Verb Fast Mapping and Imitation in Children with Down Syndrome

by

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This thesis is dedicated to my cousin Suzanne, for teaching me to enjoy both the little and big things in life.

To my parents, for endless support and love, and for their incredible examples of what it means to work hard.

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ABSTRACT

Fast mapping is the ability to learn a new word after one or a few exposures. Research on verb fast mapping in children with Down syndrome (DS) has found mixed results. Imitation aids fast mapping of nouns (Schwartz & Leonard, 1985). Imitation and fast mapping of verbs has not been studied. The goal of this study was to investigate the impact of imitation on verb fast mapping in children and adolescents with DS. Fourteen English monolingual children with DS and fifteen English monolingual TD children matched on nonverbal mental age (DS) and chronological age (TD) participated in a fast mapping task. Participants were exposed to 8 novel verbs and actions using a figure with moveable limbs—half the verbs in an elicited imitation condition and half the verbs in a no imitation condition. They were then tested on their ability to produce and comprehend the novel verbs both immediately after exposure and after a delay of 15 minutes. Data were analyzed using two 3-way mixed Analyses of Covariance (ANCOVAs), as well as post hoc t-tests. Results showed that both groups performed better on the comprehension tasks than the production tasks, that TD participants performed significantly better than participants with DS on the production tasks and that both groups performed significantly better on immediate probes compared to delayed probes. Imitation did not improve fast mapping for either group, which was not expected.

LIST OF ABBREVIATIONS USED

DS	Down Syndrome
TD	Typically Developing
MA	Mental Age
MA-CA	Mental Age-Chronological Age
SB4	Stanford-Binet Intelligence Test- 4th Edition
WISC-4	Wechsler Intelligence Scales for Children- 4th Edition
SD	Standard Deviation
ANCOVA	Analysis of Covariance

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CHAPTER 1 INTRODUCTION

Statement of Purpose

The purpose of the study was to further learn about the difficulties that children with Down syndrome (DS) have with vocabulary acquisition, specifically verb fast mapping, and to investigate whether elicited imitation of novel words impacts novel verb fast mapping in this population.

Background and Rationale

Down syndrome (DS), usually Trisomy 21, is a disorder caused by an extra copy of the 21st chromosome (Chapman & Kay-Raining Bird, 2011; Selikowitz, 2008; Wiseman, Alford, Tybulewicz, & Fisher, 2009). DS is one of the most common chromosomal disorders, occurring in about 1 in every 700 live births (Andreou & Katsarou, 2013). Research on children with DS has found evidence of both physical and cognitive deficits as a result of the syndrome (Chapman & Kay-Raining Bird, 2011). Children with DS vary in cognitive abilities; with IQs ranging from 36 to 90 (Chapman & Kay-Raining Bird, 2011). Research looking at the specific areas of ability in children with DS have generally found that they show difficulties with language learning, particularly with the acquisition of syntax and morphology (Andreou & Katsarou, 2013; Chapman & Kay-Raining Bird, 2011).

Recent research regarding children with DS has focused on an aspect of vocabulary development called fast mapping, which is the ability to map a novel word to a novel object or action after a single or few exposures (Chapman, Sindberg, Bridge, Gigstead, & Hesketh, 2006; Cleave, Kay-Raining Bird, Trudeau, & Sutton, 2014). The ability to fast map and acquire new words after a few exposures requires the learner to use working memory. To understand the role that working memory plays in fast mapping, it is helpful to understand the components of

working memory, which allow for the encoding and storage of new words. The Baddeley Hitch model of working memory (Baddeley & Jarrold, 2007) is a well-accepted model that represents how new information is encoded and stored in the brain. It is comprised of 4 components. These components are: the phonological loop, the visuospatial sketchpad, the central executive and the episodic buffer. The most important component of the Baddeley-Hitch model in regard to novel spoken word learning, is the phonological loop. The phonological loop receives speech input and stores it for a short period of time, after which the memory begins to break down if the information is not rehearsed. Rehearsal allows for the information to be encoded and transferred into long term storage (Baddeley & Jarrold, 2007). Difficulties in the use of the phonological loop can have a detrimental effect on long-term storage of new words and thus general vocabulary acquisition (Baddeley & Jarrold, 2007; Laws & Gunn, 2004).

Children with DS have demonstrated difficulties with working memory (Baddeley & Jarrold, 2007; Laws & Gunn, 2004). Baddeley and Jarrold (2007) reviewed previous research in the field of working memory in children with DS. Most research found that children with DS have verbal memory deficits. Baddeley and Jarrold (2007) described 3 ways in which phonological loop processes in children with DS may account for their verbal memory deficits: inefficient acoustic analysis of phonological information, rapid loss of phonological traces, and reduced capacity for new verbal information (Baddeley & Jarrold, 2007). However, based on their review of the literature, Baddeley and Jarrold (2007) concluded that although these 3 factors do have an effect on verbal memory, tests of each of these components found that they were not responsible for the verbal deficits in children with DS. The authors discuss that these findings do not dismiss the role of the phonological loop in verbal memory deficits in children with DS. Rather, more research into the phonological loop is needed in order to specifically

pinpoint what the phonological loop deficit in children with DS involves. In the present study, the relationship between performance on fast mapping tasks and performance on digit span working memory tasks will be explored.

Research has also investigated behavioural measures of neural function to determine if the behavioural measures might imply structural differences in children with DS that may account for differences in verbal memory. Pennington, Moon, Edgin, Stedrom and Nadel (2012) studied neuropsychology in adolescents with DS, specifically hippocampus dysfunction. They tested a group of 33 participants with DS ages 11-19, and a MA-CA matched control group of typically developing (TD) children on different measures of memory. The hippocampal function measures included measures of visual and verbal long term memory (LTM) and ecological memory (memory for everyday events). The researchers also used two additional measures of LTM including a pattern recognition memory test and a paired associates test. The non-hippocampal measures included visuoconstructive function measures (spatial ability). The researchers found that individuals with DS performed more poorly on the hippocampal measures than MA matched TD controls, concluding that hippocampal dysfunction in individuals with DS was a contributor to memory deficits, but it is not the only cause of these deficits. As these tests are behavioural measures, not direct measures of neural function, it cannot be concluded that children with DS do have different neural structure differences that account for verbal memory deficits. Rather, the findings imply that the hippocampus as well as other neural structures associated with memory may play a role in verbal memory. This research provides more information about verbal memory deficits in children with DS, but as findings suggest, more research is needed to determine what other factors contribute to verbal memory deficits.

Research on verbal memory deficits in children with DS is important as it provides insight into general word learning deficits in children with DS. Fast mapping ability is interconnected with verbal memory, that is being able to learn novel words that one hears is connected to our ability to remember those words. With a general understanding of verbal memory deficits and the effect on fast mapping ability, the question of more specific word learning deficits arises. If children with DS have verbal memory deficits that impact word learning ability, is important to look at how children with DS compare to their TD peers in their ability to fast map and consequently learn new words. This comparison brings up various questions that different researchers have attempted to answer. Do children with DS fast map novel nouns differently than their TD peers? Do children with DS fast map verbs differently than their TD peers? Do children with DS fast map nouns differently than verbs? The following review of the literature research will address these questions, giving a better understanding of the differences in fast mapping between children with DS and TD children.

Fast mapping studies in individuals with DS.

Noun fast mapping studies: group differences. Attempting to answer the question of whether or not children with DS fast map novel nouns differently than their TD peers, Chapman, Kay-Raining Bird and Schwartz (1990) conducted a fast mapping task. This task compared children with DS ages 5;6-20;6, to TD mental age (MA)-matched peers ages 2;0-6;0. Participants were tested on immediate and delayed production and comprehension tasks. It was found that the children with DS did not differ from their MA-matched TD controls in their ability to fast map a single novel noun (koob) during the experiment. Kay-Raining-Bird, Chapman and Schwartz (2004) also examined group differences of noun fast mapping. They conducted a study looking at how children with DS (ages 12;8-20;3) fast map novel nouns in spoken story contexts

compared to TD MA-matched controls (ages 4;1-6;1). Participants listened to pre-recorded stories that had 2 novel nouns within the story (repeated 3 times each). Fast mapping was measured by the presence of the novel words in the participant's retelling of the story (scored as present or absent). Participants were also scored on the number of correct definitions they gave for the novel words. It was found that both children with DS and the MA- matched TD children produced a similar number of novel words during story recall (production task) but children with DS performed more poorly on novel word definitions (comprehension task) than TD children (although the number of definitions produced by each group was low). Although the comprehension task required participants to produce the definitions, it was considered a comprehension task as participants had to comprehend what each novel word was, and correctly answer when the researcher asked "What is a _____?".

Mosse and Jarrold (2011) conducted a study that also examined differences in noun fast mapping between children with DS and TD children, through a multi-experiment study. They conducted 3 experiments that required participants with DS ages 9;3-28;11 (TD participants ages 4;9-6;9) (experiment 1), 11;11-29;8 (TD participants ages 4;3-5;2) (experiment 2) and 13;1-30;4 (TD participants ages 4;9-5;9) (experiment 3) to fast map novel proper nouns to their referents. Mosse and Jarrold (2011) argued that although their study included fast mapping of proper nouns, the task was comparable to that of fast mapping common nouns to referents. The first experiment examined the ability to fast map novel nouns when participants were required to repeat the proper noun after each exposure. Participants with DS and TD participants performed equally well on production probes following this task. The second experiment examined how similarity of a novel word to existing words affected participants' ability to fast map the words. This experiment also required participants to repeat the noun after each exposure. As in the first

experiment, participants were tested on their ability to produce the names for the novel referents following the exposure task. They found that participants with DS performed better on novel words that had a high wordlikeness to existing words than those that had a lower wordlikeness; however, they did not differ in their performance when compared to the TD control group. The last experiment examined the findings from the first two experiments and compared them to an existing study by Jarrold et al. (2009), which considered the relationships between verbal memory, phonological awareness and word learning in children with DS and TD children. Mosse and Jarrold (2011) tested participants to see if word learning involved phonological representation of the new words in the short term memory and also considered the role of verbal memory in the word learning process. Participants were exposed to novel animate figures that were aliens, as well as their associated novel names. After this, to test participant's comprehension of the novel names, they completed a three-choice task. In this task, one by one, each of the aliens from the exposure task appeared on the screen, along with three names, two foil names and the target name of the alien. Participants were required to choose the correct target name for the alien out of the three choices. Three foils differed from the target in phonological form, the researchers changed the word structure for the foils by differing initial phonemes for each of the targets. To learn the novel word, participants had to learn the phonological form of the word and discriminate it from the similar phonological form of the foils. After this, also to test their comprehension of the novel names, participants completed a yes/no task. In this task, one by one, each of the aliens from the exposure task appeared on screen and a name for the alien was played out loud. Participants were required to push a "right" or "wrong" button to indicate if the name played out loud was the correct name for the alien. Results showed that participants with DS performed similarly to TD participants on both the

yes/no word learning task and the three-choice word learning task. Participants also completed a verbal memory task that involved immediate serial recall. The researchers compared the performance of the children with DS on the word learning task and the verbal memory task and found that verbal memory task performance < three-choice task performance, verbal memory task performance = yes/no task performance and that when comparing the two word learning tasks (three-choice/yes/no), three-choice task < yes/no task, as the three choice task requires a greater memory load (Mosse & Jarrold, 2011). The researchers compared performance on the verbal memory versus the word learning tasks by calculating *z* scores separately for the verbal memory task and the two word learning tasks (three-choice/yes/no) (Mosse & Jarrold, 2011). Overall, there was no effect for group found on the verbal memory tasks, and performance of the participants with DS across the previous and current study was equivalent, as the previous study found that children with DS performed more poorly on both the short term verbal memory tasks and the word learning tasks. The authors concluded that they did not find a word learning deficit in the groups with DS, however they found that word learning ability exceeded their verbal short term memory skill.

In order to discuss the findings of the third experiment, comparing the first two studies to Jarrold et al (2009) it is necessary to understand the procedures and findings of the latter. Jarrold et al (2009) conducted a study that tested how word learning is related to phonological awareness and verbal short term memory. This experiment involved 22 individuals with DS and 64 TD children, who were tested on two different word learning tasks (form learning and referent learning) as well as 3 verbal memory measures, 3 phonological awareness measures and a sound discrimination measure. Form learning involves children learning novel words that have word like sound patterns (changing the initial phonemes of the exposed novel CVC words), and as

discussed above, learning to discriminate similar phonological forms. For the form learning component, participants were exposed to 3 animate aliens one by one, and each alien was named as it was shown. In the test phase, participants were shown each alien from the exposure phase, one by one, and 3 animal characters appeared at the bottom of the screen. Each animal took turns naming the alien via an audio recording. The names included 2 foil names (that differed from the target name by one phoneme) and the target name. Once all possible names were heard, participants were instructed to point to the animal that had said the correct name for the alien. This task included 10 trials of choosing the alien name. The three different measures of verbal memory included the same tasks, with the non-target names changing in lexical neighbourhood size, and phoneme frequency. In the referent learning measures, like the previous measure, there were 10 trials where participants were exposed to 3 monsters in sequence, and each were named using an audio recording as they were shown. In the test phase, the 3 monsters appeared on the screen all at once, and one by one, the names of the monsters were played and participants had to point to the monster that matched the name they heard. As in the first task, the 3 verbal memory conditions were controlled by changing the type of the non-word by having words with low neighbourhood size and high sound frequency, low neighbourhood size and low sound frequency, and high neighbourhood size and low sound frequency.

The study then tested participants on tasks of serial recall, item recognition, phonological awareness and sound discrimination. Jarrold et al (2009) found that although children with DS were able to identify referents of exposed words in the referent learning task, they showed impairments on the verbal memory measures and form learning measures. Overall, the study found that children with DS showed impaired short-term verbal memory abilities.

Mosse and Jarrold's (2011) compared the findings of the first two experiments to the findings of the 2009 study reported above. Comparing the results of each study shows a discrepancy in findings. Mosse and Jarrold (2011) found that there was no significant effect for group on the 3 choice task which incorporated phonological form learning, as well as the yes/no task. Jarrold et al (2009) found that children with DS performed more poorly than TD controls on the verbal memory tasks and the form learning tasks. Mosse and Jarrold (2011) attempt to explain the discrepancy by discussing that the poorer performance of the children with DS in the earlier study, may be due to the effect of the nature of the foils used in the experiment. Overall, the findings from the third experiment of Mosse and Jarrold's (2011) study show that participants with DS and MA-CA matched TD participants performed similarly on the noun fast mapping tasks, which is consistent with the findings from Chapman et al. (1990). Mosse and Jarrold (2011) did not find a difference in performance between nouns that were repeated and nouns that were not.

McDuffie and colleagues (2007) conducted a 4-task study on both noun and verb fast mapping in adolescents with DS ages 12;0-18;0. Task 1 examined nouns and speaker intent, Task 2 examined verbs and speaker intent, Task 3 examined nouns and grammatical cues, and Task 4 examined verbs and grammatical cues. Their aim was to determine if participants with DS would be able to fast map novel nouns and verbs similarly to syntax matched controls, when the tasks relied on the use of grammatical versus pragmatic cues. Tests of fast mapping performance included comprehension and production probes for each task. The grammatical cues included past tense endings or future tense sentence structure, which would help the participants to figure out whether the object the experimenter was referring to was one they had already seen or one they had yet to see. The pragmatic cues involved what the researchers call speaker intent.

Participants needed to use statements such as: “there!” or “oops, I didn’t mean that one” to disambiguate the reference for a novel word during an exposure task. Grammatical and pragmatic cues required the participants to attend to the linguistic versus communicative context to determine what the correct verb or noun referent was. To answer the question of whether or not nouns are fast mapped differently across groups, Tasks 1 and 3 (noun tasks) of McDuffie and colleagues’ study will be examined. Task 1 (nouns, speaker intent) consisted of two trials with four novel words in each. The researchers tested participants on a comprehension probe after each trial of four words, as well as a production and another comprehension probe after both trials were completed. They found that the TD group performed better than participants with DS in the condition where the researcher did not give pragmatic cues such as “oops, I didn’t mean that one” compared to the condition where the researcher did use pragmatic cues such as “oops, I didn’t mean that one”. There was no significant difference for group in comprehension performance of the speaker intent condition. Due to lack of useable data for the production probe, the production performance across groups was not reported for this task. In Task 3 (nouns, use of grammatical cues) the researchers found that after testing participants on a comprehension probe after one trial of four words was exposed and a production probe after both trials were exposed, there were no significant difference between groups when it came to using grammatical cues to decipher speaker intent in the noun fast mapping task, as both groups performed equally well when the cue to disambiguating speaker intent was indicated through past or future tense. One of the tasks involved both grammatical cues and speaker intent together. The results of the other two tasks will be reported in the verb fast mapping section.

