containing marbles being shaken, and a spoon banging against the bottom of a bowl. The soundtrack will match one of the images. Again, we will measure your child’s looking.

Part Two

After a break, you and your child will participate in a play session. For part of the time we will ask you to play with your baby as you would at home. Shana will then instruct you on certain ways she would like you to play with your child. Your child will also interact with Shana; he or she will be seated in a high chair and presented with some objects to explore. When your child is 9 months old, the final task will involve your child, you, and Shana. Shana will demonstrate some actions to your child that she would like your child to copy. Some of these actions will be hand and face movements or sounds such as wave bye, clap, stick out tongue, say “ba ba ba”, while others will be actions with objects, such as knock over a block, push a button, shake a rattle. After Shana has demonstrated the actions, you will be asked to try to get your child to copy you.

Possible Risks and Discomforts

We know of no risks to participating in this study. You will be with your child at all times. The only discomforts we can foresee are if your child objects to sitting in the high chair or infant seat, or if he/she becomes fatigued or upset during the testing session. To reduce this possibility, your child will be given breaks after each task as needed. The session will be discontinued if your child becomes upset, or you wish to stop for any reason. The visit can be rescheduled for another time if you wish to do so.
Title: Information Processing Abilities and Parent-Child Interaction: Prediction of Imitative Ability in the First Year

Possible Benefits
Although we don’t expect your child to benefit directly from participating in this research, we do expect the experience of interacting with the experimenter to be enjoyable for him or her. The study also gives you and your child the opportunity to benefit others in that the results of the study may provide useful information about how infants think and communicate and what abilities are important for them to become skilled at copying others’ actions and learning about their world. Through participating in this study and talking with the investigators, you may also learn more about how infants think and interact with others and their environment.

Compensation
There will be no monetary compensation for this project. Your child will receive a toy at the end of each visit to thank him/her for participating. You will also receive a Centre for Child Studies infant t-shirt and a certificate of appreciation at the end of the second visit!

Confidentiality
After you and your child complete the study, both of your names will be removed from all information and replaced with numbers. In addition, information from this study, including videotapes, questionnaires, and response sheets will be kept in a locked filing cabinet that only the staff directly involved in the research will be able to access.

Questions
As noted on the title page, you may contact Shana Nichols or Dr. Isabel Smith if you have any questions or concerns about this study at any time. In addition, you will be provided with any new information that might affect your decision to participate in the study.

Follow-up
At the outset of this study, you will receive a copy of this consent form for your records. In addition, you will be provided with a summary of the findings from this study as soon as they become available. After your 4-month visit, you will be contacted by Shana Nichols to arrange a time to participate for the 9-month visit. This will be a phone contact and will happen when your baby is approximately 8-8.5 months old.

Termination
You have the right to stop participating in the study at any time.

Problems or Concerns
In the event that you have any difficulties or wish to voice concerns about any aspect of your participation in this study, you may contact the Human Research Ethics / Integrity Coordinator at Dalhousie University’s Office of Human Research Ethics and Integrity for assistance: (902) 494-1462.
Title: Information Processing Abilities and Parent-Child Interaction: Prediction of Imitative Ability in the First Year

Signatures

I have been given the opportunity to read the explanation for this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby give consent for my child, ____________________, and I, ____________________, to participate in this study. However, I realize that our participation is voluntary and that we may withdraw from the study at any time.

_________________________________________  ____________
Signature of Parent            Date

_____________________________  __________________________  ____________
Researcher's Name            Signature of Researcher            Date

Consent to videotape: I understand that my child and I will be videotaped when we complete the tasks and that the sole purpose of videotaping is to be able to code behaviour that takes place during the session. I was informed of these purposes and I consent to this procedure.

_________________________________________  ____________
Signature of Parent            Date

_____________________________  __________________________  ____________
Researcher's Name            Researcher's Signature            Date
Dear Parents,

Welcome back! We’re thrilled you could join us again. We’re sure a lot has changed since your last visit!

We wanted to review with you what will happen during this visit. Most of the activities are the same as last time - watching colourful patterns on a screen, watching different images on television, playing with objects, having a play session.

We do have two new tasks that we’d like to tell you about. The first one is an imitation task, where we will try to get your baby to copy us doing some simple actions (i.e. tapping a table). The second one is a gaze-following task. In this task, we will try to get your baby to follow where we are looking by turning our heads towards a fun toy that is located on the wall. In both of these tasks, you may be asked to participate and see if you can get your baby to copy you, or follow your gaze. We don’t expect the babies to be successful at all parts of these tasks. These skills (imitating and following gaze) are just emerging at 9 months!!

If you have any questions about anything, please ask. We will walk you through each of the tasks as we go along and will explain what we’re doing. We hope it will be fun and a learning experience for both of you!

We are also interested in learning how your baby’s imitation skills develop over the next 3 months. We have a short questionnaire that we would like to mail to you when your baby is 12 months of age, and have you complete and mail back to us. Please indicate below whether you would be interested and willing to complete this questionnaire.

Yes __________ No __________

Has your address changed? ____________________________

__________________________

__________________________

I hereby give consent for my child, ________________________, and I, ________________________, to participate in this study. However, I realize that our participation is voluntary and that we may withdraw from the study at any time.
<table>
<thead>
<tr>
<th>Signature of Parent</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature of Researcher</td>
<td>Date</td>
</tr>
</tbody>
</table>

**Consent to videotape:** I understand that my child and I will be videotaped when we complete the tasks and that the sole purpose of videotaping is to be able to code behaviour that takes place during the session. I was informed of these purposes and I consent to this procedure.

<table>
<thead>
<tr>
<th>Signature of Parent</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher’s Signature</td>
<td>Date</td>
</tr>
</tbody>
</table>

Thank you!