Also looking at fast mapping of both nouns and verbs, Cleave et al. (2014) investigated the impact that bilingualism plays on fast mapping abilities of children with DS ages 3;2-19;3

using a syntactic bootstrapping task. As the current study focused on monolingual children, only the monolingual results of Cleave et al. (2014)'s study will be discussed.Cleave and colleagues compared children with DS and MA-matched TD children who were either bilingual or monolingual, on their ability to fast map novel nouns and novel verbs when the words were presented using syntactic cues, specifically the suffix *–ing* for verbs, and the article *a* for nouns. Participants were tested on their ability to fast map using a comprehension probe immediately after the presentation of each stimulus. The comprehension probe prompted participants to point to the target object on a digital array using the prompt "point to *X*". It was found that all groups fast mapped more nouns than verbs and that monolingual children with DS performed more poorly than monolingual TD children on the noun fast mapping comprehension probes, which is different from findings that noun fast mapping is similar in children with DS and TD children. Bilingual children in the study performed differently than the monolingual children. The difference between Cleave et al.'s study and previous fast mapping studies, was that their task was reported to be more complex as it required morphosyntactic knowledge to complete the task properly, and morphosyntax is an area of deficit for individuals with DS. Cleave and colleagues discuss that such differences in the study may have contributed to the difference in findings from other fast mapping studies due to the demand put on participants' language abilities, specifically the group with DS (Cleave et al., 2014). No effect of group was found for bilingual participants. The differences in verb fast mapping across groups will be reported below, along with comparisons between verb and noun fast mapping in children with DS, which will be reported in a later section.

The research reviewed so far has examined noun fast mapping in children with DS and the difference in performance with children with DS and their TD peers. To summarize,

Chapman et al (1990) found no differences across groups as did Mosse and Jarrold (2011) while Kay-Raining Bird et al. (2004) found that children with DS performed similarly to TD children on production tasks, but performed more poorly on comprehension tasks. Jarrold (2009) found that children with DS performed worse than TD children on verbal memory and form learning tasks, but performed similarly on noun referent learning task, where participants learned novel nouns. McDuffie et al (2007) found no differences across groups on the noun comprehension probes in the speaker intent condition (pragmatic cues such as "oops, I didn't mean that one!" that alluded to which object the researcher meant), but children with DS performed more poorly on the referent first (target object appeared immediately after presentation of novel label) comprehension probe. No difference in noun fast mapping across groups was found by these authors when use of grammatical cues was required to determine word class. In contrast, Cleave et al (2014) found that children with DS performed more poorly on comprehension of nouns compared to monolingual TD children when they were required to determine the word class using syntactic cues when fast mapping novel words.

As it is important to consider the differences in verb fast mapping to understand fast mapping abilities, the following research addresses the question of whether monolingual children with DS perform differently when fast mapping verbs than their TD peers.

Verb fast mapping: group differences. Several studies have compared fast-mapping of nouns and verbs in individuals with DS. As described above, McDuffie et al (2007) conducted a study that examined the impact of grammatical cues, and speaker intent (pragmatic cues) on children with DS's ability to fast map nouns and verbs. To answer the question of differences in verb fast mapping, the two verb tasks (Tasks 2 and 4) will be focused on. The verb tasks differed from the noun task in that the participants were told that a magician friend would like to

make stars move, using two different apparatuses. The researcher moved the stars in four different ways (two targets and two foils) and were told "look, I'm going to _____ the stars!". It was found that participants with DS performed similarly to TD children regardless of condition. In Task 4 (same structure of two trials) which examined verbs and pragmatic cues, no significant differences between groups was found for fast mapping of verbs, based on the comprehension probe after one trial and the production comprehension probes done after both trials were complete. Overall, these researchers found that across both verb fast mapping tasks, participants with DS did not perform significantly worse than their TD syntax-matched counterparts. However, some studies, have found that children with DS display weaknesses in verb fast mapping tasks.

Cleave et al (2014) conducted a study that considered fast mapping of both nouns and verbs and found nouns were fast mapped proportionately more often than verbs, with a main effect for group, for participants with DS and an MA-matched TD group. However, these authors did not find a word class by group interaction meaning that both nouns and verbs were fast mapped less in the DS group, as measured by a comprehension probe.

To summarize the findings of the verb fast mapping studies, McDuffie et al (2007) found that in the verb fast mapping tasks (2 and 4), children with DS performed similarly to TD children on both tasks. Cleave et al (2014) found that children with DS performed more poorly than TD children when fast mapping both nouns and verbs.

A possible explanation for such discrepancies are that McDuffie and colleagues used syntax matched controls to compare performance of participants with DS, as opposed to the MA-matched controls that the other fast mapping study with participants with DS use. When the researchers included children with DS and syntax matched controls (McDuffie et al., 2007) this

meant that the children in the TD control group performed at the same syntax level as the children with DS, but were younger in MA because children with DS exhibit morphosyntactic deficits and therefore children with DS do not perform the same as TD children with the same MA. Consequently, when children with DS are matched with TD controls based only on mental age, they start off with a less developed syntactic ability going into the task than their MA-matched counterparts, which could contribute to the differences seen in verb fast mapping ability in research that involves MA-matching (Cleave et al, 2014). Research that looks at how participants with DS use speaker intent and grammatical cues when fast mapping nouns and verbs compared to MA- matched controls is needed to determine if findings would be consistent with previous research.

Reviewing studies that look at the differences between TD children and children with DS when fast mapping nouns and verbs is important to understand fast mapping abilities of children with DS. Additionally, in order to create a complete picture of children with DS's fast mapping abilities, it is important to consider if children with DS fast map nouns differently than verbs. The literature in following section will address this question.

Fast mapping of nouns versus verbs in children with DS. Two of the studies addressed above examined both nouns and verbs together. McDuffie et al (2007) found that after testing participants on the 4 different tasks described previously, in task 2 which examined verbs, participants with DS showed poorer performance when fast mapping verbs compared to fast mapping of nouns in task 1. Overall, it was found that all participants performed worse on the verbs than the nouns, which indicates that children with DS do fast map nouns differently than verbs.

The second study that examined nouns and verbs together was conducted by Cleave et al (2014). They did not look at the effect of nouns versus verbs specifically, but found that participants with DS performed more poorly than TD children when fast mapping both nouns and verbs on a comprehension probe, but did not look at whether verbs were fast mapped more poorly than nouns. It is important to note that although children with DS were found to fast map nouns and verbs differently in McDuffie et al (2017), this difference may not be specific to children with DS.

Summarizing the studies on noun versus verb fast mapping in children with DS, it was found that in one noun versus verb study, children with DS performed more poorly when fast mapping verbs compared to nouns (McDuffie et al., 2007).

Given research describing verb fast mapping deficits compared to nouns, in children with DS, the question of strategies that can help such children fast map verbs more easily arises. Few studies have examined the strategies for fast mapping, however the ones that have done so have focused on imitation as a strategy (Chapman et al., 2006; Schwartz & Leonard, 1985). Imitation is defined as having participants repeat the novel word right after exposure. It is important to address the question of whether or not imitation does impact fast mapping. The next section reviews the fast mapping literature that addresses this question.

The effect of imitation on fast mapping

An important area of research in child language disorders involves examining strategies that can aid children's lexical development. One such strategy is imitation- having children repeat the words they are exposed to out loud.

Studies have investigated the "production effect", which is defined as a memory advantage for words that are said aloud versus words that are memorized quietly (Icht & Mama,

2015; Ozubko, Major, & MacLeod, 2014) . In Icht and Mama's (2015) study, 30 five year olds who were native Hebrew speakers participated. Participants were shown flashcards of 30 familiar nouns which were split into groups of 10 that the participants had to either "look at", "look and say" or "look and listen" while the examiner says the word. Following this, participants were asked to recall as many words as they could. Children remembered about twice as many words in the "look and say" condition compared to the "look at" or "look and listen" conditions. This relates to fast mapping and imitation, as it suggests that when children repeat the words they are exposed to, they may have an easier time learning those words and producing them later. Icht and Mama (2015) conducted a second experiment with 30 TD five-year olds looking at the acquisition of unfamiliar nouns. Researchers sent a list of 100 Hebrew words (bisyllabic low-frequency nouns) to speech-language pathologists, who were asked to rate the likelihood that each word would be in the lexicon of a five-year old. From this, a set of 'rare' words were identified and a picture was found for each. Children were asked to recall lists of words in two conditions: *look and say* and *look and listen*. In the look and say condition, participants heard the experimenter say the word once, and had to repeat the word. In the look and listen condition, participants heard the experimenter say the word twice. The production effect was observed again. The results showed that children better remembered unfamiliar words in the *look and say* condition. Thus, having children imitate unfamiliar words seems to aid their ability to remember the words. It is likely the same effect may be observed in a novel word fast mapping task.

Zamuner, Strahm and Page (2016) conducted an experiment that aimed to reproduce and extend findings on the production effect. For their first experiment, 24 university students were exposed to 16 novel words (eight words that were produced and eight that were only listened to)

using a pre-recorded voice. These novel words were simply phoneme strings and did not have any pictures or meanings attached to them. Participants then were presented with either words they had been trained on, or new untrained words and asked to press one button to indicate whether the word was one they had seen before (trained) or press a second button if the word was a new word (untrained). Response times were calculated. Zamuner and colleagues (2016) found that for reaction time, in the produced condition, participants responded to trained versus untrained words equally fast, but in the listen only condition, participants took longer to respond to untrained words than trained words. They did not find a traditional production effect with their experiment, but discuss that study methodology was different, specifically the number of items was fewer than in other studies of the production effect which may have led to different results.

Schwartz and Leonard (1985) conducted a study involving children with specific language impairment that investigated the role that unsolicited imitation (unasked for, immediate repetition) of lexical items had on both the comprehension and production of novel nouns and verbs. The researchers exposed participants to 16 novel nouns and verbs, over 10 experimental sessions. Participants first did a pretest where they were asked to produce the name for a referent (production) and asked to select a referent from an array (comprehension). After this, the participants were exposed to the 16 novel words, through informal play sessions. The researchers would expose the words using phrases such as “here’s the chuck” or “watch the baby lean” (while manipulating the doll). All of the words were novel words that were not in the child’s spontaneous lexicon already (Schwartz & Leonard, 1985). Participants were exposed to each word and its referent five times per session. After the 10 experimental sessions, participants took part in post-testing. First they did a production post-test which was identical to the pre-test, and a comprehension post-test which was also identical to the pre-test. The post-tests were run

for each of the 16 words. Productions of the unfamiliar words during the experimental sessions were identified and coded as either spontaneous or imitated. Spontaneous word use was defined as the child producing a target word without it being immediately modeled by the adult; child imitations were immediate reproductions of the adult's modelled target word. For production scoring, the child was said to have produced the novel words if the production contained one consonant and one vowel that were identical to the target word or if they had alternations (substitutions, stopping) found in a young child's productions. For comprehension, correct responses were only recorded if the correct referent was chosen.

Schwartz and Leonard (1985) found that unsolicited imitations during the experimental session aided the ability to produce the same words on the production probes, but did not impact performance on the comprehension probes, as children comprehended a high number of words regardless of whether they had imitated them or not. Specifically, they found that for the words produced during the post-test, the more number of spontaneous imitations that the children made during the exposure tasks, the more the children produced the words on the post-test. Schwartz and Leonard (1985) suggested that children's imitations of novel words aid in their lexical development because imitations provide children with the opportunity to verbally practice new words, thus potentially facilitating working memory processes.

Chapman, Sindberg, Bridge, Gigstead and Hesketh (2006) studied the effect of elicited imitations and multiple adult exposures on noun fast mapping in adolescents with DS and TD children matched on syntactic comprehension. Participants were exposed to the novel noun either once (low memory) or five times (high memory) and were asked to repeat the novel nouns two times during the exposure task (imitation condition) or no requests for repetition were made. Participant comprehension and production of novel words was tested immediately after exposure

and again after a delay of an hour. For immediate comprehension, Chapman et al. (2006) found that five exposures of the novel nouns improved performance compared to one exposure for the TD children only. There was no effect of elicited imitation for either group. For immediate production, both groups benefitted from five exposures to the novel nouns when no imitation was required, but they did not benefit from the five exposures when elicited imitation was requested. It may be that both TD children and children with DS have trouble using two different strategies at once, as it is too cognitively demanding. In the current study, only one strategy (elicited imitation) will be focused on, with number of repetitions increased from two to three.

Summary

In summary, the fast mapping studies reviewed to this point suggest that children with DS perform similarly to their MA-CA matched TD peers when fast mapping nouns (Chapman et al., 1990; Kay-Raining Bird et al., 2004; McDuffie et al., 2007; Mosse & Jarrold, 2011), with the exception of findings from Cleave et al. (2014) that found that monolingual participants with DS performed more poorly than TD participants on both the noun and verb fast mapping comprehension tasks. McDuffie et al (2007) and Cleave et al. (2014) found that although DS and TD groups had more trouble fast mapping verbs compared to nouns, there was no interaction of group, meaning that participants with DS did not do significantly worse in fast mapping verbs. Further research is needed to determine under what conditions children with DS fast map verbs differently than TD children. Studies have also considered production effects on word learning, finding that both TD children and adults better remember lists of words they are asked to say than words they are not asked to say (Icht & Mama, 2015; Ozubko et al., 2014) . In a naturalistic novel word learning task Schwartz and Leonard (1985) found that children with specific

language impairment, a population which also has trouble with fast mapping, benefitted from unsolicited imitations of the novel words, when tested on production on a post-test. Chapman and colleagues' (2006) study found that for immediate comprehension, there was no effect of elicited imitation, and both groups of participants benefitted from the increased number of exposures to the novel words when they were not required to imitate the novel words, but not when imitation was requested. It is possible that increasing the number of times the children are asked to imitate the novel words from 2 times (Chapman et al., 2006) to 3 times would result in larger effect sizes. This was done in our study.

The aim of increasing the number of imitations is to provide the participants as much opportunity as possible to overcome verbal memory deficits, by allowing them to rehearse the novel words, which may in turn impact verb fast mapping abilities. In general, production effect and imitation studies have given some indication of that may be a useful fast mapping strategy; however, more research is needed to see if imitation truly improves fast mapping ability in children with DS. In addition, the existing research on imitation only includes nouns. Therefore, this study aimed to extend this work to the study of elicited imitation effects on verb fast mapping in children with DS.

Objectives

The study aimed to a) examine how children with DS differ in their ability to fast map verbs compared to MA-CA matched TD peers, b) determine if having children with DS imitate the novel verbs three times immediately after each of 3 exposures will improve verb fast mapping abilities, c) determine how fast mapping of verbs in imitated and non-imitated conditions changes after a delay and d) determine how production and comprehension fast mapping performance differs. It was hypothesized that a) children with DS would perform more

poorly on both the production and comprehension probes, than MA-CA matched TD children when fast mapping verbs (Chapman et al., 1990; McDuffie et al., 2007; Mosse & Jarrold, 2011) b) that both DS and TD children would perform better in the imitation condition than the no imitation condition, c) that both groups would perform more poorly in the delayed comprehension and production probes than the immediate probes, and that d) both children and adolescents with DS and TD children would perform more poorly on the production tasks than the comprehension tasks.

CHAPTER 2 METHODOLOGY

Participants

The study included 14 English monolingual children and adolescents with Down syndrome, specifically Trisomy 21, between the ages of 12 and 21. This chronological age range resulted in a mental-age (MA) range between 4 and 8 years, which is the MA range used in previous studies of fast mapping in individuals with DS (Chapman et al., 2006; McDuffie et al., 2007). The group with DS was matched on nonverbal mental age using the *Bead Memory* and *Pattern Analysis* subtests of the *Stanford-Binet Intelligence Test fourth edition* (Thorndike, Hagan, & Sattler, 1986) to the chronological ages of a group of 15 younger TD English monolingual controls (aged 4;5-8;0) . These particular subtests of the SB-4 have been used with children with DS in previous studies (e.g., Cleave et al., 2014; McDuffie et al., 2007). Participant characteristics (i.e., chronological age, mental age, MADSCATD, scores on the *SB4* subtests, scores on the *WISC*-4, scores on the PPVT, and SES proxies are reported below in Table 1.

Participants with DS were recruited through the Down Syndrome Association of Toronto/Ontario, Special Olympics programs in Ontario and Nova Scotia, by word of mouth and through posters in public spaces such as libraries. Recruitment of TD children took place through word of mouth and through posters in public spaces such as libraries.