*Dalhousie Centre for Child Studies ©*
APPENDIX G

Questions on the KIDS and the MacArthur That Comprise the Secondary Imitation Scores

Table G1

**Questionnaire Measures**

<table>
<thead>
<tr>
<th>KIDS Imitation Questions (0-5) for each set</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imitates familiar actions of mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imitates “ma-ma” or “da-da”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Able to copy sounds</td>
<td>3.59</td>
<td>1.35</td>
</tr>
<tr>
<td>Copies simple actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mimics the facial expressions of an adult</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tries to repeat words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imitates pat-a-cake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imitates an action of an adult long after it occurred</td>
<td>1.73</td>
<td>1.42</td>
</tr>
<tr>
<td>Repeats words when asked to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imitates another child</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MacArthur Imitation Questions (0-15)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweep with broom or mop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Put key in door or lock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pound with hammer or mallet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attempt to use saw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Type” at a typewriter or computer keyboard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Read” (opens book, turns page)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water plants</td>
<td>1.51</td>
<td>1.69</td>
</tr>
<tr>
<td>Play musical instrument (e.g., piano, trumpet)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Drive” car by turning steering wheel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wash dishes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean with cloth or duster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write with a pen, pencil, or marker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dig with a shovel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Put on glasses</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: N = 72 for MacArthur imitation; N = 69 for simple KIDS imitation; N = 67 for complex KIDS imitation*
APPENDIX H

Detailed Findings from the IBQ-R

Age and sex differences

Age and sex differences in temperament were examined using a 2 (Age: 4 and 9 months) x 2 (Sex: Male and Female) repeated measures MANOVA. An overall main effect of Age was found ($F(14,57) = 20.89, p < .0005$), with significant age effects emerging for a number of subscales including Activity Level, Fear, Duration of Orienting, High Intensity Pleasure, Low Intensity Pleasure, Distress to Limitations, Cuddliness/Affiliation, Perceptual Sensitivity, Approach, and Vocal Reactivity (see Table H1). Older infants received higher scores on Activity Level, Fear, High Intensity Pleasure, Distress to Limitations, Perceptual Sensitivity, Approach, and Vocal Reactivity. Young infants' scores were higher for Low Intensity Pleasure, Duration of Orienting, and Cuddliness/Affiliation. Age differences were not found for Smiling and Laughter, Soothability, Rate of Falling Reactivity, and Sadness.

An overall effect of Sex was not found ($F(1,57) = .85, p > n.s.$), however it was expected that sex differences would exist for a number of individual subscales. Simple ANOVAs were examined for sex differences and a single finding emerged for the High Intensity Pleasure subscale ($F(1,70) = 6.16, p < .02$). Male infants obtained higher scores ($M = 5.87, SE = .11$) than female infants ($M = 5.48, SE = .11$). As expected, the interaction between Age and Sex did not reach statistical significance.

Gartstein and Rothbart’s (2003) analysis of the factor structure of the IBQ-R yielded three broad factors: (1) Surgency/Extraversion, including loadings for Approach, Vocal Reactivity, High Intensity Pleasure, Smiling and Laughter, Activity Level, and
Perceptual Sensitivity; (2) Negative Affectivity, with loadings for Sadness, Distress to Limitations, Fear, and negatively for Falling Reactivity; and (3) Orienting/Regulation, comprised of loadings for Low Intensity Pleasure, Cuddliness/Affiliation, Duration of Orienting, Soothability, and a secondary loading for Smiling and Laughter. As in Gartstein and Rothbart (2003), factor scores for these three broad dimensions were created by summing the scores for the subscales that loaded onto each of the factors.

Developmental and sex differences were then examined for the three broad factors using a 2 (age: 4- and 9-months) x 2 (Sex: Male and Female) repeated measures MANOVA. An overall main effect of Age was found \( (F(3,68) = 75.35, p < .0005) \). Significant age differences emerged for all three broad temperament factors: Surgency/Extraversion \( (F(1,70) = 131.25, p < .0005) \); Negativity \( (F(1,70) = 16.38, p < .0005) \); and Orienting/Regulation \( (F(1,70) = 13.47, p < .0005) \). Younger infants had lower mean scores for Surgency/Extraversion (4 months: \( M = 25.27, SD = .52 \); 9 months: \( M = 29.76; SD = .34 \)) and Negativity (4 months: \( M = 10.28, SD = .26 \); 9 months: \( M = 11.42, SD = .31 \)), and had a higher mean score for Orienting/Regulation (4 months: \( M = 24.96, SD = .36 \); 9 months: \( M = 23.80, SD = .34 \)). As expected, the effect of sex and the interaction between age and sex were not significant.

**Relationships Among IBQ-R Subscales**

Relationships among the 14 IBQ-R subscales and among the 3 composite temperament factors were examined. At both 4 and 9 months, low to moderate correlations were found across the three broad factors (see Table H2). Scores at 4 months were highly correlated with 9-month scores for each of the individual factors.
Surgency/Extraversion and Orienting/Regulation had the highest concurrent (at both 4 and 9 months) and longitudinal associations.

Relationships between the 14 individual subscales were examined at each age and longitudinally. At 4 months, a number of moderate and significant correlations between the subscales were found (See Table H3). In particular, Smiling and Laughter was most strongly related to both High and Low Intensity Pleasure, Vocal Reactivity, and Approach. Distress to Limitations was negatively related to Rate of Falling Reactivity, and positively related to Sadness. At 9 months, similar relationships were found for Distress to Limitations, however Smiling and Laughter was no longer strongly related to the other subscales. Low Intensity Pleasure at 9 months was positively associated with Duration of Orienting and High Intensity Pleasure.

Longitudinal associations among subscales were also examined. For each of the 14 subscales, across-age relationships were addressed. For a number of subscales, scores at 4 months were significantly associated with scores at 9 months, indicating a developmental stability in the construct being measured. The strongest across-age relationships were for Smiling and Laughter, Perceptual Sensitivity, and Duration of Orienting (See Table H4).

Findings of concurrent and longitudinal relationships in the current study are similar to those reported by Gartstein & Rothbart (2003). Although a number of sex differences in the strength of the relationships were noted in the current study, exploration of these differences was not the focus of these analyses.
Table H1