Trisomy 21 was determined through caregiver report. Participants with DS were excluded if they were reported to have types of DS other than Trisomy 21 (i.e., translocation, mosaic) as children with other types of DS may exhibit different cognitive and linguistic impairments than those with Trisomy 21 (Laws & Bishop, 2004). All participants were required to have no more than a mild hearing loss in the better ear (i.e., no greater than 40dB) determined through direct testing by the researcher, consistent with Cleave et al. (2014). Participants in either group were also excluded if they had a vision impairment that has not been corrected that

would impact their ability to participate or if they had any current or previous diagnoses (besides DS) such as autism or traumatic brain injury that would affect language or cognitive development.

Typical development was established through both parent report and direct standardized testing. TD children's scores on the PPVT ranged from 85-121 (mean 100, SD 22.5), with a cutoff of 1.5 SD from the mean. One TD participant was dropped from the study because his PPVT score was almost 3 standard deviations above the mean for his age. Another two TD participants were missing *PPVT* data. For the *SB4* subtests, TD participant's scores ranged from 66 -134. One participant scored higher than 1.5 standard deviations from the mean (134). Two TD participants scored more than two standard deviations below the mean on the SB-4 (66, 68). Their SB-4 data were omitted from analyses as these low scores were not considered reflective of true abilities, as they were inconsistent with the participants' *PPVT* standard scores which were 97 and 99 respectively. Consequently, to compare mental age of the participants with DS and chronological age of TD participants, a factor called MADSCATD (mental age DS, chronological age TD) was used. This was appropriate as two participants from the TD group could not be included in a mental age match due to low mental age scores and consequently, it was better to use chronological age of the TD children. Previous studies have just used mental age alone to compare individuals with DS to TD children. MADSCATD was calculated by taking the mental age of the DS participants in months and taking the chronological age of the TD participants in months.

Three proxies for SES were used, mother's and father's education and family income, reported through a caregiver questionnaire. Mother's and father's education was measured by asking the level of education completed by each parent (e.g. some high school, high school,

college degree). Family income was measured by asking annual family income amount separated into various income brackets (e.g. 0-25,000). Caregivers could choose to not report income or education level. See tables 2 and 3 for categories used to measure each SES component.

An independent samples t-test compared groups on each measure of SES and found no significant group differences on any measure. An independent samples t-test also compared mental ages of the two groups (MA on the SB4) finding no significant differences, although the effect approached significance (2 TD participants omitted from analysis). An independent samples t-test also compared *PPVT* standard scores and age equivalent scores for each group, finding a significant difference for standard scores but not for age equivalent scores. Another independent samples t-test was run on the WISC raw scores comparing the group with DS to the TD group, finding a significant difference between groups, showing that the TD group performed significantly better on the combined forward and backward WISC digit span tasks than the group with DS.

Table 1. Participant Characteristics: means (standard deviations)

Variable	Participants with DS	TD controls	Group Comparisons (t-tests) p value and significance
Number	14	15	
Chronological age (years)	16.78 (2.59)	6.25 (1.23)	$p = < .001$*
Chronological age range	12;2-21;5	4;5-8;0	
Mental age (years)	5.41 (1.30)	6.51 (2.00) n=13	$p = .082$ (NS)
SAS SB4[c]	49.21(12.7)	104.38 (14.73)[a]	$p < .001$*
SAS SB4 range	36-75	80-134[a]	
MADSCATD	64.86 (15.56)	72.47 (15.15)	$p = .193$ (NS)
Income (see table 3 for categories)	4.33 (0.89)	4.64 (0.67)	$p = .365$ (NS)

Variable	Participants with DS	TD controls	Group Comparisons (t-tests) p value and significance
Mother's education (see table 2 for categories)	3.71 (0.99)	3.50 (0.73)	p = .513 (NS)
Father's education (see table 2 for categories)	4.14 (1.10)	3.40 (1.17)	p = .133 (NS)
PPVT Standard Score[c]	42.79 (15.09)	105.77 (10.74)[b]	p < .001*
PPVT Standard Score range	20-71	85-121	
PPVT age equivalent (years)	6.14 (2.01)	6.69 (1.30)[b]	p = .411 (NS)
WISC Raw score (total)	6.86 (3.09) [d]	10.00 (3.53)[d]	p = .017*
WISC (total) raw score range	2-13	6-15	
WISC Raw score (DSF)	4.57 (1.22)	6.73 (1.16)	p < .001*
WISC Raw score (DSB)	2.29 (2.46)	3.27 (2.84)	p = .328 (NS)
WISC Scaled Scores[c]	1.57 (1.51) [d] n=7	9.33 (3.54) [d] n= 9	
WISC age equivalent scores DSF (months)	73.0 (3.74)	88.53 (23.84)	p = .023*
WISC age equivalent scores DSB (months)	77.71 (15.53)	82.40 (15.73)	p = .427 (NS)

Notes. NS= not significant; * p < .05, DSF = digit span forward, DSB = digit span backwards, SAS= Standard Age Score, SB4= Stanford-Binet Intelligence Test-fourth edition, MADSCATD= Mental age DS, chronological age TD, WISC= Weschler Intelligence Scale for Children, PPVT= Peabody Picture Vocabulary Test; [a] 2 participants' data are not included in the SAS SB4 as their scores were not representative of true abilities; [b] 2 participants' data are missing from the PPVT scores, as they did not complete the task. [c] The mean score for the PPVT is 100 with a standard deviation of 15, the mean score for the SB4 is 100 with a standard deviation of 16, the mean score for the WISC is 10 with a standard deviation of 3. Standard

scores were only available for participants between the ages of 6;0 and 16;11. [d] Scaled and raw scores for the WISC combined both the forward and backwards digit span tasks.

Table 2. Parental Education Categories

Mother and Father's Education Values		
Level of Education		Value
Some High School		1
High School		2
College		3
Bachelor's Degree		4
Master's Degree		5
Professional Degree		6
Doctoral		7

Table 3. Family Income values

Family Income Values	
Annual Income ($)	Value
0-25,000	1
25,000-50,000	2
50,000-75,000	3
75,000-100,000	4
100,000+	5

Procedures

To ensure that participants met inclusion criteria, the following three activities were completed:

Eligibility Questionnaire. Caregivers completed a brief questionnaire by phone before the experimental session to ensure that participants met specified inclusion and exclusion criteria for the study (See Appendix A). If participants were eligible for the study based on the questionnaire, a testing date and time were set up.

Hearing Screening. In order to ensure that participants could hear adequately to complete the tasks on the day of testing, they were tested at 40dB, at 1000, 2000 and 4000 Hz

using a Beltone Portable Audiometer, as the criteria for inclusion is a pass at 40dB in the better ear at all 3 frequencies. If the participants did not pass the hearing screening, testing would be ended at that time. All participants passed the hearing screening.

Grammatical Screening. Grammar was tested using a modification of the Past Tense Probe of the *Test of Early Grammar Impairment* (*TEGI*) (Rice & Wexler, 2001) to ensure the participants had the grammatical abilities to perform the fast mapping tasks. Participants were tested on their production and comprehension of present progressive and past tense forms. For the production test, participants were shown five series of two pictures, one of a present progressive action, and one of the past tense of the same action. The researcher pointed to the present progressive pictures and asked the participant: *what is he/she doing* and for the past tense picture the researcher asked: *what did he/she do*. If participants did not produce the target sentence, the researcher prompted them by saying "he/she is_____, or he/she _____. For the comprehension test, the researcher showed the participant five series of two pictures, one of a present progressive action, and one of the past tense of the same action. The researcher asked the participant to point to either the present progressive picture or the past tense picture using instructions such as *show me he is raking the leaves* versus *show me he raked the leaves*. If the participant did not produce and comprehend (point to the correct picture) at least 4/5 of the picture series without a prompt, testing ended at this point. One DS participant could not be included as they did not produce at least 4/5 of the picture series without a prompt.

If all the inclusionary criteria were met, the parents were asked to fill out the caregiver questionnaire described next and cognitive and language testing was completed.

Caregiver Questionnaire. Caregivers completed a short questionnaire on the day of testing. This questionnaire provided SES information.

Articulation Screener. As participants with DS often have articulation difficulties, a short articulation task was administered in which 11 words were elicited, using picture cards, to document any systematic speech production errors they have which could impact the fast mapping production probes. This screener was developed by the researchers. Words were selected to test production ability of the initial and final sounds that were found in the words in the fast mapping task. The sounds and words used to each elicit sound were: /m/ (monkey), /n/ (nail), /p/ (pig), /k/ (cake), /f/ (fan), /w/ (watch), /z/ (zebra), and /t/ (teapot) in initial position and /n/ (fan), /v/ (stove), /s/ (bus), /k/ cake/, and /b/ (lightbulb/bulb) in final position. Each word was transcribed online using the International Phonetic Alphabet. All participants were able to produce all target sounds correctly. See Appendix C for articulation screener document.

Digit Span. Participants completed the digit span task of the *Weschler Intelligence Scale for Children – Fourth Edition (WISC-4)* (Wechsler, 2003) to test their working memory skills. The digit span task involved participants listening to a series of numbers and repeating the numbers in sequence, forwards for the forward digit span and backwards for the backwards digit span. The items increased in difficulty, with more numbers needing to be recalled in later items. Raw scores and scaled scores were generated for the forward and backward digit span tasks combined by taking the individual scores from the backwards and forwards digit span tasks and totalling them to get one raw score, and then using the combined raw score to get a combined scaled score for each participant. Age equivalent scores for the forward and backwards digit span task were calculated separately. For the scaled scores only seven participants with DS were able to be scored as the remaining seven participants did not fall within the age range for the test; which was 6;0 – 16;11. For the TD children, nine participants were included in the scoring and seven were out of the age range for the test. Age equivalent scores were calculated for all

participants. The lowest possible age-equivalent score was <6;2. These were recorded as 6;0 or 72 months in SPSS for purposes of analysis. The group with DS had great difficulty with this task; 12/14 participants scored <.6;2 for the digit span forward task and 12/14 participants scored <6;2 for the digit span backwards. For the TD group 1/15 participant scored <6;2 for the digit span forward task and 7/15 participants scored <6;2 for the digit span backwards task. For the TD group, 6/15 participants were younger than the test norms. Because of the reduced variability in age-equivalent scores (many participants scores <6;2) in both groups, raw scores (which were more variable) on the WISC-4 were used in any statistical analyses (see table 1 for descriptive statistics).

Receptive Vocabulary. Participants in both groups were tested on the *Peabody Picture Vocabulary Test- Fourth Edition* (*PPVT- IV)* (Dunn & Dunn, 2007) in order to obtain a measure of receptive vocabulary. In the *PPVT-IV*, participants are shown arrays of 4 pictures and asked to point to the picture that matches a spoken word given by the administrator. Raw, age-equivalent and standard scores were generated. For one participant who was originally tested, their data had to be omitted from the study as their score fell above 3 standard deviations from the mean, and two participants who were included in the study had missing data for all *PPVT* scores. Normative sample ages for the *PPVT-IV* are 2;6 -90+.

Nonverbal Cognition. All participants completed the *Bead Memory (BM)* and *Pattern Analysis (PA)* subtests of the *SB-4*. The *BM* subtest materials involved four shapes of beads that each came in three colours (red, blue and white) and a stick to put the beads on. Participants were asked to recreate bead patterns from pictures that the researcher showed them. The *PA* subtest involved two levels of testing. At the easiest level, a form board with indents for triangular, circular and square whole and half pieces was used. Participants were asked to

complete the puzzle in a variety of ways. For the higher level of testing, cubes with different black and white patterns on each side were used. Participants were asked to replicate a series of block patterns either demonstrated by the researcher or presented in a picture. Normative sample ages for the *SB4* are 2;0 - 23;11. Raw scores, standard scores and age-equivalent scores were generated following directions in the manual. MA was calculated by averaging the age-equivalent scores for the two *SB4* subtests. For two participants who were originally tested, their data had to be omitted from the study due to inaccurate scores, and two participants' data were omitted from the *SB4* analyses due to low scores, that were inaccurate representations of ability.

Experimental Fast Mapping (FM) Tasks

Eight verb fast mapping tasks were administered in two blocks: imitation and a no-imitation. The verb fast mapping tasks were based on that used in Experiment 2 by Eyer et al. (2002). The elicited imitation component was based on the imitation task used by Chapman et al. (2006).

Eight novel verbs and eight novel actions the verbs represent were used (see Table 5). First, the words were paired to the actions for each participant using the Latin square method. Then, the order of words/action pairs was randomized for each individual participant. Following this, the order of the imitation conditions (elicited and not imitation) were counterbalanced across individuals in each group, such that the first four word/action pairs in a participant's order were assigned to Condition 1 and the second four word/action pairs were assigned to Condition 2. Whether the elicited or no imitation condition came first was counterbalanced for all participants within a group (DS, TD). See Appendix B for the assignment of words to actions.

Training. In both the Imitation and No Imitation conditions, participants completed two training trials, one with a familiar verb and action and one with a novel verb and action, using an

animate figure, Frankie, who had moveable limbs. Frankie was used to demonstrate the verb actions.

Frankie was first introduced to the participants. In the Imitation condition, they were then given the following instructions: *I'm going to say some action words and show you some actions. I want you to watch carefully and repeat the action word every time I point to you, ok? Now the first action word that you will say when I point to you is "walk/jump". Are you ready? Let's practice!* The researcher then demonstrated and labeled the familiar verb using Frankie and elicited imitations from the child by saying: "look, Frankie's going to walk/jump (point to child) Frankie's walk/jump-ing (point to child), did you see how Frankie walk/jump-ed? (point to child). If the participant did not imitate the verb when they were pointed to, the researcher said *say X*. Following this, verb learning was tested, first in a production probe, then in a comprehension probe. The same procedure was used with the unfamiliar novel training verb, and production followed by comprehension probes were completed again.

In the no imitation condition, the training was the same as in the elicited imitation condition, except participants were asked to listen silently when the familiar and novel verbs and actions were demonstrated, using the following instructions: *I'm going to say some words and show you some actions and I want you to watch carefully and listen but don't say anything while I do, ok? Let's practice! Look, Frankie's going to X, Frankie's X-ing, did you see how Frankie X-ed?*

For the training production probes, participants were asked to produce the target verb when the researcher showed them the action for the verb, saying "what's Frankie doing, what's that called?". If participants did not produce the verb correctly or if they did not respond at all, they were prompted by the researcher "What's Frankie doing?". Following this, if the

participant did not respond again or responded incorrectly, corrective feedback was given by the researcher, which included the researcher modelling the verb for the participant. For the production probe, 3 participants (2 DS, 1 TD) required corrective feedback. Participants were then asked to show the researcher the corresponding actions when the researcher said the familiar word, saying "make Frankie x". If participants did not produce the action for the training stimuli or if they produced the wrong action, they were prompted by the researcher: "make Frankie X". If the participant still did not produce the correct action for the verb or if they did not produce an action for the verb at all, they were given corrective feedback, which included the researcher modelling the action using Frankie. All participants were able to complete the training comprehension probes without corrective feedback.

For the training trials in each condition, the verbs and their corresponding actions were always the same. The words and actions that the participants were trained on for each condition are presented in table 4.

Table 4. Training stimuli

Familiar verbs	**Novel verbs**	**Novel actions**
Training- Elicited Imitation		
Walk	Dack	Full body roll in mid air
Training session- No Imitation		
Jump	Nep	Swing both legs in pendulum motion

Exposure tasks. In the experimental exposure tasks for the elicited imitation condition participants were instructed to watch as the novel verb was demonstrated using Frankie. They were asked to repeat the novel word, each time it was said, when the researcher pointed to the child (just as in the training task). The following instructions were used: *OK for these next games, remember to listen and watch carefully and say the action words when I point to you! Are*

you ready? Look, Frankie's going to X (points), Frankie is X-ing (points), did you see how Frankie X-ed? (points). Let's try another one.

In the no imitation condition, participants were instructed to watch and listen silently as the researcher demonstrated and modeled the four verbs. The following instructions were used for the no imitation condition. *Now I'm going to say some words and show you some actions and I want you to listen and watch carefully but don't say anything, ok? Here's the first one. Look, Frankie's going to X , Frankie is X-ing (points), did you see how Frankie X-ed? Let's do another one.*

If the child failed to imitate the novel verb in the elicited imitation condition exposure task, the researcher prompted the child only once by asking the child *Say x.* The researcher recorded the use of prompts for all stimuli. If the child did not imitate the word after one prompt, the researcher recorded the absence of imitation. For the children with DS, three out of fourteen needed prompting once to imitate a novel word, and for the TD children five out of sixteen needed prompting once to imitate a novel word.