*IBQ-R Age comparisons: 4 and 9 months of age (N = 72)*

<table>
<thead>
<tr>
<th>Temperment Variable</th>
<th>4 Months</th>
<th>9 Months</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity Level</td>
<td>M 3.76</td>
<td>4.45</td>
<td>36.59**</td>
</tr>
<tr>
<td></td>
<td>SD .90</td>
<td>.94</td>
<td></td>
</tr>
<tr>
<td>Distress to Limitations</td>
<td>M 3.17</td>
<td>3.74</td>
<td>28.41**</td>
</tr>
<tr>
<td></td>
<td>SD .77</td>
<td>.97</td>
<td></td>
</tr>
<tr>
<td>Fear</td>
<td>M 2.02</td>
<td>2.46</td>
<td>19.07**</td>
</tr>
<tr>
<td></td>
<td>SD .72</td>
<td>.88</td>
<td></td>
</tr>
<tr>
<td>Duration of Orienting</td>
<td>M 4.23</td>
<td>3.73</td>
<td>18.03**</td>
</tr>
<tr>
<td></td>
<td>SD 1.04</td>
<td>.97</td>
<td></td>
</tr>
<tr>
<td>Smiling and Laughter</td>
<td>M 4.69</td>
<td>4.87</td>
<td>2.93</td>
</tr>
<tr>
<td></td>
<td>SD 1.05</td>
<td>.75</td>
<td></td>
</tr>
<tr>
<td>High Intensity Pleasure</td>
<td>M 5.35</td>
<td>5.98</td>
<td>34.46**</td>
</tr>
<tr>
<td></td>
<td>SD .94</td>
<td>.67</td>
<td></td>
</tr>
<tr>
<td>Low Intensity Pleasure</td>
<td>M 5.33</td>
<td>4.92</td>
<td>14.69**</td>
</tr>
<tr>
<td></td>
<td>SD .84</td>
<td>.84</td>
<td></td>
</tr>
<tr>
<td>Soothability</td>
<td>M 4.82</td>
<td>5.03</td>
<td>3.72</td>
</tr>
<tr>
<td></td>
<td>SD .73</td>
<td>.74</td>
<td></td>
</tr>
<tr>
<td>Falling Reactivity/Rate of Recovery</td>
<td>M 5.21</td>
<td>5.17</td>
<td>.09</td>
</tr>
<tr>
<td>from Distress</td>
<td>SD .88</td>
<td>.94</td>
<td></td>
</tr>
<tr>
<td>Cuddliness/Affiliation</td>
<td>M 5.87</td>
<td>5.25</td>
<td>39.99**</td>
</tr>
<tr>
<td></td>
<td>SD .65</td>
<td>.90</td>
<td></td>
</tr>
<tr>
<td>Perceptual Sensitivity</td>
<td>M 3.34</td>
<td>4.11</td>
<td>38.26**</td>
</tr>
<tr>
<td></td>
<td>SD 1.25</td>
<td>1.09</td>
<td></td>
</tr>
<tr>
<td>Sadness</td>
<td>M 3.30</td>
<td>3.38</td>
<td>.56</td>
</tr>
<tr>
<td></td>
<td>SD .91</td>
<td>.83</td>
<td></td>
</tr>
<tr>
<td>Approach</td>
<td>M 3.94</td>
<td>5.51</td>
<td>123.54**</td>
</tr>
<tr>
<td></td>
<td>SD 1.27</td>
<td>.68</td>
<td></td>
</tr>
<tr>
<td>Vocal Reactivity</td>
<td>M 4.18</td>
<td>4.82</td>
<td>32.69**</td>
</tr>
<tr>
<td></td>
<td>SD .97</td>
<td>.81</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* Degrees of freedom were (1,70) for all comparisons.

**p < .0005.
Table H2

Concurrent and longitudinal intercorrelations between temperament composite scores
(N = 88 at 4 months, 73 at 9 months)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgency/Extraversion</td>
<td>—</td>
<td>-.03</td>
<td>.63**</td>
<td>.66**</td>
<td>-.06</td>
<td>.48**</td>
</tr>
<tr>
<td>4 Months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Affectivity</td>
<td>—</td>
<td>-.24*</td>
<td>.03</td>
<td>.51**</td>
<td>-.29*</td>
<td></td>
</tr>
<tr>
<td>4 Months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orienting/Regulation</td>
<td>—</td>
<td>.42**</td>
<td>-.24*</td>
<td>.59**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgency/Extraversion</td>
<td>—</td>
<td>-.05</td>
<td>.59**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Affectivity</td>
<td>—</td>
<td></td>
<td>-.27*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: *p < .05. **p < .0005.
<table>
<thead>
<tr>
<th>IBQ-R Subscale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Activity Level</td>
<td></td>
<td>.14</td>
<td>.19</td>
<td>.07</td>
<td>.36**</td>
<td>.31*</td>
<td>.00</td>
<td>.00</td>
<td>-.41***</td>
<td>-.48***</td>
<td>.24</td>
<td>.33*</td>
<td>.47***</td>
<td>.13</td>
</tr>
<tr>
<td>2. Distress to Limitations</td>
<td>.08</td>
<td>—</td>
<td>.26</td>
<td>-.09</td>
<td>-.40***</td>
<td>-.13</td>
<td>-.20</td>
<td>-.41***</td>
<td>-.63</td>
<td>-.39**</td>
<td>-.08</td>
<td>.67</td>
<td>-.22</td>
<td>-.06</td>
</tr>
<tr>
<td>3. Fear</td>
<td>.23</td>
<td>.22</td>
<td>—</td>
<td>.07</td>
<td>.16</td>
<td>.06</td>
<td>-.06</td>
<td>.00</td>
<td>-.20</td>
<td>.02</td>
<td>.24</td>
<td>.27</td>
<td>.11</td>
<td>.35*</td>
</tr>
<tr>
<td>4. Duration of Orienting</td>
<td>.18</td>
<td>.10</td>
<td>.05</td>
<td>—</td>
<td>.35</td>
<td>.14</td>
<td>.62</td>
<td>.38**</td>
<td>.01</td>
<td>.12</td>
<td>.09</td>
<td>-.04</td>
<td>.27</td>
<td>.33*</td>
</tr>
<tr>
<td>5. Smiling and Laughter</td>
<td>.10</td>
<td>-.07</td>
<td>.13</td>
<td>.37*</td>
<td>—</td>
<td>.53</td>
<td>.44**</td>
<td>.48***</td>
<td>.10</td>
<td>.18</td>
<td>.27</td>
<td>-.19</td>
<td>.68</td>
<td>.53*</td>
</tr>
<tr>
<td>6. High Intensity Pleasure</td>
<td>.12</td>
<td>-.17</td>
<td>.05</td>
<td>.31*</td>
<td>.61</td>
<td>—</td>
<td>.28</td>
<td>.39**</td>
<td>.00</td>
<td>-.09</td>
<td>.17</td>
<td>-.21</td>
<td>.53</td>
<td>.37*</td>
</tr>
<tr>
<td>7. Low Intensity Pleasure</td>
<td>.12</td>
<td>-.09</td>
<td>.04</td>
<td>.40**</td>
<td>.59</td>
<td>.51</td>
<td>—</td>
<td>.44**</td>
<td>.17</td>
<td>.30</td>
<td>.12</td>
<td>-.23</td>
<td>.37</td>
<td>.28</td>
</tr>
<tr>
<td>8. Soothability</td>
<td>.23</td>
<td>-.44**</td>
<td>.12</td>
<td>.15</td>
<td>.28</td>
<td>.26</td>
<td>.25</td>
<td>—</td>
<td>.36*</td>
<td>.36*</td>
<td>.19</td>
<td>-.45**</td>
<td>.29</td>
<td>.36*</td>
</tr>
<tr>
<td>9. Rate of Falling Reactivity</td>
<td>.05</td>
<td>-.57</td>
<td>-.13</td>
<td>-.02</td>
<td>.10</td>
<td>.16</td>
<td>.18</td>
<td>.32*</td>
<td>—</td>
<td>.46**</td>
<td>.29</td>
<td>-.63</td>
<td>.08</td>
<td>.18</td>
</tr>
<tr>
<td>10. Cuddliness</td>
<td>-.39**</td>
<td>-.06</td>
<td>-.08</td>
<td>.06</td>
<td>.15</td>
<td>.07</td>
<td>.49***</td>
<td>.01</td>
<td>.11</td>
<td>—</td>
<td>-.16</td>
<td>-.50***</td>
<td>.10</td>
<td>.08</td>
</tr>
<tr>
<td>11. Perceptual Sensitivity</td>
<td>.23</td>
<td>.32*</td>
<td>.35*</td>
<td>.27</td>
<td>.43**</td>
<td>.31*</td>
<td>.25</td>
<td>.12</td>
<td>-.08</td>
<td>-.06</td>
<td>—</td>
<td>.01</td>
<td>.43**</td>
<td>.53*</td>
</tr>
<tr>
<td>12. Sadness</td>
<td>.07</td>
<td>.32*</td>
<td>.18</td>
<td>.08</td>
<td>.19</td>
<td>-.41**</td>
<td>-.11</td>
<td>-.33</td>
<td>-.27</td>
<td>-.03</td>
<td>.00</td>
<td>—</td>
<td>-.01</td>
<td>-.01</td>
</tr>
<tr>
<td>13. Vocal Reactivity</td>
<td>.28</td>
<td>-.07</td>
<td>.11</td>
<td>.38**</td>
<td>.52</td>
<td>.41**</td>
<td>.51***</td>
<td>.32*</td>
<td>.19</td>
<td>.12</td>
<td>.36*</td>
<td>-.09</td>
<td>—</td>
<td>.51*</td>
</tr>
<tr>
<td>14. Approach</td>
<td>.22</td>
<td>-.08</td>
<td>.09</td>
<td>.50***</td>
<td>.52</td>
<td>.31*</td>
<td>.46**</td>
<td>.24</td>
<td>.25</td>
<td>-.01</td>
<td>.34*</td>
<td>-.11</td>
<td>.39**</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: Values below the diagonal represent correlation coefficients for female infants (n = 44); correlations for male infants (n = 44) lie above the diagonal.