If the child tried to repeat the word during the no imitation condition, the researcher stopped them by saying *remember, don't talk just listen*. If the child continued to imitate the words after being prompted not to, the researcher recorded the presence of imitation during the non-imitation task. For the children with DS, five out of fourteen needed prompting to sit quietly and listen during the no imitation condition, and for the TD children two out of sixteen needed prompting to sit quietly and listen during the no imitation condition.

Immediate Production Probes. The production probes tested participants' ability to produce the novel verbs associated with a given action in the exposure task. The production probes were administered before the comprehension probes, immediately after each novel word

was exposed. The researcher demonstrated a novel action on Frankie and asked the participant to name the action saying*: What is Frankie doing? What is that called?*

Participants were given a score of 2 if they produced the target word with all phonemes correct, a score of 1 if they produced at least 2 of 3 phonemes of the target word correctly and in the correct order (Chapman et al., 2006), with or without affixation. Participants were given a score of 0 if they produced a different word, or produced the target verb but with less than 2 of the 3 phonemes correct (Chapman et al., 2006), or if they did not respond. Scores were summed for the four fast mapping tasks in a given condition (maximum = 8).

Immediate Comprehension Probes. The comprehension probe tested participants' comprehension of the novel verbs they had been exposed to, and were administered immediately after the production probes for each novel word. The researcher said the verb and instructed the participant to demonstrate the action on Frankie, using the following instructions: *Make Frankie X*. Scoring was modified from that used by Bedore and Leonard (2000). Participants were given a score of 2, if they used the correct limb of Frankie and demonstrated the action correctly; a score of 1 if the participant demonstrated the right action but with the wrong limb (e.g. arm instead of leg); and a score of 0 if they demonstrated an incorrect action (for example, the action for another word) or did not demonstrate any action at all. Scores were summed for the four fast mapping tasks in a given imitation condition (maximum = 8). See table 5 for a summary of scoring methods for both comprehension and production.

Table 5. Scoring the fast mapping tasks

Production	Comprehension
2- Target word produced with all phonemes correct 1-Target word produced with 2/3 phonemes correct 0- Target word not produced or produced with < 2/3 phonemes correct	2- Correct action with correct limb 0- Correct action with wrong limb 1- 0- Incorrect action/no action

Delayed Production and Comprehension Probes. Participants completed delayed production and then comprehension probes in blocks after a delay of approximately 15 minutes after the immediate probes. These were conducted exactly as the immediate probes, except that all four novel words in a block were probed in random order, first in production then in comprehension. Delayed production and comprehension probes were scored using the same system as the immediate production and comprehension probes. Exposure tasks were not repeated prior to the delayed probes.

Reliability. A second trained rater in addition to the lead researcher scored production and comprehension probe responses for 10% of participants (participants involved were selected randomly) and disagreements were discussed and resolved. Interrater reliability of scoring was greater than 90% for both the comprehension and production probes.

Verb stimuli.

Novel verbs. There were eight novel verbs. All were intransitive verbs. The novel words were taken from Chapman et al. (2006) and Bedore and Leonard (2002). All novel words had a CVC syllable structure (Chapman et al., 2006). See table 6 for the novel verb and action stimuli.

Novel actions. Novel actions were matched to novel verbs. The novel actions were taken from Bedore and Leonard (2000). The novel actions were tested by these authors to make sure they did not resemble any familiar actions that participants might already know. The novel actions were also piloted to make sure that the actions could not be described using already existing verbs. In order to pilot this, the researcher completed the fast mapping tasks with a graduate student volunteer. The volunteer was shown each action and asked to describe the action using one English word. No actions had to be modified. The researcher and the volunteer

also discussed the words themselves. One word /flk/ was changed to /fik/ to make fewer real words similar to it.

Table 6. Novel verb and action stimuli

Novel verbs	**Novel actions**
1. Zug	Spin on head
2. Wis	Swing one arm
3. Poon	Hop up and down on one arm
4. Fik	Clap with arms behind body
5. Mook	Jump up and down on head
6. Neen	Jump from head to feet
7. Koob	Slide on one foot
8. Tiv	Walking on hands

Table 7 presents the order of administration of the testing protocol which was as follows. First, participants participated in a hearing screening. Then participants did the grammatical screener, followed by the articulation task and the forward and backward digit span task. The participants then took part in the *SB4* subtests. After this the first block of fast mapping tasks were administered including immediate probes. These were followed by the *PPVT-IV*. After this, delayed production and comprehension probes for the first block were administered. A 15-minute game called "Get to Know" separated the first and second blocks of fast mapping tasks. On completion of the game, the second block of fast mapping tasks were administered in the same sequence as the first with the exception that a second 15-minute game called "My

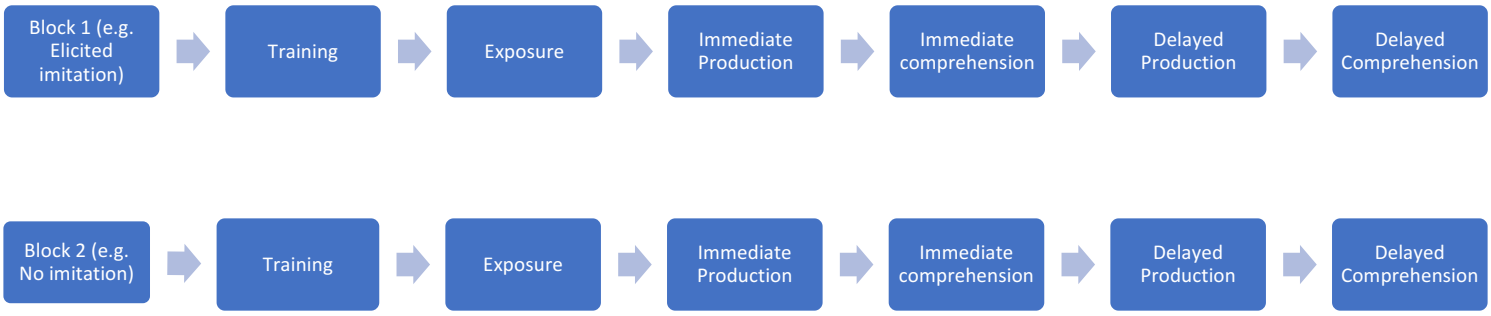
favourite, your favourite" intervened between the immediate and delayed probes. Thus, three experimental manipulations were used, one to test the impact of imitation on fast mapping (elicited imitation, no imitation conditions), the second to test whether fast mapping comprehension or production changes after a short delay (immediate, delayed conditions) and the third to test differences in fast mapping abilities in terms of production and comprehension.

Table 7. Testing protocol.

Items used to determine inclusion/exclusion: Eligibility Questionnaire, Hearing screening, TEGI grammatical screening	
Items used to describe participants: Caregiver questionnaire, Articulation Screener, WISC-4 digit span tasks, SB4 Subtests	
Experimental Fast Mapping Tasks Block 1 •	Training Exposure • Task 1 (exposure, immediate production, immediate comprehension) • Task 2 (exposure, immediate production, immediate comprehension) • Task 3 (exposure, immediate production, immediate comprehension) • Task 4 (exposure, immediate production, immediate comprehension)
PPVT-IV test	
Delayed probes, Block 1	
15-minute game	
Experimental Fast Mapping Tasks Block 2 •	Training Exposure • Task 1 (exposure, immediate production, immediate comprehension) • Task 2 (exposure, immediate production, immediate comprehension) • Task 3 (exposure, immediate production, immediate comprehension) • Task 4 (exposure, immediate production, immediate comprehension)
15-minute game	
Delayed probes, block 2	

Figure 1 presents the specific order of the fast mapping tasks for further clarification.

Figure 1. Protocol of the fast mapping tasks by block



Two 3-way mixed ANCOVAs were conducted, with comprehension and production scores (maximum of 8) as the dependent variables. The covariate was mental age of the group with DS combined with the chronological age of the TD group (MADSCATD). As explained earlier, this covariate was used to account for differences in mental age of the group with DS and the chronological age of the TD group, as reported in table 1. MA was not used for the TD group, as there were two TD participants whose scores on the SB4 were omitted due to inaccurate scores, and so chronological age of the TD participants (all TD participants) was used instead. In the ANCOVA, there was one between-subjects factor (group: DS, TD) and two within-subject factors (time: immediate, delayed; imitation: elicited, no imitation). Production scores were calculated by averaging the scores of the 4 production conditions (immediate production, elicited imitation condition; immediate production, no imitation condition; delayed production, elicited imitation condition; delayed production, no imitation condition). The same

was also done for the 4 comprehension conditions by averaging comprehension scores across the 4 comprehension conditions. Significance was set *a priori* at $p < .05$ but corrected using a Bonferroni correction for all post-hoc analyses investigating significant interactions using t-tests. Pearson product moment correlations were also completed to look at relationships between fast mapping performance and scores on the digit span working memory and the *PPVT* task within each group separately. For the WISC correlations, raw scores were used, as there was much more variability than in age equivalent scores. Statistical analyses were completed using IBM Statistics SPSS software.

CHAPTER 3 RESULTS

Production

The first 3-way ANCOVA analyzed performance on the fast mapping production abilities (see Table 8 for descriptive statistics and Appendix E for all statistical results).

Table 8. Fast mapping production: Means and Standard Deviations by time and condition and group, table of descriptive statistics.

Time/Condition	Group	Mean	Std. Deviation	N
Immediate, Imitation	DS	4.71	3.024	14
	TD	6.60	1.844	15
Immediate, No Imitation	DS	4.71	2.199	14
	TD	7.20	1.612	15
Delayed, Imitation	DS	.36	.745	14
	TD	.27	.594	15
Delayed, No Imitation	DS	.07	.267	14
	TD	.80	2.111	15

Notes. SD = standard deviation; maximum score =8

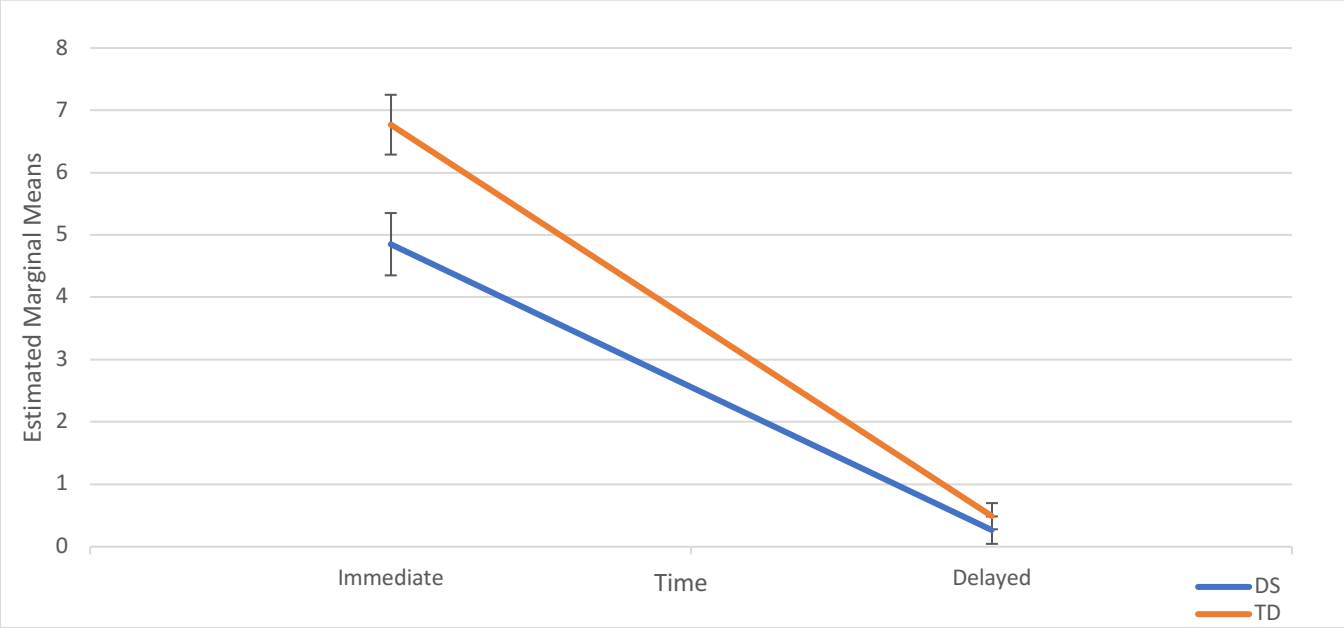
A significant main effect of time (F (1, 26) = 6.05; p = .021; η_p^2 = .189) was found, with higher production performance during the immediate probes (M = 5.81; SE = 0.34) than the delayed probes (M = 0.37; SE = 0.15).

A significant interaction of time by group (F (1, 26) = 6.02; p = .021; η_p^2 = .19) was also found. Table 9 shows the means and standard errors for the interaction of time by group. The time by group interaction is depicted in Figure 2.

Table 9. Means and standard errors for interaction of time by group

Group	Time	Mean	Std. Error
DS	Immediate	4.853	.497
	Delayed	.266	.220
TD	Immediate	6.770	.480
	Delayed	.485	.212

Figure 2. Time by Group interaction for Production Probes



Note: error bars represent standard errors for each mean

Four post-hoc t-tests were completed to investigate the interaction further. Bonferroni correction for four comparisons adjusted significance to $p < .0125$. Two independent t-tests compared the groups with DS and the TD on immediate and delayed probes respectively. For the immediate probes, the difference approached significance (t (27) = -2.23; p =.034; d = -1.34),

with the TD group performing marginally better than the DS group. For the delayed probes, there was no significant effect between groups.

Two post-hoc paired samples t-tests compared each group's immediate versus delayed probe performance. For the group with DS, there was a significant difference from immediate to delayed probes t (13) = 8.90; $p < .001$; $d = 2.38$). For this group, performance on the immediate probes was significantly better than performance on the delayed probes. For the TD group, immediate performance was also significantly higher than delayed performance t (12) = 11.34; $p < .001$, $d = 2.93$).

Comprehension

Descriptive statistics for fast mapping comprehension performance by group, time and condition are presented in Table 10. The 3-way ANCOVA revealed no significant main effects or interactions. See Appendix E for all statistical results.

Table 10. Fast mapping comprehension: Means and Standard Deviations by time and condition and group, table of descriptive statistics

Time/Condition	Group	Mean	Std. Deviation	N
Immediate Imitation	DS	6.43	2.377	14
	TD	6.60	2.165	15
	Total	6.52	2.230	29
Immediate No Imitation	DS	6.64	1.823	14
	TD	7.47	1.125	15
	Total	7.07	1.534	29
Delayed Imitation	DS	5.79	2.833	14
	TD	5.20	2.569	15
	Total	5.48	2.668	29
Delayed No Imitation	DS	6.00	2.746	14
	TD	5.67	2.743	15

	Total	5.83	2.700	29

Comprehension and Production comparison

The study also examined the comparison between performance on production probes and comprehension probes. An independent samples t-test compared the groups with DS and the TD on production probes and comprehension probes. Production scores were calculated by averaging the scores for each of the 4 production probes (immediate production, elicited imitation condition; immediate production, no imitation; delayed production, elicited imitation condition; delayed production, no imitation condition). Comprehension probes were calculated the same way but averaging the scores for the 4 comprehension conditions (immediate comprehension, elicited imitation condition; immediate comprehension, no imitation; delayed comprehension, elicited imitation condition; delayed comprehension, no imitation condition). See Table 11 for means and standard deviations by group and probe.

Table 11. Means and standard deviations for production and comprehension

Process	Group	N	Mean	Std. Deviation	Std. Error Mean
Prod	DS	14	2.4643	1.26665	.33853
	TD	15	3.7167	.99043	.25573
Process	Group	N	Mean	Std. Deviation	Std. Error Mean
Comp	DS	14	6.2143	2.23576	.59753
	TD	15	6.2333	1.44069	.37199

Paired samples t-tests compared each group's production versus comprehension probe performance. For the group with DS there was a significant difference between production and

comprehension (t (13) = -9.99; $p < .001$; d = -2.68). For this group, performance on the comprehension probes was significantly better than performance on the production probes. For the TD group, there was also a significant difference between production and comprehension (t (14) = -5.92; $p < .001$; d = -1.53). Note that for the TD group, there was a lower effect size for the difference between comprehension and production. For this group, performance on the comprehension probes was also significantly better than performance on the production probes.