*p < .05. **p < .01. ***p < .001. ¹p < .0005.
Table H4

Concurrent Correlations Among the 14 IBQ-R Subscales at 9 Months

<table>
<thead>
<tr>
<th>IBQ-R Subscale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Activity Level</td>
<td>—</td>
<td>.39*</td>
<td>.04</td>
<td>-.12</td>
<td>.19</td>
<td>.16</td>
<td>-.14</td>
<td>.12</td>
<td>-.16</td>
<td>-.36*</td>
<td>-.18</td>
<td>.42**</td>
<td>.13</td>
<td>.10</td>
</tr>
<tr>
<td>2. Distress to Limitations</td>
<td>.12</td>
<td>—</td>
<td>.25</td>
<td>-.09</td>
<td>-.13</td>
<td>.25</td>
<td>-.29</td>
<td>-.10</td>
<td>-.55***</td>
<td>-.23</td>
<td>-.05</td>
<td>.52***</td>
<td>.03</td>
<td>.10</td>
</tr>
<tr>
<td>3. Fear</td>
<td>.35*</td>
<td>.11</td>
<td>—</td>
<td>.09</td>
<td>.11</td>
<td>.18</td>
<td>.10</td>
<td>-.24</td>
<td>-.25</td>
<td>.12</td>
<td>-.01</td>
<td>.20</td>
<td>-.03</td>
<td>-.24</td>
</tr>
<tr>
<td>4. Duration of Orienting</td>
<td>.14</td>
<td>-.16</td>
<td>-.18</td>
<td>—</td>
<td>.02</td>
<td>.49**</td>
<td>.34*</td>
<td>.18</td>
<td>.11</td>
<td>.24</td>
<td>.29</td>
<td>-.32</td>
<td>.34*</td>
<td>.22</td>
</tr>
<tr>
<td>5. Smiling and Laughter</td>
<td>.12</td>
<td>-.25</td>
<td>-.23</td>
<td>.57i</td>
<td>—</td>
<td>.30</td>
<td>.12</td>
<td>.29</td>
<td>-.02</td>
<td>.32</td>
<td>.11</td>
<td>.07</td>
<td>.21</td>
<td>.13</td>
</tr>
<tr>
<td>6. High Intensity Pleasure</td>
<td>.08</td>
<td>-.22</td>
<td>-.26</td>
<td>.51***</td>
<td>.21</td>
<td>—</td>
<td>.46**</td>
<td>.10</td>
<td>.17</td>
<td>.25</td>
<td>.03</td>
<td>-.02</td>
<td>.38*</td>
<td>.40*</td>
</tr>
<tr>
<td>7. Low Intensity Pleasure</td>
<td>.16</td>
<td>-.22</td>
<td>-.29</td>
<td>.66i</td>
<td>.55i</td>
<td>.58i</td>
<td>—</td>
<td>.26</td>
<td>.44**</td>
<td>.33*</td>
<td>.16</td>
<td>-.25</td>
<td>.41*</td>
<td>.15</td>
</tr>
<tr>
<td>8. Soothability</td>
<td>-.15</td>
<td>-.10</td>
<td>-.25</td>
<td>.17</td>
<td>.35*</td>
<td>-.08</td>
<td>.24</td>
<td>—</td>
<td>.16</td>
<td>.43**</td>
<td>.09</td>
<td>-.23</td>
<td>.25</td>
<td>.11</td>
</tr>
<tr>
<td>9. Rate of Falling Reactivity</td>
<td>-.09</td>
<td>-.47**</td>
<td>.07</td>
<td>.09</td>
<td>.04</td>
<td>.17</td>
<td>.11</td>
<td>-.02</td>
<td>—</td>
<td>.02</td>
<td>-.18</td>
<td>.48**</td>
<td>.21</td>
<td>.13</td>
</tr>
<tr>
<td>10. Cuddliness</td>
<td>.15</td>
<td>-.01</td>
<td>-.06</td>
<td>.33*</td>
<td>.56i</td>
<td>.26</td>
<td>.37*</td>
<td>.32</td>
<td>-.06</td>
<td>—</td>
<td>.28</td>
<td>-.24</td>
<td>.21</td>
<td>.14</td>
</tr>
<tr>
<td>11. Perceptual Sensitivity</td>
<td>.15</td>
<td>-.07</td>
<td>.03</td>
<td>.32</td>
<td>.19</td>
<td>.16</td>
<td>.09</td>
<td>.32</td>
<td>.17</td>
<td>.06</td>
<td>—</td>
<td>.01</td>
<td>.32</td>
<td>.33*</td>
</tr>
<tr>
<td>12. Sadness</td>
<td>.24</td>
<td>.59i</td>
<td>.25</td>
<td>-.42**</td>
<td>-.29</td>
<td>-.10</td>
<td>-.26</td>
<td>.00</td>
<td>-.43**</td>
<td>-.04</td>
<td>.12</td>
<td>—</td>
<td>-.15</td>
<td>.12</td>
</tr>
<tr>
<td>13. Vocal Reactivity</td>
<td>.14</td>
<td>-.23</td>
<td>-.11</td>
<td>.49**</td>
<td>.64i</td>
<td>.44**</td>
<td>.52***</td>
<td>.20</td>
<td>.36*</td>
<td>.40*</td>
<td>.44**</td>
<td>-.15</td>
<td>—</td>
<td>.28</td>
</tr>
<tr>
<td>14. Approach</td>
<td>-.04</td>
<td>-.26</td>
<td>-.34*</td>
<td>.05</td>
<td>.26</td>
<td>.23</td>
<td>.04</td>
<td>.17</td>
<td>.02</td>
<td>.07</td>
<td>.30</td>
<td>-.11</td>
<td>.39*</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: Values below the diagonal represent correlation coefficients for female infants (n = 37); correlations for male infants (n = 35) lie above the diagonal.