Error Analysis

Individual responses for production and comprehension probes were scrutinized. See Appendix D for tables of individual participant responses. For the immediate production no imitation condition participants with DS were more likely to have phonological errors in their productions of the words (e.g. saying "tib" instead of "tiv"). For the delayed production probes in both conditions, when participants did not produce the novel word correctly, TD participants were more likely to attempt a word or substitute the word for another action, compared to participants with DS who were more likely to say "I don't know".

For the immediate production probes in the elicited imitation condition, for TD children, 10% of responses were errors, with 17% of those errors being "I don't know", and 83% of those errors being real word substitutions for the target words. For the delayed production probes in the elicited imitation condition, for TD participants, 75% of responses were errors, with 22% of those errors being "I don't know", 44% of those errors being real word substitutions (often descriptions of the actions with phrases), and 33% of those errors being substitutions of another target word. For the no imitation immediate production condition for TD participants, only 3% of responses were errors, and of those errors, 100% were real word substitutions. For the no

imitation delayed production condition for TD participants, 82% of responses were errors, with 22% of those errors being "I don't know", 61% of those errors being real word substitutions, 6% of those errors being phonologically poor attempts, and 10% being substitutions of another target word.

For the group with DS, for the immediate production in the elicited imitation condition, 36% of responses were errors, with 5% of those errors being "I don't know", 90% of those errors being real word substitutions, and 5% of errors being substitutions of another target word. For the group with DS in the delayed production in the elicited imitation condition, 91% of responses were errors, with 25% of those errors being "I don't know", 63% of those errors being real word substitutions, 2% of those errors being phonologically poor attempts, and 4% of those errors being substitutions for another target word. For the group with DS in the immediate production no imitation condition, 34% of responses were errors, with 21% of those errors being "I don't know", 74% of those errors were real word substitutions, and 5% were phonological poor attempts at the target word. For the group with DS in the delayed production no imitation condition, 88% of responses were errors, with 31% of those errors being "I don't know", 61% of those errors being real word substitutions, 4% of those errors being phonologically poor attempts, and 4% of those errors being substitutes for another target word.

For the comprehension probes, both groups performed fairly well in both the immediate and delayed conditions, but when unsure of a novel action, they occasionally produced the right action with the wrong limb, but more often either substituted the target action with the action for another novel verb or they made up an action (which was considered unrecognizable).

Specifically, for the TD group in the immediate comprehension elicited imitation condition, 13% of responses were errors, with 25% of those errors being "I don't know", 13% of

those errors being the right action with the wrong limb, 50% of those responses being a substitution of an action for another target word, and 13% being unrecognizable actions. For the TD group in the delayed comprehension, elicited imitation condition, 23% of responses were errors, with 7% of those errors being "I don't know", 50% of those errors being substitutions of another novel action, and 43% of those being unrecognizable actions. For the TD group in the immediate comprehension in the no imitation condition, only 3% of responses were errors, 100% of which were unrecognizable actions. For the delayed comprehension in the no imitation condition, 25% of responses were errors with 13% being "I don't know", 7% being the right action with the wrong limb, 60% being substitutions of another novel action, and 20% being unrecognizable actions.

For the group with DS, in the immediate comprehension elicited imitation condition, 18% of responses were errors, with 40% being "I don't know", 10% being right action wrong limb (e.g. using the leg instead of the arm), 20% being substitutions of another novel action, and 30% being unrecognizable actions.

For the group with DS in the delayed comprehension elicited imitation condition, 29% of responses were errors, with 25% of those being "I don't know", 31% of those being substitutions, and 44% of those being unrecognizable actions. For the group with DS in the immediate comprehension no imitation condition, 16% of responses were errors, with 22% of those being right action wrong limb, 33% of those being substitutions of another novel action and 44% of those being unrecognizable actions. For the group with DS in the delayed comprehension no imitation condition, 21% of responses were errors, with 58% being "I don't know", 8% being right action wrong limb, 8% being substitutions of another novel action and 25% being unrecognizable actions.

Correlations

Correlations between fast mapping performance in each condition and receptive vocabulary (PPVT age equivalent) were conducted separately for each group. For the group with DS, a moderate positive correlation between PPVT age equivalent and delayed production in the elicited imitation condition ($r = .670$; $p = .009$) was found. For the TD group, a strong positive correlation between PPVT age equivalent and immediate comprehension in the no imitation condition ($r = .707$; $p = .007$) was found. No other correlations that were moderate or higher were found.

Correlations between fast mapping performance and working memory were also conducted. Correlations were conducted separately for immediate and delayed probes. For the group with DS, a moderate positive correlation was found between the WISC raw score (forward and backwards digit span task combined) and delayed production in the elicited imitation condition only ($r = .626$; $p = .017$). For the TD group, no significant correlations between fast mapping and working memory were found. See Appendix E for all correlational results.

CHAPTER 4 DISCUSSION

The objectives of the study were to a) examine how children with DS differ in their ability to fast map verbs compared to TD peers (mental age of the group with DS and chronological age of the TD group were statistically controlled; groups were matched on SES), b) determine if having participants imitate the novel verbs immediately after each of 3 exposures will improve verb fast mapping abilities, c) determine how fast mapping of verbs changes after a delay, and d) determine how production and comprehension performance differs.

Overall, it was found that for production, participants in both groups were able to fast map verbs in the immediate condition but had trouble with production of verbs in the delayed condition. It was also found that children and adolescents with DS had a marginal production deficit compared to TD children. Another finding was elicited imitation did not aid in production for either group (no significant effect for elicited imitation condition). For comprehension, participants with DS and TD participants showed the ability to comprehend novel verbs in both the immediate and delayed conditions. There was no significant difference between groups for either the immediate or delayed comprehension conditions, and imitation did not aid in comprehension of the novel words. It was also found for both children and adolescents with DS and TD children, production performance was poorer than comprehension performance. These findings will be discussed in detail below.

Do children with DS differ in their ability to fast map verbs compared to MA-CA matched TD peers?

As predicted, children and adolescents with DS performed (marginally) more poorly on immediate production probes than their TD peers (Chapman et al., 2006; McDuffie et al., 2007; Mosse & Jarrold, 2011). This finding is consistent with reports that children and adolescents

with DS tend to have more trouble with expressive language than TD peers (Chapman & Kay-Raining Bird, 2011). Not all fast mapping studies have found production differences however. Some have found that children and adolescents with DS did not differ significantly in their ability to produce novel words during immediate probes of fast mapping tasks (e.g. Kay-Raining Bird et al., 2004; Chapman et al., 1990). A possible explanation for the inconsistency with previous studies is that both Kay-Raining Bird et al. (2004) and Chapman et al. (1990) used novel nouns for their fast mapping tasks, whereas the current study used verbs, although Chapman et al. (2006) also used nouns and found differences in performance on the immediate production probe. It is possible that children with DS have a harder time producing novel verbs, as they are more abstract to learn (learning a novel action and mapping that to a word rather than mapping a novel object to a word). Cleave et al. (2014) when comparing nouns to verbs, found noun fast mapping performance was better than verb fast mapping performance, which supports the idea that verbs may be harder to learn. It is possible that the difference in word class accounts for the difference in findings on the immediate production probe, but this explanation may be less likely as some verb studies have found no group differences on the immediate production probe.

Scrutiny of the individual responses on the immediate production probe showed that participants with DS tended to produce the novel verbs less accurately than TD children. That is, participants with DS produced a similar number of attempts to produce the novel words on the immediate production probe, but phonologically, their attempts were less accurate (for example saying “tib” instead of “tiv”), which resulted in lower scores (more one’s than two’s). This is consistent with reported articulatory difficulties in children and adolescents with DS (Kumin, 2003). It would appear that although participants with DS could produce all the sounds in target

words in the articulation screener, it was harder for them to produce the sounds in the novel words used in the current study.

Contrary to the group difference found for immediate production probes, children and adolescents with DS and did not differ significantly from TD controls on the delayed production probes. Both groups had difficulty in the delayed production condition, resulting in a floor effect. This is inconsistent with the findings of Chapman et al. (1990) that children and adolescents with DS performed more poorly on the delayed production probe. Similar floor effects have been found by McDuffie et al. (2007) who did not analyze production data, as few participants correctly produced any of the novel words.

With regards to comprehension probes, it was found that children and adolescents with DS did not differ significantly in their performance at either time-period compared to MA-CA matched TD children, meaning their performance on the comprehension probes was MA appropriate. Further, both groups did quite well on the comprehension probes, even after a delay. It was predicted that children and adolescents with DS would perform more poorly than TD children on the comprehension probes based on the findings of Cleave et al. (2014) and Kay - Raining Bird et al. (2000). Kay-Raining Bird et al. (2000) found that children with DS performed more poorly on comprehension probes than TD children, and suggested that poorer performance may have been found because the children in their study were younger and the task was more complex than tasks used in previous studies. Cleave et al. (2014) found that the monolingual children with DS in their study performed more poorly on a comprehension task, compared to the monolingual TD children.

Contrary to the findings that children with DS differ in comprehension abilities (Kay-Raining Bird et al, 2000), and consistent with the findings of the current study, Chapman et al

(2006) also found that children with DS did not differ on comprehension probes compared to MA-matched TD peers which supports the findings of the current study. One explanation for the current study's finding of good performance on the comprehension probes in both immediate and delayed probes and no group differences may be the order in which probes were administered. The production probe was administered before the comprehension probe in the present study. Thus, participants in both groups may have been "primed" to the action queried in the comprehension probe by seeing it in the previous production probe. This is especially true for the immediate comprehension probe because each word was tested individually following the exposure task, first in production and then comprehension. Chapman et al. (1990) also tested production before comprehension, thus probing in the same order as in the current study, and also found no group differences relative to MA-matched TD controls, which may support this interpretation. Cleave et al. (2014) obtained DS and TD group differences on the comprehension probe they used, at least for the monolinguals they studied. The authors suggest that the reason why differences may have been found is because the Cleave et al. (2014) task involved syntactic bootstrapping, which is an area of deficit for children with DS, and so performance on comprehension may have been lower due to more difficult demands placed on children with DS; demands that do not exist in the current study.

Did having children imitate the verbs three times improve fast mapping ability?

Previous studies of the effects of imitation on word learning have shown inconsistent results. One study found that the number of unsolicited imitations a child made during and exposure task made it more likely that participants would produce those novel words on a production post-test for children with SLI, in other words the higher the number of unsolicited imitations, the more likely they produced them (Schwartz & Leonard, 1985). In order to

analyze the effect of imitation, the study used analyses of variance for words produced on the post-test and the number of words that had been imitated during the experimental sessions. An imitation of a novel word was considered spontaneous when the child produced the novel word or part of the word without being asked specifically to do so, and often occurs immediately after exposure. Children tend to spontaneously imitate novel words they are attending to and interested in, and this is thought to help in acquiring language (K. Nelson, 1973). Elicited imitation occurs when participants are specifically asked to imitate the novel words and it may play less of a facilitative role as it is not initiated by the child. Thus, a possible explanation for the lack of an imitation effect in the present study is that participants were instructed to imitate words rather than choosing to do so. In addition, because Schwartz and Leonard (1985)'s study was not a fast mapping task, participants had more opportunities to imitate the novel words during the extended mapping phase of word learning.

Another aspect of imitation to consider is the number of imitations asked of the participants during the present fast mapping task. It is possible that a reason for the lack of an imitation effect is that the number of imitations was still too low to facilitate fast mapping. In the current study, participants were asked to imitate the novel verbs three times, and this was predicted to be enough imitations for participants to learn novel verbs. Chapman et al. (2006) required 2 imitations of the novel verbs, and did not find any effects, so it was thought that increasing the number of imitations from two to three in the present study might aid in fast mapping performance. It is possible that three imitations of the novel verbs was still not enough, and that participants need even more imitations in order for the imitations to be useful as a strategy and support forming a more complete phonological representation of the words in their long-term memory. Schwartz and Leonard (1985) found that children in their study

spontaneously imitated the novel words an average of 6.85 times (SD=4.32) over all of ten the experimental sessions, with a range of 1-13 repetitions. This increased number of imitations as well as the type of imitation – spontaneous versus required (as discussed above) – may have contributed to their finding of a production effect.

Another possible explanation for why there was no effect of imitation on fast mapping performance in the present study is that the level cognitive demand placed on the participants during the elicited imitation condition of the fast mapping task may have impeded their ability to fast map. During the elicited imitation condition of the fast mapping task, participants were instructed to imitate the novel word that the researcher just said, every time they were pointed to. The researcher would point to the participant for imitation after each of the 3 exposures to the word. It is possible that participants were focused on remembering to repeat the novel word when they were pointed to, and that the imitations acted less like a rehearsal strategy and more of an attentional distraction to semantic mapping. That is, it is possible that they needed to imitate both the novel words and the actions in order to be able to learn to correctly pair the novel verb to the novel action. The idea of imitations acting as more of an attentional distraction is supported by the fact that there was a positive correlation between working memory and delayed production in the elicited imitation condition, at least for children and adolescents with DS. This indicated that only those children and adolescents with DS who had better working-memory skills were at all successful in producing recognizable target words after a delay. The idea of imitation being more of a distractor and less of a strategy is also supported by a work studying "recasting" in young children. Recasting involves the child saying an utterance with an error such as "I throwed the ball" and an adult recasting the utterance and correcting the error such as "you threw the ball, didn't you?" (Nelson & Baker, 1984). Recasting allows the child to

immediately compare their production to a more complete or accurate production, which has been shown to help children acquire new syntactic structures more easily (Nelson & Baker, 1984). Research has shown that recasts aid in language acquisition as they give feedback to the children that highlights elements of language that the child has not mastered yet (Cleave, Becker, Curran, Owen Van Horne, & Fey, 2015). In terms of the efficacy of recasting, a systematic review and meta-analysis of efficacy of recasts in language intervention found that many studies concluded that recasting produced better performance than interventions that did not use recasting. It could be that recasting is a strategy that children find more helpful than interventions that involve disruptions during the input in language learning. Recasting does not require any imitation by the child. It is thought that recasting is beneficial for children to learn, as they are not expected to produce any output such as through elicited imitation, but rather they learn through patterns in the input, which is also known as statistical learning (Plante & Gómez, 2018). It is thought that having children imitate words places a cognitive demand on them, by taking cognitive resources away from use for implicit learning through detection of language patterns (Plante & Gómez, 2018). Plante and Gomez (2018) discuss that one language learning study by Courtright and Courtright in 1976 included a modelling condition where participants simply heard models of the pronoun "they" (these participants had not acquired this pronoun yet). In another condition, participants were required to imitate the pronouns after hearing the model, for expressive practice. It was found that imitation resulted in better results than the heard only condition after the first session, but participants in the elicited imitation condition did not make further progress later when they were tested on their ability to use "they" in novel contexts. In contrast children who had heard the model only showed greater progress on subsequent sessions, and began to use the pronoun "they" in new contexts over 70% of time.

Camarata et al. (1994) also conducted a study that compared conversational recasts to imitation in children with SLI. One of the points they discuss is that the learning that comes from imitation is very narrow, as elicited imitation occurs under such tightly controlled contexts. They found that children's spontaneous productions of words were higher in conversational recast conditions, and that children with SLI acquired the conversational recast targets with fewer clinician presentations of the targets. Camarata et al. (1994) discuss that conversational recasts allow children to jump past the problem of generalization from word level to conversation, as they are already being presented with models at the conversational level.

These findings provide evidence for the fact that imitation may disrupt children learning from the input. and could help explain why imitation did not result in increased fast mapping performance in the present study; supporting the notion that requiring the children to repeat the words used cognitive resources, that could have otherwise been used for simply implicitly learning from the input. Relating recasting to fast mapping tasks, it could be possible that using recasting, specifically recasting incorrect utterances (phonological errors) during fast mapping production probes could assist children in learning the correct production of words in subsequent probes. Phonological recasts have been used in recasting studies. Cleave and colleagues (2015) report that one study looked at the use of both grammatical recasts and phonological recasts and found that alternating grammatical and phonological recasts resulted in the greatest gains for individuals.

How does fast mapping of verbs change with a delay?

Fast mapping in this study was tested immediately and again after a 15-minute delay. For the production probe, it was found that the children and adolescents with DS and TD children performed significantly better on the immediate probes than on the delayed probes.

These findings are consistent with Chapman et al. (2006) who also found that participants with DS and TD participants did better in the immediate production condition than the delayed production condition; the recall rate for the delayed production was 5% for the group with DS and 2.5% for the TD group, even lower than in the present study.