*p < .05. **p < .01. ***p < .001. ¹p < .0005.
Table H5

Concurrent Correlations Among the 14 IBQ-R Subscales at 4 and 9 Months for the Full Sample

<table>
<thead>
<tr>
<th>IBQ-R Subscale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Activity Level</td>
<td></td>
<td>.26*</td>
<td>.19</td>
<td>.01</td>
<td>.15</td>
<td>.12</td>
<td>.01</td>
<td>.00</td>
<td>-.12</td>
<td>-.13</td>
<td>-.02</td>
<td>.33**</td>
<td>.13</td>
<td>.03</td>
</tr>
<tr>
<td>2. Distress to Limitations</td>
<td>.09</td>
<td></td>
<td>.19</td>
<td>-.13</td>
<td>-.19</td>
<td>.00</td>
<td>-.26*</td>
<td>-.10</td>
<td>-.51†</td>
<td>-.13</td>
<td>-.07</td>
<td>.54†</td>
<td>-.09</td>
<td>-.06</td>
</tr>
<tr>
<td>3. Fear</td>
<td>.19</td>
<td>.25†</td>
<td></td>
<td>-.04</td>
<td>-.07</td>
<td>-.08</td>
<td>-.24*</td>
<td>-.10</td>
<td>-.24†</td>
<td>-.10</td>
<td>.04</td>
<td>.01</td>
<td>.22</td>
<td>-.07</td>
</tr>
<tr>
<td>4. Duration of Orienting</td>
<td>.13</td>
<td>-.01</td>
<td>.05</td>
<td></td>
<td>.33**</td>
<td>.46†</td>
<td>.51†</td>
<td>.17</td>
<td>.11</td>
<td>.27*</td>
<td>.31**</td>
<td>-.36**</td>
<td>.42†</td>
<td>.12</td>
</tr>
<tr>
<td>5. Smiling and Laughter</td>
<td>.22*</td>
<td>-.21†</td>
<td>.14</td>
<td>.36***</td>
<td></td>
<td>-.23*</td>
<td>.37***</td>
<td>.32**</td>
<td>.01</td>
<td>.43†</td>
<td>.15</td>
<td>-.12</td>
<td>.44†</td>
<td>.20</td>
</tr>
<tr>
<td>6. High Intensity Pleasure</td>
<td>.24*</td>
<td>-.17</td>
<td>.03</td>
<td>.24†</td>
<td>.56†</td>
<td></td>
<td>.50†</td>
<td>-.01</td>
<td>.14</td>
<td>.25*</td>
<td>.07</td>
<td>-.08</td>
<td>.40†</td>
<td>.31**</td>
</tr>
<tr>
<td>7. Low Intensity Pleasure</td>
<td>.05</td>
<td>-.14</td>
<td>.00</td>
<td>.50†</td>
<td>.52†</td>
<td>.38†</td>
<td></td>
<td>.25†</td>
<td>.27†</td>
<td>.34‡</td>
<td>.13</td>
<td>-.25†</td>
<td>.46†</td>
<td>.08</td>
</tr>
<tr>
<td>8. Soothability</td>
<td>.11</td>
<td>-.43†</td>
<td>.06</td>
<td>.28**</td>
<td>.37†</td>
<td>.33**</td>
<td>.35***</td>
<td>.22</td>
<td>.19</td>
<td>-.13</td>
<td>.22</td>
<td>.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Rate of Falling Reactivity</td>
<td>-.17</td>
<td>-.59†</td>
<td>-.16</td>
<td>.00</td>
<td>.10</td>
<td>.09</td>
<td>.17</td>
<td>.34***</td>
<td></td>
<td>-.02</td>
<td>.00</td>
<td>-.45†</td>
<td>.28‡</td>
<td>.07</td>
</tr>
<tr>
<td>10. Cuddliness</td>
<td>-.41†</td>
<td>-.32†</td>
<td>-.05</td>
<td>.10</td>
<td>.16</td>
<td>.02</td>
<td>.39†</td>
<td>.19</td>
<td>.27**</td>
<td></td>
<td>.17</td>
<td>-.16</td>
<td>.30**</td>
<td>.12</td>
</tr>
<tr>
<td>11. Perceptual Sensitivity</td>
<td>.23*</td>
<td>.12</td>
<td>.30**</td>
<td>.18</td>
<td>.36***</td>
<td>.24*</td>
<td>.19</td>
<td>.15</td>
<td>.08</td>
<td>-.10</td>
<td></td>
<td>.06</td>
<td>.37**</td>
<td>.29*</td>
</tr>
<tr>
<td>12. Sadness</td>
<td>.20</td>
<td>.51†</td>
<td>.22*</td>
<td>.02</td>
<td>-.19</td>
<td>-.32**</td>
<td>-.17</td>
<td>-.40†</td>
<td>-.44†</td>
<td>-.26‡</td>
<td>.01</td>
<td></td>
<td>-.15</td>
<td>-.01</td>
</tr>
<tr>
<td>13. Vocal Reactivity</td>
<td>.36***</td>
<td>-.14</td>
<td>.10</td>
<td>.33**</td>
<td>.58†</td>
<td>.45†</td>
<td>.44†</td>
<td>.31**</td>
<td>.15</td>
<td>.12</td>
<td>.39†</td>
<td>-.06</td>
<td></td>
<td>.34**</td>
</tr>
<tr>
<td>14. Approach</td>
<td>.15</td>
<td>-.05</td>
<td>.21†</td>
<td>.40†</td>
<td>.52†</td>
<td>.30**</td>
<td>.37†</td>
<td>.30**</td>
<td>.22†</td>
<td>.02</td>
<td>.43†</td>
<td>-.05</td>
<td>.44†</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: Values below the diagonal represent correlation coefficients at 4 months (N = 37); correlations at 9 months (N = 72) lie above the diagonal.

*p < .05. **p < .01. ***p < .001. †p < .0005.
**Table H6**

*Longitudinal Relationships Among the 14 IBQ-R Subscales*

<table>
<thead>
<tr>
<th>Subscale</th>
<th>4-mos</th>
<th>9-mos</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Activity Level</td>
<td>.28</td>
<td>.13</td>
<td>.02</td>
<td>.28</td>
<td>.15</td>
<td>-.30</td>
<td>-.10</td>
<td>-.26</td>
<td>-.47**</td>
<td>-.07</td>
<td>.31</td>
<td>.17</td>
<td>.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Distress to Limitations</td>
<td>-.10</td>
<td></td>
<td>-.04</td>
<td>-.08</td>
<td>-.19</td>
<td>.10</td>
<td>-.32</td>
<td>-.12</td>
<td>-.33</td>
<td>-.39*</td>
<td>-.04</td>
<td>.61*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Fear</td>
<td>.04</td>
<td>-.25</td>
<td></td>
<td>.33</td>
<td>.32</td>
<td>.23</td>
<td>.01</td>
<td>-.01</td>
<td>-.19</td>
<td>.18</td>
<td>.21</td>
<td>.19</td>
<td>.11</td>
<td>-.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Duration of Orienting</td>
<td>-.10</td>
<td>-.12</td>
<td>-.28</td>
<td></td>
<td>.00</td>
<td>.19</td>
<td>.13</td>
<td>.00</td>
<td>.11</td>
<td>.11</td>
<td>.14</td>
<td>-.16</td>
<td>.09</td>
<td>.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Smiling and Laughter</td>
<td>.04</td>
<td>-.18</td>
<td>-.23</td>
<td>.52***</td>
<td></td>
<td>.29</td>
<td>.16</td>
<td>.09</td>
<td>.04</td>
<td>.12</td>
<td>.03</td>
<td>-.09</td>
<td>.08</td>
<td>.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. High Intensity Pleasure</td>
<td>.28</td>
<td>-.35*</td>
<td>-.32</td>
<td>.41**</td>
<td>.40**</td>
<td></td>
<td>.05</td>
<td>.03</td>
<td>.04</td>
<td>.05</td>
<td>.11</td>
<td>-.12</td>
<td>.28</td>
<td>.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Low Intensity Pleasure</td>
<td>.11</td>
<td>-.21</td>
<td>-.27</td>
<td>.42**</td>
<td>.51***</td>
<td>.49**</td>
<td></td>
<td>.43**</td>
<td>.02</td>
<td>.35*</td>
<td>.11</td>
<td>-.05</td>
<td>.13</td>
<td>.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Soothability</td>
<td>-.01</td>
<td>-.20</td>
<td>-.03</td>
<td>.29</td>
<td>.29</td>
<td>.20</td>
<td>.10</td>
<td></td>
<td>.12</td>
<td>.41**</td>
<td>.21</td>
<td>-.32*</td>
<td>.12</td>
<td>.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Rate of Falling Reactivity</td>
<td>.03</td>
<td>-.27</td>
<td>.12</td>
<td>.09</td>
<td>.06</td>
<td>-.02</td>
<td>.12</td>
<td>.25</td>
<td></td>
<td>.51**</td>
<td>.27</td>
<td>-.49**</td>
<td>.03</td>
<td>.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Cuddliness</td>
<td>-.19</td>
<td>.13</td>
<td>-.05</td>
<td>-.06</td>
<td>.14</td>
<td>.01</td>
<td>-.05</td>
<td>.21</td>
<td>-.28</td>
<td></td>
<td>-.10</td>
<td>-.31</td>
<td>.07</td>
<td>.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Perceptual Sensitivity</td>
<td>-.04</td>
<td>-.12</td>
<td>-.09</td>
<td>.26</td>
<td>.33*</td>
<td>.21</td>
<td>.15</td>
<td>.19</td>
<td>.25</td>
<td>.11</td>
<td></td>
<td>-.13</td>
<td>.45**</td>
<td>.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Sadness</td>
<td>-.09</td>
<td>.28</td>
<td>.33*</td>
<td>-.31</td>
<td>-.14</td>
<td>-.27</td>
<td>-.18</td>
<td>.04</td>
<td>-.18</td>
<td>-.05</td>
<td>-.17</td>
<td></td>
<td>-.09</td>
<td>-.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Vocal Reactivity</td>
<td>.22</td>
<td>.12</td>
<td>-.05</td>
<td>.31</td>
<td>.28</td>
<td>.35*</td>
<td>.31</td>
<td>.24</td>
<td>.01</td>
<td>.29</td>
<td>.45**</td>
<td>.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Approach</td>
<td>-.15</td>
<td>-.25</td>
<td>-.12</td>
<td>.37*</td>
<td>.32</td>
<td>.29</td>
<td>.20</td>
<td>.26</td>
<td>.10</td>
<td>.11</td>
<td>.38*</td>
<td>-.12</td>
<td>.44**</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Values below the diagonal represent correlation coefficients for female infants (n = 37); correlations for male infants (n = 35) lie above the diagonal.*

*p < .05. **p < .01. ***p < .001. 'p < .0005.
Table H7

Longitudinal Relationships Among the 14 IBQ-R Subscales for the Full Sample (N = 72)