It makes sense that immediate production performance was better than delayed production performance in that during the immediate probes they only had one verb to remember (each production probe came immediately after exposure). This would make it easier to produce the novel verbs. In the delayed probes, all four verbs in a condition were tested together. This is harder to do, which could in part explain the immediate-delayed performance gap. As well, participants may be relying more on short term memory for the immediate probes and long term memory for the delayed probes, which could help explain why they did not perform as well on the delayed probes. They may not have successfully transferred information from short to long-term memory during the exposure phase of the study.

For the comprehension probe no significant effects or interactions of time were found, meaning that there was not a significant difference between immediate and delayed performance for either group. Both groups performed quite well on both the immediate and delayed comprehension probes. For the comprehension probes in the immediate elicited imitation condition the group with DS had a mean score of 6.43 with a standard deviation of 2.38 out of a total of 8, and the TD group had a mean of 6.60 with a standard deviation of 2.17 out of a total of 8. For the immediate probes no imitation, the group with DS had a mean score of 6.64 with a standard deviation of 2.82 out of a total of 8, and the TD group had a mean score of 7.47 with a standard deviation of 1.13 out of a total of 8. For the delayed comprehension probes in the elicited imitation condition, the group with DS had a mean score of 5.79 with a standard

deviation of 2.83 out of a total of 8, and the TD group had a mean of 5.20 with a standard deviation of 2.57 out of a total of 8. For the delayed comprehension probes no imitation, the group with DS had a mean score of 6.00 with a standard deviation of 2.75 out of a total of 8, and the TD group had a mean score of 5.67 with a standard deviation of 2.74 out of a total of 8. A possible reason for the no significant differences between the immediate and delayed comprehension probes is that, as discussed earlier, the participants were exposed to the novel action during the production probe. Comprehension performance therefore may have been enhanced by seeing the action performed during the production probe, which was immediately before the comprehension probe. Despite this, the findings that comprehension did not differ significantly across the immediate and delayed condition are consistent with findings by Cleave et al., (2014).

Do comprehension performance and production performance differ?

One of the predictions was that children and adolescents with DS and TD children would perform more poorly on the production tasks than the comprehension tasks. This was confirmed. In general, children (both TD and with DS) comprehend words more readily than they can produce them (Muzi, 2000) and comprehension is a relative strength compared to production for children and adolescents with DS (Pelatti, 2015). The findings of the current study are consistent with findings in previous fast mapping studies, showing that production performance was lower than comprehension performance (Chapman et al., 2006). In verb fast mapping, in order to produce the novel word, children must map the word onto a novel action, and verbally recall the word. For comprehension, children hear a word, which they again have to pair with the appropriate action, but they only have to recognize, not recall the verb; a simpler task. This

could be why production performance was lower in children and adolescents with DS and TD children.

Limitations

Some of the limitations of the current study involve the study design, specifically having the production probe before the comprehension probe. As discussed earlier, participant performance on the comprehension probes (especially in the delayed condition) may have been enhanced by seeing the researcher produce the action for the novel word immediately before administering the comprehension probe, as for both the immediate and delayed condition production was tested, then comprehension right after for each word. One study (McDuffie et al., 2007) had the comprehension probe before the production probe, which may have eliminated enhanced performance on the comprehension probes, though this may enhance performance on the production probes. A possible way to eliminate enhanced performance on either probes could be to do all of the comprehension probes for all of the words in that condition (in a block), then do all of the production probes in a block. Another possible way to reduce factors such as order effects could be to counterbalance the production and comprehension probes, so that production does not always come before comprehension, although this was considered and deemed not to be useful as there would be order effects for comprehension first probes as well.

Another study design limitation is that for the delayed probes, participants had to remember the target novel word from a group of four, which is more difficult. It is possible that by changing the design so that participants do not have to remember as many words after the delay, floor effects (specifically for production) would be eliminated. This being said, it should be noted that both groups were able to fast map in comprehension after a delay, so some learning did take place, even with four novel words tested in a group.

Another limitation of the current study is that participants were shown the actions during the production probes prior to testing comprehension. Especially after a delay, this could have primed the actions being tested in comprehension and inflated comprehension performance.

Another limitation of the study was the sample size. It may be that more effects and interactions would be seen with a larger sample.

Future research

Future research should consider looking at the number of imitations needed in order for participants with DS to be able to store words and their meanings in long term memory as well as studying if increasing the number of imitations aids in fast mapping. A way of testing whether increasing the number of imitations aids in fast mapping could be to have words that participants imitate three times, and have words that participants imitate more times (for example five times) and analyze the difference in production and comprehension performance for words that were imitated fewer versus more times. This, however, would mean that the novel words would be modelled each time before the participant would be asked to imitate, which would also increase the number of exposures, which would move the type of mapping from fast mapping to extended mapping. Future research could also examine the use of recasting as a strategy as opposed to elicited imitation, to see if recasting helps with word learning. This could include recasting incorrect phonological productions during production probes, to promote children's learning from the input without the cognitive demand of having to imitate words. It is important, however, to consider that recasting may be better suited for extended mapping tasks, where children receive more exposures of the target words rather than just one or a few exposures of the word as in fast mapping tasks.

Also, on the topic of imitation, future research should consider looking at the role of spontaneous imitation versus elicited imitation. This could be done by having an elicited imitation condition where participants are required to repeat the novel words and having a comparison condition where participants are not instructed to sit quietly as they were in the current study but have the opportunity to spontaneously imitate the novel words. It could be possible that having the children engaged in the task in such a way that they are self-motivated to produce spontaneous imitations would be helpful. This could include having a more naturalistic task, such as doing an unstructured play session rather than a structured session like was done in the present study, or it could include using materials such as stories. Even so, it may be that unsolicited imitations may not be possible in a fast mapping task, rather they may be more viable in extended mapping tasks, such as the one done by Schwartz & Leonard (1985).

Another factor that future research should consider is that children may need to imitate both the novel word and the associated action in order to facilitate fast mapping. Future research might change the imitations to involve this.

Future research should also consider increasing the sample size of both groups in order to see if that would produce any significant effects or interactions.

Future research should also consider changing the design of the study, specifically the order of the comprehension and production probes. As discussed in the limitations section, the current study had the production probe first before the comprehension probe, which may have enhanced comprehension of the words due to exposure to the novel actions in the production probe. Future research might also consider testing comprehension in blocks after all words for that block are taught. Future research should consider the order of the probes for this reason.

Conclusions

In conclusion, the findings of the current study did not support the hypothesis that imitation aided fast mapping for children with DS and TD children. This may be due to the nature of the imitations (required versus spontaneous) that were used in the current study and may also be due to the combination of strategies such as number of exposures and imitation itself, as other studies have found that imitation in combination with other strategies such as increased number of exposures did not aid in fast mapping performance (Chapman et al., 2006). It may be that children with adolescents need to use spontaneous imitations of novel words to help them fast map novel words, and it may be that increased exposures of the novel words are needed, but not in combination with increased imitations. It was also found that children with DS seemed to have a verb fast mapping production deficit compared to TD children. Clinical implications for such a finding may be that children with DS may need to be explicitly taught to produce verbs correctly. Further research is needed in the area of imitation and verb fast mapping.

APPENDIX A

Screening Questionnaire- Study Eligibility

Participant # _____

BACKGROUND/HISTORY OF CHILD

1. Child's chronological age: _____

2. Child's grade in school: _____

3. a) Does your child have a diagnosis of Down syndrome that is trisomy 21?
   ☐Yes
   ☐ No

   b) If yes, does your child have any additional diagnoses that may affect their language and learning besides Down syndrome?
   ☐Yes
   ☐ No

4. Does your child have any history of language learning or speech problems?
   ☐Yes
   ☐ No

5. Has your child had a hearing screening?
   ☐Yes
   ☐No

   If yes, was any hearing loss reported?
   ☐ Yes (please specify): _____
   ☐ No

6. Does your child have any history of vision loss? If yes, please explain.

   _____

7. Has the vision loss been corrected?
   ☐Yes
   ☐No

8. Does your child speak only English?
   ☐Yes
   ☐No

9. Has your child been exposed regularly to any languages other than English? If yes, please specify.
   ☐Yes: _____
   ☐No

Caregiver Questionnaire

The following questions will provide us with information about you and your child. Please fill out the questionnaire as best as you can.

1. Guardian/parent's Name: _____

2. Relationship to child (parent, guardian, grandparent etc.)

   _____

3. How many adults and children live in your home?

   Adults: _____

   Children: _____

4. Please check the box that best describes your family's yearly income

   ☐ < $25,000
   ☐ $25,000-$50,000
   ☐ $50,000-$75,000
   ☐ $75,000-$100,000
   ☐ >$100,000
   ☐ Would rather not answer

5. What is the highest level of education of each parent/guardian living in the home?

Guardian/Parent 1	Guardian/Parent 2
☐ Some high school ☐ High School ☐ College/apprenticeship ☐Bachelor's Degree ☐Master's degree ☐Professional degree ☐Doctoral degree ☐Other (please specify): _____ ☐Would rather not answer	☐ Some high school ☐ High School ☐ College/apprenticeship ☐Bachelor's Degree ☐Master's degree ☐Professional degree ☐Doctoral degree ☐Other (please specify): _____ ☐Would rather not answer

BACKGROUND/HISTORY OF CHILD

10. Has your child ever received speech-language therapy (SLT) services?

☐ Currently receiving speech-language therapy
☐ Received therapy in the past but no longer

If yes, at what age did they start receiving SLT services?
_____

If your child no longer receives speech-language therapy, at what age did they stop receiving the services? _____

If your child is currently receiving SLT services, please describe what therapy is focusing upon:

11. What other healthcare professionals is your child currently involved with?

☐Family physician
☐Audiologist
☐Occupational Therapist
☐Physiotherapist
☐Psychologist
☐ None of the above
☐Other: (please specify) _____

Thank you for taking the time to fill out this questionnaire.

APPENDIX B

Counterbalancing method

Word exposure order for participants with DS	
Participant	**Order of novel words**
1	koob, tiv, wis, zug, fik, neen, poon, mook
2	Tiv, mook, poon, koob, wis, neen, fik, zug
3	Neen, mook, fik, zug, tiv, poon, wis, tiv,
4	Fik, tiv, koob, mook, wis, neen, zug, poon
5	Zug, wis, koob, neen, poon, tiv, mook, fik
6	Poon, fik, koob, zug, mook, tiv, neen, wis
7	Wis, fik, tiv, poon, koob, neen, zug, mook
8	Mook, wis, neen, fik, poon, zug, koob,tiv
9	Neen, wis, poon, koob, fik, mook, tiv, zug
10	Mook, tiv, wis, fik, zug, poon, koob, neen
11	Fik, koob, zug, neen, mook, wis, poon, tiv
12	Zug, fik, wis, neen, tiv, poon, mook, koob
13	koob, neen, tiv, mook, wis, poon, zug, fik
14	Poon, neen, wis, zug, mook, tiv, fik, koob
15	Wis, mook, poon, fik, koob, tiv, neen, zug
16	Tiv, fik, poon, koob, wis, mook, zug, neen

Word order for TD participants	
Participant	**Order of novel words**
1	Koob, zug, mook, wis, tiv, poon, fik, neen
2	Neen, tiv, zug, koob, mook, poon, wis, fik
3	Zug, koob, tiv, fik, mook, neen, poon, wis
4	Tiv, wis, koob, poon, fik, nook, zug, neen
5	Poon, zug, wis, koob, neen, mook, tiv, fik
6	Poon, mook, wis, zug, koob, tiv, fik, neen
7	Mook, fik, koob, zug, tiv, neen, wis, poon
8	Wis, tiv, fik, neen, koob, poon, zug, mook
9	Fik, zug, poon, neen, koob, tiv, wis, mook
10	Tiv, poon, fik, koob, mook, zug, neen wis
11	Koob, neen, mook, tiv, wis, fik, poon, zug
12	Fik, neen, poon, koob, mook, zug, wis, tiv
13	Zug, neen, poon, tiv, mook, wis, fik, koob
14	Mook, koob, wis, tiv, neen, fik, poon, zug
15	Wis, poon, neen, mook, fik, koob, tiv, zug
16	Neen, fik, poon, wis, zug, koob, tiv, mook

Matching of actions to words (both groups, 16 participants in each group)								
Participants	**Word/action match**							
P1	Koob→ walking on hands	Mook→ Slide on one foot	Wis→ Jumping from head to feet	Tiv→ Jump up and down on head	Neen→ Clap with arms behind body	Fik→ Hop up and down on one arm	Poon→ Swing one arm	Zug→ Spin on head
P2	Koob→ Spin on head	Mook→ walking on hands	Wis→ Slide on one foot	Tiv→ Jumping from head to feet	Neen→ Jump up and down on head	Fik→ Clap with arms behind body	Poon→ Hop up and down on one arm	Zug→ Swing one arm
P3	Koob→ Swing one arm	Mook→ Spin on head	Wis→ walking on hands	Tiv→ Slide on one foot	Neen→ Jumping from head to feet	Fik→ Jump up and down on head	Poon→ Clap with arms behind body	Zug→ Hop up and down on one arm
P4	Koob→ Hop up and down on one arm	Mook→ Swing one arm	Wis→ Spin on head	Tiv→ walking on hands	Neen→ Slide on one foot	Fik→ Jumping from head to feet	Poon→ Jump up and down on head	Zug→ Clap with arms behind body
P5	Koob→ Clap with arms behind body	Mook→ Hop up and down on one	Wis→ Swing one arm	Tiv→ Spin on head	Neen→ walking on hands	Fik→ Slide on one foot	Poon→ Jumping from head to feet	Zug→ Jump up and down on head
P6	Koob→ Jump up and down on head	Mook→ Clap with arms behind body	Wis→ Hop up and down on one	Tiv→ Swing one arm	Neen→ Spin on head	Fik→ walking on hands	Poon→ Slide on one foot	Zug→ Jumping from head to feet
P7	Koob→ Jumping from head to feet	Mook→ Jump up and down on head	Wis→ Clap with arms behind body	Tiv→ Hop up and down on one	Neen→ Swing one arm	Fik→ Spin on head	Poon→ walking on hands	Zug→ Slide on one foot

P8	Koob→ Slide on one foot	Mook→ Jumping from head to feet	Wis→ Jump up and down on head	Tiv→ Clap with arms behind body	Neen→ Hop up and down on one	Fik→ Swing one arm	Poon→ Spin on head	Zug→ walking on hands
P9	Koob→ walking on hands	Mook→ Slide on one foot	Wis→ Jumping from head to feet	Tiv→ Jump up and down on head	Neen→ Clap with arms behind body	Fik→ Hop up and down on one arm	Poon→ Swing one arm	Zug→ Spin on head
P10	Koob→ Spin on head	Mook→ walking on hands	Wis→ Slide on one foot	Tiv→ Jumping from head to feet	Neen→ Jump up and down on head	Fik→ Clap with arms behind body	Poon→ Hop up and down on one arm	Zug→ Swing one arm
P11	Koob→ Swing one arm	Mook→ Spin on head	Wis→ walking on hands	Tiv→ Slide on one foot	Neen→ Jumping from head to feet	Fik→ Jump up and down on head	Poon→ Clap with arms behind body	Zug→ Hop up and down on one arm
P12	Koob→ Hop up and down on one arm	Mook→ Swing one arm	Wis→ Spin on head	Tiv→ walking on hands	Neen→ Slide on one foot	Fik→ Jumping from head to feet	Poon→ Jump up and down on head	Zug→ Clap with arms behind body
P13	Koob→ Clap with arms behind body	Mook→ Hop up and down on one	Wis→ Swing one arm	Tiv→ Spin on head	Neen→ walking on hands	Fik→ Slide on one foot	Poon→ Jumping from head to feet	Zug→ Jump up and down on head
P14	Koob→ Jump up and down on head	Mook→ Clap with arms behind body	Wis→ Hop up and down on one	Tiv→ Swing one arm	Neen→ Spin on head	Fik→ walking on hands	Poon→ Slide on one foot	Zug→ Jumping from head to feet
P15	Koob→ Jumping from	Mook→ Jump up and	Wis→ Clap with arms	Tiv→ Hop up and	Neen→ Swing one arm	Fik→ Spin on head	Poon→ walking on hands	Zug→ Slide on one foot

	head to feet	down on head	behind body	down on one				
P16	Koob→ Slide on one foot	Mook→ Jumping from head to feet	Wis→ Jump up and down on head	Tiv→ Clap with arms behind body	Neen→ Hop up and down on one	Fik→ Swing one arm	Poon→ Spin on head	Zug→ walking on hands

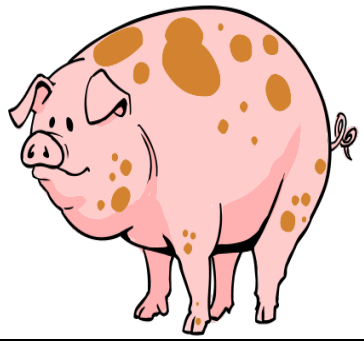
APPENDIX C

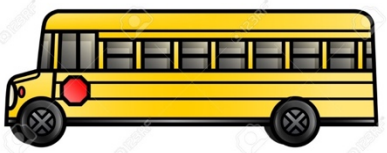
Articulation Screener

Participants will be asked to name the following pictures. Altogether, the pictures include all of the sounds (word initial and word final) that they will be expected to produce in the words from the fast mapping task.