<table>
<thead>
<tr>
<th>Subscale</th>
<th>4-mos \ 9-mos</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Activity Level</td>
<td></td>
<td>-</td>
<td>.16</td>
<td>.02</td>
<td>.12</td>
<td>.19</td>
<td>.21</td>
<td>-.05</td>
<td>.05</td>
<td>-.09</td>
<td>-.15</td>
<td>-.04</td>
<td>.15</td>
<td>.21</td>
<td>.06</td>
</tr>
<tr>
<td>2. Distress to Limitations</td>
<td></td>
<td>.21</td>
<td>-</td>
<td>.02</td>
<td>-.15</td>
<td>-.26*</td>
<td>-.04</td>
<td>-.26*</td>
<td>-.05</td>
<td>-.24*</td>
<td>-.44*</td>
<td>.00</td>
<td>.48*</td>
<td>-.05</td>
<td>.06</td>
</tr>
<tr>
<td>3. Fear</td>
<td></td>
<td>.16</td>
<td>.01</td>
<td>-</td>
<td>.29*</td>
<td>.35**</td>
<td>.03</td>
<td>.17</td>
<td>.11</td>
<td>.03</td>
<td>.15</td>
<td>.07</td>
<td>-.03</td>
<td>.22</td>
<td>-.05</td>
</tr>
<tr>
<td>4. Duration of Orienting</td>
<td></td>
<td>-.09</td>
<td>-.22</td>
<td>-.18</td>
<td>-</td>
<td>.13</td>
<td>.30**</td>
<td>.12</td>
<td>.08</td>
<td>.05</td>
<td>.12</td>
<td>.18</td>
<td>-.11</td>
<td>.26*</td>
<td>.17</td>
</tr>
<tr>
<td>5. Smiling and Laughter</td>
<td></td>
<td>.04</td>
<td>-.16</td>
<td>-.08</td>
<td>.41*</td>
<td>-</td>
<td>.34**</td>
<td>.26*</td>
<td>.22</td>
<td>.05</td>
<td>.23*</td>
<td>.18</td>
<td>-.13</td>
<td>.29*</td>
<td>.20</td>
</tr>
<tr>
<td>6. High Intensity Pleasure</td>
<td></td>
<td>.10</td>
<td>-.10</td>
<td>-.10</td>
<td>.29*</td>
<td>-.37***</td>
<td>-</td>
<td>.14</td>
<td>.20</td>
<td>.09</td>
<td>.15</td>
<td>.22</td>
<td>-.13</td>
<td>.34**</td>
<td>.32***</td>
</tr>
<tr>
<td>7. Low Intensity Pleasure</td>
<td></td>
<td>.04</td>
<td>-.14</td>
<td>-.10</td>
<td>.40***</td>
<td>.34**</td>
<td>.40***</td>
<td>-</td>
<td>.44*</td>
<td>.01</td>
<td>.39***</td>
<td>.22</td>
<td>-.04</td>
<td>.34**</td>
<td>.13</td>
</tr>
<tr>
<td>8. Soothiability</td>
<td></td>
<td>-.11</td>
<td>-.27</td>
<td>-.10</td>
<td>.24*</td>
<td>.23</td>
<td>.18</td>
<td>.17</td>
<td>-</td>
<td>.26*</td>
<td>.41*</td>
<td>.25*</td>
<td>-.26*</td>
<td>.27*</td>
<td>.08</td>
</tr>
<tr>
<td>9. Rate of Falling Reactivity</td>
<td></td>
<td>-.16</td>
<td>-.37</td>
<td>.01</td>
<td>.13</td>
<td>.03</td>
<td>.02</td>
<td>.32**</td>
<td>.30**</td>
<td>-</td>
<td>.43*</td>
<td>.19</td>
<td>-.32**</td>
<td>.06</td>
<td>-.03</td>
</tr>
<tr>
<td>10. Cuddliness</td>
<td></td>
<td>-.23</td>
<td>-.10</td>
<td>-.02</td>
<td>.05</td>
<td>.11</td>
<td>.08</td>
<td>.15</td>
<td>.21</td>
<td>-.03</td>
<td>-</td>
<td>.07</td>
<td>-.18</td>
<td>.06</td>
<td>.14</td>
</tr>
<tr>
<td>11. Perceptual Sensitivity</td>
<td></td>
<td>-.04</td>
<td>-.01</td>
<td>.00</td>
<td>.29*</td>
<td>.31**</td>
<td>.17</td>
<td>.22</td>
<td>.15</td>
<td>.08</td>
<td>.10</td>
<td>-</td>
<td>.09</td>
<td>.52*</td>
<td>.31**</td>
</tr>
<tr>
<td>12. Sadness</td>
<td></td>
<td>.20</td>
<td>.33**</td>
<td>.19</td>
<td>-.23*</td>
<td>-.10</td>
<td>-.24*</td>
<td>-.26*</td>
<td>-.18</td>
<td>-.28*</td>
<td>-.31**</td>
<td>-.03</td>
<td>-</td>
<td>-.04</td>
<td>-.04</td>
</tr>
<tr>
<td>13. Vocal Reactivity</td>
<td></td>
<td>.17</td>
<td>.07</td>
<td>.04</td>
<td>.31**</td>
<td>.32**</td>
<td>.32**</td>
<td>.30**</td>
<td>.15</td>
<td>.03</td>
<td>.11</td>
<td>.27*</td>
<td>.11</td>
<td>-</td>
<td>.14</td>
</tr>
<tr>
<td>14. Approach</td>
<td></td>
<td>-.10</td>
<td>-.11</td>
<td>.00</td>
<td>.40*</td>
<td>.33**</td>
<td>.17</td>
<td>.18</td>
<td>.27*</td>
<td>.01</td>
<td>.14</td>
<td>.45*</td>
<td>-.05</td>
<td>.27*</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: Values below the diagonal represent correlation coefficients for female infants (n = 37); correlations for male infants (n = 35) lie above the diagonal.

*p < .05.  **p < .01.  ***p < .001.  'p < .0005.
Table H8

*Longitudinal Stability of the 14 IBQ-R Subscales. Correlations Between 4- and 9-month Scores*