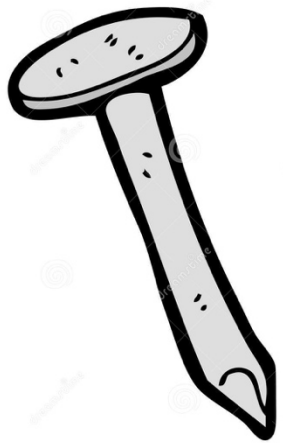
Sounds/word positions

- Initial /z/ (Zebra)
- Final /v/ (Stove)
- Initial /w/ (Watch)
- Final /s/ (Bus)
- Initial /p/ (Pig)
- Final /n/ (Fan)
- Initial /f/ (Fan)
- Final /k/ (Cake)
- Initial /m/ (Monkey)
- Initial /n/ (Nail)
- Initial /k/ (Cake)
- Final /b/ (Lightbulb/bulb)
- Initial /t/ (Teapot)





Record form (IPA transcription of responses):

1. Zebra _____
2. Watch _____
3. Pig _____
4. Bus _____
5. Fan _____
6. Cake _____
7. Monkey _____
8. Nail _____
9. Teapot _____
10. Lightbulb/bulb _____
11. Stove _____

APPENDIX D

Individual Participant characteristics tables

Participant #	Chronological Age	Mental Age	Family Income	Mother's Education	Father's Education
DS-1	14:6	4;4	4	3	2
DS-2	12;2	6;9	5	4	5
DS-3	17;5	8;1	5	4	5
DS-4	15;9	4;9	5	3	4
DS-5	17;9	4;6	4	2	5
DS-6	16;8	4;9	5	5	7
DS-7	15;2	5;2	4	4	3
DS-8	17;5	4;5	5	4	4
DS-9	17;10	4;11	4	2	5
DS-10	16;7	5;0	2	4	3
DS-11	12;10	4;6	-	5	4
DS-12	21;5	7;4	-	4	3
DS-13	19;9	4;2	4	5	5
DS-14	19;8	7;0	5	3	4

- = preferred not to answer

*= only one parent recorded

Participant #	Chronological Age	Family Income	Mother's Education	Father's Education
TD-1	5;11	5	4	5
TD-2	6;1	5	3	3
TD-3	6;1	5	3	3
TD-4	4;6	4	5	*
TD-5	7;8	-	4	-
TD-7	4;6	3	3	1
TD-8	4;5	-	3	-
TD-9	6;1	-	3	-
TD-10	4;8	5	3	4
TD-11	8;0	-	3	-
TD-12	5;3	5	4	4
TD-13	6;4	5	4	4
TD-14	7;4	5	4	4
TD-15	7;1	-	2	2
TD-16	7;8	4	4	5

- = preferred not to answer

*= only one parent recorded

Participant responses (production) fast mapping task

TD group

	Elicited imitation								No imitation							
participant	Immediate				Delayed				Immediate				Delayed			
1	T=Tiv R=Tiv	T=Poon R=Poon	T=Fik R=Flik	T=Neen R=Neen	T=Poon R=DK	T=Neen R=DK	T=Tiv R=Poon	T=Fik R=DK	T=Koob R=Koob	T=Zug R=Zug	T=Mook R=Mook	T=Wis R=Wis	T=Mook R=fly	T=Koob R=Mook	T=Wis R=DK	T=Zug R=DK
2	T=Neen R=Neen	T=Tiv R=Tiv	T=Zug R=Zug	T=Koob R=Koov	T=Zug R=needling	T=Neen R=Needling	T=Koob R=spin on head	T=Tiv R=DK	T=Wis R=Wis	T=Poon R=Poon	T=Fik R=Fik	T=Mook R=Mook	T=Poon R=Poon	T=Mook R=IDK	T=Wis R=walk on hands	T=Fik R=Hop on 1 hand
3	T=Mook R=Mook	T=Neen R=Neen	T=Poon R=Poon	T=Wis R=Wis	T=Poon R=Poon	T=Mook R=DK	T=Wis R=Koon	T=Neen R=Wis	T=Zug R=Deik	T=Koob R=Koob	T=Tiv R=Tiv	T=Fik R=Fik	T=Tiv R=Skating	T=Zug R=Tiv	T=Fik R=DK	T=Koob R=Kuving
4	T=Tiv R=Tiv	T=Wis R=Wis	T=Koob R=Koob	T=Poon R=Poon	T=Koob R=Poon	T=Tiv R=Koon	T=Poon R=Koon	T=Wis R=Koon/Poon	T=Fik R=Fik	T=Mook R=Mook	T=Zug R=Zug	T=Neen R=Neen	T=Zug R=Kap	T=Neen R=Neen	T=Mook R=DK	T=Fik R=boxing
5	T=Neen R=Neen	T=Mook R=Mook	T=Tiv R=Tiv	T=Fik R=Fik	T=Tiv R=pank	T=Neen R=Plank	T=Fik R=Squish	T=Mook R=Hip	T=Poon R=Poon	T=Zug R=Zug	T=Wis R=Wis	T=Koob R=Koob	T=Wis R=Wak	T=Poon R=pank	T=Koob R=Poon	T=Zug R=bob
7	T=Tiv R=Tiv	T=Neen R=Neen	T=Wis R=Wis	T=Poon R=Poon	T=WIs R=Zog	T=Tiv R=Zog	T=Poon R=Walking handstand	T=Neen R=Swinging arm	T=Mook R=Mook	T=Fik R=Fik	T=Koob R=Koob	T=Zug R=Zug	T=Koob R=Chog	T=Mook R=Sog	T=Zug R=Skog	T=Fik R=Stirling
8	T=Wis R=Wis	T=Tiv R=Tiv	T=Fik R=Fik	T=Neen R=Need	T=Fik R=DK	T=Wis R=Fik	T=Neen R=Wisking	T=Tiv R=Clap	T=Koob R=Koob	T=Poon R=Poon	T=Zug R=Zug	T=Mook R=Mook	T=Zug R=Clobbing	T=Koob R=Skate	T=Mook R=Clobbing	T=Poon R=Swobbing
9	T=Koob R=Woob	T=Tiv R=Twiv	T=Wis R=Wis	T=Mook R=Mook	T=Wis R=DK	T=Koob R=Diving	T=Mook R=Skating	T=Tiv R=Boinging	T=Fik R=FIk	T=Zug R=Zug	T=Poon R=Poon	T=Neen R=Neen	T=Poon R=waynning	T=Fik R=buping	T=Neen R=Clap	T=Zug R=twiking
10	T=Tiv R=dying	T=Poon R=Poov	T=Fik R=Sik	T=Koob R=Toob	T=Poon R=jumping	T=Koob R=flipping	T=Fik R=Hive	T=Tiv R=Diving	T=Mook R=Mook	T=Zug R=Zug	T=Neen R=Tuing	T=Wis R=WIs	T=Neen R=DK	T=Mook R=walking	T=Wis R=kicking	T=Zug R=Hi
11	T=Wis R=Wis	T=Fik R=Fik	T=Poon R=Poon	T=Zug R=Zug	T=Poon R=Doing	T=Zug R=ziging	T=Wis R=dugging	T=Fik R=Suking	T=Koob R=Koob	T=Neen R=Neen	T=Mook R=Mook	T=Tiv R=Tiv	T=Tiv R=Chewing	T=Koob R=Bobing	T=Neen R=hewing	T=Mook R=jewing
12	T=Fik R=Fik	T=Neen R=Neen	T=Poon R=Poon	T=Koob R=side stand	T=Neen R=skating	T=Koob R=Crawling	T=Poon R=handstand	T=Fik R=Pochib	T=Mook R=Mook	T=Zug R=zug	T=Wis R=Wis	T=TIv R=Tiv	T=Zug R=DK	T=Tiv R=handstand	T=Mook R=armpit move	T=WIs R=Spin on head

13	T=Mook R=Mook	T=Wis R=Wis	T=Fik R=Fik	T=Koob R=Foobing	T=Fik R=Swim	T=Mook R=Fik	T=Koob R=Clap	T=Wis R=pooking	T=Zug R=Zug	T=Neen R=Neen	T=Poon R=Poon	T=Tiv R=Tiv	T=Tiv R=DK	T=Zug R=Pooing	T=Neen R=Pooing	T=Poon R=Pooing
14	T=Mook R=Mook	T=Koob R=Koob	T=Wis R=Wis	T=Tiv R=Tiv	T=Wis R=DK	T=Koob R=DK	T=Tiv R=DK	T=Mook R=Tiving	T=Neen R=Neen	T=Fik R=Fik	T=Poon R=Poon	T=Zug R=Zug	T=Zug R=DK	T=Neen R=spin on head	T=Fik R=walking handstand	T=Poon R=Sate
15	T=Fik R=FIk	T=Koob R=Koob	T=Tiv R=TIv	T=Zug R=Zug	T=Tiv R=tapping	T=Fik R=bowwowing	T=Zug R= skating	T=Koob R=tapping	T=WIs R=Wisp	T=Poon R=Poon	T=Neen R=Neen	T=Mook R=Mook	T=Mook R=pooching	T=Wis R=clapping	T=Poon R=DK	T=Neen R=Wisping
16	T=Neen R=Neen	T=Fik R=Fik	T=Poon R=Poon	T=Wis R=Wisk	T=Poon R=Skitching	T=Neen R=Chuning	T=Wis R=Poon	T=Fik R=Wisking	T=Zug R=Zug	T=Koob R=Koob	T=Tiv R=Tiv	T= Mook R=Mook	T=Mook R=wobble	T=Koob R=Mook	T=Zug R=walk handstand	T=Tiv R=Clap

DK= said they didn't know
T= Target word
R= Response

Participant responses (production)- fast mapping task- DS Group

DK= said they didn't know, T=Target R= Repsonse

	Elicited imitation								**No imitation**							
participant	Immediate				Delayed				Immediate				Delayed			
1	T= fik R=neck	T=Neen R=cap	T= poon R=poon	T=Mook R=Mook	T=Neen R=cap	T=Mook R=deck	T=poon R=DK	T=Fik R=hammer	T=koob R=koob	T=tiv R=tube	T=wis R= wip	T= zug R=Zug	T=tiv R=tap	T=Zug R= tap	T=Wis R=tap	T= koob R=walk
2	T=tiv R=tiv	T=Mook R=myuk	T=poon R=poon	T=koob R=koov	T=Poon R=	T=Tiv R=	T=Poon R=poon	T=Koob R=Koov	T=Wis R=Wis	T=Neen R=Nee	T=Fik R=Finked	T=Zug R=Zug	T=Fik R=tap	T=Wis R=Lug	T=Zug R=Wis	T=Neen R=Tupping
3	T=Poon R=Poon	T=Tiv R=Tiv	T=Wis R=Wist	T=Koob R=Koob	T=Wis R=Nuging	T=Koob R=Koob	T=Tiv R=Nuging	T=Poon R=DK	T=Neen R=Need	T=Mook R=Mook	T=Fik R=Fik	T=Zug R=Zug	T=Zug R=Nog	T=Neen R=DK	T=Fik R=Nugging	T=Mook R=Spaz
4	T=Zug R=Zug	T=Wis R=Wis	T=Koob R=Koob	T=Neen R=nicking	T=Koob R=clap hands	T=Zug R=DK	T=Neen R=DK	T=Wis R=Pump arms	T=Poon R=Poop	T=Tiv R=Tib	T=Mook R=Book	T=Fik R=Feet	T=Mook R=DK	T=Poon R=DK	T=Fik R=DK	T=Tiv R=Spin on head
5	T=Wis R=big	T=neen R=Kiding	T=Zug R=Clap	T=Poon R=DK	T=Zug R=Fist	T=Wis R=Spinning	T=Poon R=DK	T=Neen R=Skate	T=Fik R=Flip	T=Tiv R=Tib	T=Koob R=jump	T=Mook R=move arm	T=Koob R=tap	T=Fik R=Flip	T=Mook R=move arm	T=Tiv R=Walk on hands
6	T=Poon R=Fly	T=Fik R=Handstand	T=Koob R=jump on head	T=Zug R=Flipping	T=Koob R=jump on head	T=Poon R=fly	T=Zug R=Fallingdown	T=Fik R=Handstand	T=Mook R=clap hands back	T=Tiv R=Swing arms	T=Neen R=Spin on head	T=WIs R=Tapping shoulder	T=Neen R=spin on head	T=Tiv R=Swing the arm	T=Wis R=tapping	T=Mook R=Clapping
7	T=Koob R=Koob	T=Neen R=Neen	T=Zug R=Zug	T=Mook R=Mook	T=Zug R=Rake	T=Koob R=up down	T=Mook R=DK	T=Neen R=Tuking	T=Wis R=Frisking	T=Fik R=Friking	T=Tiv R=Tiv	T=Poon R=Poon	T=Tiv R=Ti	T=Wis R=Te	T=Poon R=DK	T=Fik R=DK
8	T=Mook R=Mook	T=Wis R=Wisking	T=Neen R=Need	T=Fik R=Fliking	T=Neen R=Needing	T=Fik R=Flexing	T=Mook R=ducking	T=Wis R=ducking	T=Poon R=Pood	T=Zug R=Zug	T=Koob R=Koob	T=Tiv R=Tiv	T=Koob R=sliding	T=Tiv R=clapping	T=Zug R=koobing	T=Poon R=spinning
9	T=Fik R=Fik	T=Mook R=Mooked	T=Tiv R=banging head	T=Zug R=Zug	T=Tiv R=DK	T=Zug R=DK	T=Mook R=DK	T=Fik R=DK	T=Neen R=Neen	T=Wis R=Wisking	T=Poon R=DK	T=Koob R=DK	T=Poon R=DK	T=Neen R=DK	T=Koob R=DK	T=Wis R=DK
10	T=Mook R=Mook	T=Tiv R=Tiv	T=Wis R=Wis	T=Fik R=Fik	T=Wis R=Swising	T=Mook R=Finking	T=Fik R=Fik	T=Tiv R=DK	T=Zug R=Zug	T=Poon R=Frooing	T=Koob R=Cube	T=Neen R=Neeing	T=Koon R=DK	T=Zug R=DK	T=Neen R=DK	T=Poon R=DK
11	T=Mook R=Mook	T=WIs R=Wisking	T=Poon R=Poon	T=Tiv R=TIv	T=Poon R=Gooping	T=Mook R=Koobing	T=Tiv R=Thocking	T=Wis R=Tiv	T=Fik R=Fik	T=Koob R=Koob	T=Zug R=Zung	T=Neen R=Neen	T=Zug R=Hanging	T=Fik R=Zog	T=Neen R=Head and toes	T=Koob R=Swinging
12	T=Zug R=Clapping hands behind	T=Fik R=Thinking	T=WIs R=spinning on head	T=Neen R=Skating	T=Wis R=Spinning a head	T=Zug R=Clapping behind	T=Neen R=Skating	T=Fik R=thinking	T=Tiv R=DK	T=Poon R=Poon	T=Mook R=Mook	T=Koob R=Koob	T=Mook R=Moving arm	T=Tiv R=DK	T=Koob R=Tib	T=Poon R=using the head
13	T=Wis R=thinking	T=Poon R=Zugging	T=Zug R=Stepping on head	T=Fik R=Fik	T=Poon R=sleeping	T=Fik R=Dipping	T=Wis R=moving his arm	T=Zug R=dipping his head	T=Koob R=koob	T=Neen R=walking on hands and knees	T=Tiv R=Tipping	T=Mook R=Moved	T=Tiv R=Twisting	T=Neen R=Walking	T=Mook R=Neening	T=Koob R=nicking
14	T=Poon R=poon	T=Neen R=Neen	T=Wis R=Ris	T=Zug R=Zug	T=Wis R=DK	T=Poon R=Skiing	T=Zug R=Dubbing	T=Neen R=turning	T=Mook R=Mook	T=Tiv R=Tiv	T=Fik R=Friky	T=Koob R=Koob	T=Fik R=Turking	T=Mook R=Klep	T=Koob R=Head	T=Tiv R=Reist