<table>
<thead>
<tr>
<th>IBQ-R Subscale</th>
<th>Females (n = 37)</th>
<th>Males (n = 35)</th>
<th>Full Sample (N = 72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity Level</td>
<td>.32</td>
<td>.55***</td>
<td>.44****</td>
</tr>
<tr>
<td>Distress to Limitations</td>
<td>.28</td>
<td>.62****</td>
<td>.45****</td>
</tr>
<tr>
<td>Fear</td>
<td>.33*</td>
<td>.54***</td>
<td>.43****</td>
</tr>
<tr>
<td>Duration of Orienting</td>
<td>.39*</td>
<td>.64****</td>
<td>.50****</td>
</tr>
<tr>
<td>Smiling and Laughter</td>
<td>.60****</td>
<td>.59****</td>
<td>.60****</td>
</tr>
<tr>
<td>High Intensity Pleasure</td>
<td>.35*</td>
<td>.44**</td>
<td>.42****</td>
</tr>
<tr>
<td>Low Intensity Pleasure</td>
<td>.49**</td>
<td>.33</td>
<td>.41****</td>
</tr>
<tr>
<td>Soothability</td>
<td>.21</td>
<td>.30</td>
<td>.23*</td>
</tr>
<tr>
<td>Rate of Falling Reactivity</td>
<td>.20</td>
<td>.42*</td>
<td>.30*</td>
</tr>
<tr>
<td>Cuddliness</td>
<td>.31</td>
<td>.59****</td>
<td>.47****</td>
</tr>
<tr>
<td>Perceptual Sensitivity</td>
<td>.50***</td>
<td>.71****</td>
<td>.60****</td>
</tr>
<tr>
<td>Sadness</td>
<td>.34*</td>
<td>.61****</td>
<td>.49****</td>
</tr>
<tr>
<td>Vocal Reactivity</td>
<td>.48**</td>
<td>.41*</td>
<td>.44****</td>
</tr>
<tr>
<td>Approach</td>
<td>.35*</td>
<td>.38*</td>
<td>.34**</td>
</tr>
</tbody>
</table>

*Note: *p < .05. **p < .01. ***p < .001. ****p < .0005.
APPENDIX I

*Expected Chance Value for Proportion of Time Spent Looking at Preferred Screen*

Reprinted with permission from

For both the 4-month and 9-month VPIP tasks, one of our measures was the proportion of time that infants spent looking at their preferred screen (i.e. whichever screen they spent more time looking at). By definition, this proportion is always at least .5. Our analysis required the determination of the chance value for this proportion – the expected value for an infant who does not distinguish between the two screens.

We can model such a "random" infant as one who chooses to look at one screen or the other in each of $N$ equal time slices. Each of the $N$ choices is independent, and in each time slice the infant chooses each screen with probability .5. To choose $N$, we note that the average number of gaze switches for a random infant is $(N - 1) / 2$. Thus, if the average number of observed gaze switches across all infants for an experiment is $m$, then we should model a random infant by taking $N = 2m + 1$.

The probability that the random infants spends $k$ time slices looking to the right is

$$P_k = 2^{-N} \binom{N}{k}$$

(1)

If the random infant spends $k$ time slices looking to the right, then the proportion of time spent looking at the preferred display is

$$R_k = \begin{cases} 
\frac{k}{N} \quad (k \geq m + 1) \\
\frac{N - k}{N} \quad (k \leq m)
\end{cases}$$

(2)

340
Combining (1) and (2), the expected proportion of time that the random infant spends looking at the preferred display is

\[ E(R) = \sum_{k=0}^{N} P_k \cdot R_k \]

\[ = \sum_{k=0}^{m} 2^{-k} \binom{N}{k} \frac{N-k}{N} + \sum_{k=m+1}^{N} 2^{-k} \binom{N}{k} \frac{k}{N} \]

\[ = \frac{2^{-N+1}}{N} \sum_{k=m+1}^{N} \binom{N}{k} k \]  \hspace{1cm} (3)

Expression (3) was evaluated numerically. For the 4-month VPIP task the average number of gaze switches was 42.6, so we took \( m = 42, N = 85 \), and obtained an expected proportion \( E(R) = 0.5434 \). For the 9-month VPIP task the average number of gaze switches was 19.7, so we took \( m = 19, N = 39 \), and obtained an expected proportion \( E(R) = 0.5643 \). In the text these proportions are rounded to two decimal places.
APPENDIX J

VAIP Task Findings at 4 and 9 Months

4-Month VAIP Findings

At 4 months, infants \((N = 88)\) were interested in watching the displays. Overall attention to the screens across the 6 trials was \(0.83\) \((SD = 0.13)\). Proportion of time spent attending to the displays ranged from \(0.39\) to \(0.99\). Infants also tended to prefer watching one screen over the other during each of the six 20-second trials. The average proportion of time spent watching their “preferred” screen \((>0.50)\) across the 6 trials was \(0.79\) \((SD = 0.10)\). As a group, infants preferentially attended to the matching screen (proportion of time \(>0.50\)) on an average of 52% \((SD = 0.16)\) of the trials, which did not differ from chance performance \((t(87) = 1.03, p > 0.05)\). Forty-two infants looked equally at the displays (3 matching, 3 non-matching), 20 infants looked more towards the non-matching display (2 matching, 4 non-matching), and 26 infants spent more time looking at the matching display (4-6 matching). Compared to chance performance of viewing the matching display on 3.0 trials, 4-month-old infants did not perform significantly differently \((t(87) = 1.03, p > 0.05; M = 3.10, SD= 0.94)\). Infants’ average proportion of looking time towards the matching display across the 6 trials was 0.51 \((SD = 0.10)\).

9-Month VAIP Findings

At 9 months, infants \((N = 66)\) were interested in the displays, though less so than at 4 months. Overall attention to the screens was 66% \((SD = 0.14)\) and ranged from 0.33 to 0.98, which differed significantly from attention to the displays at 4 months \((M = 83\%: t(63) = 6.97, p < 0.0005)\). Average proportion of time watching their “preferred” screen \((>0.50)\) for each of the 6 trials was 0.72 \((SD = 0.09)\), which differed significantly from an
equivalent preference value of .50 ($t(65) = 18.22, p < .0005$), and from preferential looking at 4 months ($M = .79, SD = .11: t(64) = 3.98, p < .0005$). As a group, infants attended to the matching screen (proportion of time > .50) on an average of 56% ($SD = .16$) of the trials, which did differ from chance performance ($t(65) = 3.16, p < .002$). Twenty-seven infants looked equally at both displays (3 match, 3 non-match), 10 infants looked more towards the non-matching display (1-2 matching, 4-5 non-matching), and 29 infants spent more time looking at the matching display (4-6 matching, 0-2 non-matching). Infants’ mean number of trials spent watching the matching display ($M = 3.39, SD = .97$) differed significantly from a chance performance of watching the displays on 3.0 trials. Infants’ average proportion of looking time towards the matching display across the 6 trials was .53 ($SD = .07$). This looking time also differed significantly from the chance value of .50 ($t(65) = 3.39, p < .001$).

A within-subjects repeated measures ANOVA examined whether infants spent more time viewing the matching display over trials. No difference was found in the proportion of time infants spent viewing the matching display across trials ($F(5,61) = .60, p > .05$). A series of paired t-tests across trials that compared the time infants spent watching the matching and non-matching screens found a non-significant trend for trial 1 ($t(65) = 1.67, p < .10$). Infants spent more time watching the matching display ($M = .56, SD = .28$) than the non-matching display ($M = .44, SD = .28$).