Participant responses (comprehension) fast mapping task- TD group

	Elicited imitation								**No imitation**							
participant	Immediate				Delayed				Immediate				Delayed			
1	T=Jump on head R= DK	T=Swing arm R=Swing arm	T=Hop 1 arm R=Hop 1 arm	T=Clap behind R=Clap behind	T=swing arm R=body roll in air	T=clap behind R=swing arm	T=jump on head R=slide 1 foot	T=hop 1 arm R=DK	T=walk on hands R=walk on hands	T=spin on head R=spin on head	T=slide on foot R=slide on foot	T=Jump head to feet R=Jump head to feet	T=slide on foot R=jump head to feet	T=walk on hands R=body roll in air	T=jump head to feet R=slide one foot	T=spin on head R=DK
2	T=jump on head R=jump on head	T=jump head to feet R=jump head to feet	T=swing arm R=swing arm	T=spin on head R=spin on head	T=jump on head R=jump head to feet	T=swing arm R=swing arm	T=spin on head R=spin on head	T=jump head to feet R=jump head to feet	T=walk on hands R=walk on hands	T=slide on foot R=slide on foot	T=hop 1 arm R=hop 1 arm	T=clap behind R=clap behind	T=slide 1 foot R=slide 1 foot	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=hop 1arm R=hop 1 arm
3	T=Spin on head R=spin on head	T=jump head to feet R=jump head to feet	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=clap behind R=clap behind	T=spin on head R=spin on head	T=walk on hands R=Walk on hands	T=jump head to feet R=Jump head to feet	T=hop 1 arm R=hop 1 arm	T=swing arm R=swing arm	T=slide 1 foot R=slide 1 foot	T=jump on head R=jump on head	T=side 1 foot R=slide 1 foot	T=hop 1 arm R=hop 1 arm	T=jump on head R=jump on head	T=swing arm R=swing arm
4	T=Walk on hands R=walk on hands	T=spin on head R=spin on head	T=hop 1 arm R=hop 1 arm	T=jump on head R=jump on head	T=hop 1 arm R=hop 1 arm	T=walk on hands R=hop on hands	T=jump on head R=dropped Frankie	T=spin on head R=spin on head	T=Jump head to feet R=Jump head to feet	T=Swing arm R=Swing arm	T=Clap behind R=clap behind	T=slide 1 foot R=slide 1 foot	T=clap behind R=clap behind	T=slide 1 foot R=flip	T=swing arm R=swing arm	T=jump head to feet R=jump head to feet
5	T=Walk on hands R=Walk on hands	T=Hop 1 arm R=hop 1 arm	T=spin on head R=spin on head	T=slide on foot R=slide on foot	T=spin on head R=spin on head	T=walk on hands R=walk on hands	T=slide on foot R=slide on foot	T=hop 1 arm R=hop 1 arm	T=jump head to feet R=Jump head to feet	T=jump on head R=jump on head	T=swing arm R=swing arm	T=clap behind R=clap behind	T=swing arm R=roll body in air	T=jump head to feet R=clap behind	T=Clap behind R=swing arm	T=jump on head R=clap behind
7	T=hop 1 arm R=hop 1 arm	T=swing arm R=swing arm	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=clap behind R=clap behind	T=hop 1 arm R=hop 1 arm	T=walk on hands R=jump on head	T=swing arm R=swing arm	T=Jump on head R=Jump on head	T=spin on head R=spin on head	T=jump head to feet R=jump head to feet	T=slide on foot R=slide on foot	T=jump head to feet R=jump head to feet	T=jump on head R=jump on head	T=slide on foot R=slide on foot	T=spin on head R=spin on head
8	T=Jump on head R=jump on head	T=clap arms behind R=clap arms behind	T=swing 1 arm R=swing 1 arm	T=hop 1 arm R=hop 1 arm	T=swing 1 arm R=jump on head	T=jump on head R=swing arm	T=hop 1 arm R=hop 1 arm	T=clap arms behind R=clap arms behind	T=slide on foot R=slide on foot	T=spin on head R=spin on head	T=walk on hands R=walk on hands	T=jump head to feet R=jump head to feet	T=walk on hands R=walk on hands	T=slide on foot R=slide on foot	T=jump head to feet R=jump head to feet	T=spin on head R=spin on head
9	T=walk on hands R=swing legs	T=jump on head R=jump on head	T=jump head to feet R=jump head to feet	T=slide on foot R=slide on foot	T= jump head to feet R=jump head to feet	T=walk on hands R=walk on hands	T=slide on foot R=slide on foot	T=jump on head R=jump on head	T=Hop 1 arm R=hop 1 arm	T=spin on head R=spin on head	T=swing arm R=swing 1 arm	T=clap behind R=clap behind	T=swing arm R=swing arm	T=hop 1 arm R=hop 1 arm	T=clap behind R=clap behind	T=spin on head R=spin on head

10	T=jump head to feet R=DK	T=hop 1 arm R=hop 1 foot	T=clap behind R=slide on foot	T=spin on head R=spin on head	T=hop 1 arm R=wiggle	T=spin on head R=spin on head	T=clap behind R=flip	T=jump head to feet R=jump head to feet	T=walk on hands R=walk on hands	T=swing arm R=swing arm	T=jump on head R=jump on head	T=slide on foot R=slide on foot	T=jump on head R=jump on head	T=walk on hands R=walk on hands	T=slide on foot R=jump on head	T=swing arm R=jump on head
11	T=walk on hands R=walk on hands	T=jump head to feet R=jump head to feet	T=clap behind R=clap behind	T=hop 1 arm R=hop 1 arm	T=clap behind R=clap behind	T=hop 1 arm R=hop 1 arm	T=walk on hands R=walk on hands	T=jump head to feet R=jump head to feet	T=Swing arm R=swing arm	T=jump on head R=jump on head	T=spin on head R=spin on head	T=slide on foot R=slide on foot	T=slide on foot R=slide on foot	T=swing arm R=swing arm	T=jump on head R=jump on head	T=spin on head R=
12	T=Jump head to feet R=body roll in air	T=slide 1 foot R=slide 1 foot	T=jump on head R=jump on head	T=hop 1 arm R=jump on head	T=slide 1 foot R=flying	T=hop 1 arm R=flip	T=jump on head R=jump on head	T=jump head to feet R=splits	T=swing arm R=swing arm	T=clap behind R=splits	T=spin on head R=spin on head	T=walk on hands R=splits	T=clap behind R=clap feet	T=walk on hands R=walk on hands	T=swing arm R=swing arm	T=spin on head R=spin on head
13	T=hop 1 arm R=hop 1 arm	T=spin on head R=spin on head	T=slide on foot R=slide on foot	T=clap behind R=clap behind	T=slide on foot R=slide on foot	T=hop 1 arm R=hop 1 arm	T=clap behind R=clap behind	T=spin on head R=jump on head	T=jump on head R=jump on head	T=walk on hands R=walk on hands	T=jump head to feet R=jump head to feet	T=swing arm R=swing arm	T=swing arm R=swing arm	T=jump on head R=flip	T=walk on hands R=walk on hands	T=jump head to feet R=jump head to feet
14	T=clap behind R=clap behind	T=jump on head R=jump on head	T=hop 1 arm R=hop 1 arm	T=swing arm R=swing arm	T=hop 1 arm R=swing arm	T=jump on head R=jump on head	T=swing arm R=hop 1 arm	T=clap behind R=clap behind	T=spin on head R=spin on head	T=walk on hands R=walk on hands	T=slide on foot R=slide on foot	T=jump head to feet R=jump head to feet	T=jump head to feet R=jump head to feet	T=spin on head R=spin on head	T=walk on hands R=jump on hands	T=slide on foot R=DK
15	T=spin on head R=spin on head	T=jump head to feet R=jump head to feet	T=hop 1 arm R=hop both arms	T=slide 1 foot R=slide 1 foot	T=hop 1 arm R=hop 1 arm	T=spin on head R=spin on head	T=slide on foot R=slide on foot	T=jump head to feet R=jump head to feet	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=swing arm R=swing arm	T=jump on head R=jump on head	T=jump on head R=jump on head	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=swing arm R=swing arm
16	T=hop 1 arm R=hop 1 arm	T=swing arm R=swing arm	T=spin on head R=spin on head	T=jump on head R=jump on head	T=spin on head R=spin on head	T=hop 1 arm R=hop 1 arm	T=jump on head R=jump on feet	T=swing arm R=swing arm	T=walk on hands R=walk on hands	T=slide on foot R=slide on foot	T=clap behind R=clap behind	T=jump head to feet R=jump head to feet	T=jump head to feet R=jump head to feet	T=slide on foot R=slide on foot	T=walk on hands R=walk on hands	T=clap behind R=clap behind

Participant responses (comprehension) fast mapping task- DS group

	Elicited imitation								**No imitation**							
participant	Immediate				Delayed				Immediate				Delayed			
1	T=jump on head R=DK	T=clap behind R=clap behind	T=swing arm R=swing arm	T=Slide 1 foot R=slide 1 foot	T=clap behind R=DK	T=slide1 foot R=slide 1 foot	T=swing arm R=swing arm	T=jump on head R=DK	T=Walk on hands R=Walk on hands	T=Hop 1 arm R=hop1 arm	T=jump head to feet R=jump head to feet	T=spin on head R=spn on head	T=hop 1 arm R=hop 1 arm	T=spin on head R=DK	T=jump head to feet R=DK	T=walk on hands R=DK
2	T=Jump head to feet R=Jump head to feet	T=walk on hands R=walk on hands	T=hop 1 arm R=hop 1 arm	T=spin on head R=DK	T=Hop 1 arm R=Hop 1 arm	T=Jump head to feet R=Jump head to feet	T=spin on head R=spin on head	T=walk on hands R=walk on hands	T=Slide 1 foot R=slide 1 foot	T=jump on head R=jump on head	T=clap behind R=clap behind	T=swing arm R=swing arm	T=clap behind R=DK	T=Slide 1 foot R=Slide 1 foot	T=swing arm R=DK	T=Jump on head R=Jump on head
3	T=slide 1 foot R=slide 1 foot	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=hop 1 arm R=hop 1 arm	T=walk on hands R=walk on hands	T=hop 1 arm R=hop 1 arm	T=clap behind R=clap behind	T=slide 1 foot R=slide 1 foot	T=jump head to feet R=Jump head to feet	T=Spin on head R=spin on head	T=jump on head R=jump on head	T=swing arm R=swing arm	T=swing arm R=DK	T=jump head to feet R=Jump head to feet	T=Jump on head R=jump on head	T=spin on head R=spin on head
4	T=jump on head R=jump on head	T=swing arm R=swing arm	T=clap behind R=swing arm	T=walk on hands R=DK	T=Clap behind R=clap behind	T=jump on head R=walking	T=walk on hands R=walk on hands	T=swing arm R=swing arm	T=Jump head to feet R=Jump head to feet	T=spin on head R=jump head to feet	T=hop 1 arm R=hop 1 arm	T=slide 1 foot R=slide 1 foot	T=hop 1 arm R=hop 1 arm	T=jump head to feet R=jump head to feet	T=slide 1 foot R=side 1 foot	T=spin on head R=slide on head
5	T=Spin on head R=DK	T=Slide 1 foot R=held frankie	T=Clap behind R=Clap behind	T=jump on head R=jump on head	T=clap behind R=jump on head	T=spin on head R=DK	T=Jump on head R=DK	T=Slide 1 foot R=Slide 1 foot	T=jump head to feet R=jump head to feet	T=walk on hands R=walk on hands	T=hop 1 arm R=hop 1 arm once	T=swing arm R=swing leg	T=hop 1 arm R=jumping	T=jump head to feet R=jump head to feet	T=Swing arm R=swing arm	T=walk on hands R=walk on hands
6	T=Side 1 foot R=walking	T=Walk on hands R=Walking	T=Jump on head R=splits	T=Jump head to feet R=Splits	T=Jump on head R=splits	T=slide 1 foot R=splits	T=Jump head to feet R=splits	T=walk on hands R=splits	T=clap behind R=splits	T=Swing arm R=splits	T=Spin on head R=splits	T=hop 1 arm R=splits	T=spin on head R=sitting	T=swing arm R=flip	T=hop 1 arm R=splits	T=clap behind R=walking
7	T=jump head to feet R=jump head to feet	T=swing arm R=swing arm	T=slide 1 foot R=slide 1 foot	T=jump on head R=jump on head	T=slide 1 foot R=slide 1 foot	T=jump head to feet R=jump head to feet	T=jump on head R=jump on head	T=swing arm R=swing arm	T=clap behind R=clap behind	T=spin on head R=spin on head	T=hop 1 arm R=hop 1 arm	T=walk on hands R=walk on hands	T=hop 1 arm R=hop 1 arm	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=spin on head R=spin on head
8	T=jump head to feet R=jump head to feet	T=jump on head R=jump on head	T=hop 1 arm R=hop 1 arm	T=swing arm R=swing arm	T=hop 1 arm R=hop 1 arm	T=swing arm R=swing arm	T=jump head to feet R=jump head to feet	T=jump on head R=jump on head	T=Spin on head R=spin on head	T=walk on hands R=walk on hands	T=slide on foot R=slide on foot	T=clap behind R=clap behind	T=slide 1 foot R=slide 1 foot	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=spin on head R=spin on head

9	T=hop 1 arm R=Hop 1 arm	T=slide 1 foot R=slide 1 foot	T=jump on head R=jump on head	T=spin on head R=spin on head	T=jump on head R=jump on head	T=spin on head R=spin on head	T=slide on foot R=slide on foot	T=hop 1 arm R=hop 1 arm	T=Clap behind R=clap behind	T=jump head to feet R=Jump head to feet	T=swing arm R=swing arm	T=walk on hands R=walk on hands	T=swing 1 arm R=swing 1 arm	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=jump head to feet R=jump head to
10	T=walk on hands R=walk on hands	T=jump head to feet R=jump head to feet	T=slide 1 foot R=slide 1 foot	T=clap behind R=clap behind	T=slide 1 foot R=slide 1 foot	T=walk on hands R=walk on hands	T=clap behind R=clap behind	T=jump head to feet R=jump head to feet	T=Swing arm R=swing arm	T=hop 1 arm R=hop 1 arm	T=spin on head R=spin on head	T=jump on head R=jump on head	T=spin on head R=spin on head	T=swing arm R=swing arm	T=jump on head R=jump on head	T=hop on arm R=hop on arm
11	T=spin on head R=spin on head	T=walk on hands R=walk on hands	T=clap arms behind R=	T=slide on foot R=slide on foot	T=clap behind R=clap behind	T=spin on head R=Spin on head	T=slide on foot R=slide on foot	T=walk on hands R=walk on hands	T=jump on head R=jump on head	T=swing arm R=swing arm	T=hop 1 arm R=hop 1arm	T=jump head to feet R=jump head to feet	T=hop 1 arm R=hop 1 arm	T=jump on head R=jump on head	T=jump head to feet R=Jump head to feet	T=Swing arm R=swing arm
12	T=Clap behind R=Clap behind	T=jump head to feet R=jump head to feet	T=spin on head R=spin on head	T=slide 1 foot R=slide 1 foot	T=spin on head R=Jump head to feet	T=clap behind R=roll in air	T=slide 1 foot R=slide 1 foot	T=jump head to feet R=jump head to feet	T=walk on hands R=swing legs	T=jump on head R=jump on head	T=swing arm R=swing arm	T=hop 1 arm R=hop 1 arm	T=swing arm R=swing arm	T=walk on hands R=walk on hands	T=hop 1 arm R=hop 1 arm	T=jump on head R=jump on head
13	T=swing arm R=swing arm	T=jump head to feet R=jump head to feet	T=jump on head R=jump head to feet	T=slide on foot R=slide on foot	T=jump head to feet R=moving back and forth	T=slide 1 foot R=slide 1 foot	T=swing arm R=hopping	T=jump on head R=walking	T=clap behind R=clap behind	T=walk on hands R=walk on hands	T=spin on head R=spin on head	T=hop 1 arm R=hop 1 arm	T=spin on head R=body roll in air	T=walk on hands R=hop 1 arm	T=hop 1 arm R=walking	T=clap behind R=clap behind
14	T=slide 1 foot R=slide 1 foot	T=spin on head R=spin on head	T=hop 1 arm R=hop 1 arm	T=jump head to feet R=jump head to feet	T=hop 1 arm R=hop 1 arm	T=slide 1 foot R=slide 1 foot	T=jump head to feet R=jump head to feet	T=spin on head R=spin on head	T=clap behind R=clap behind	T=swing arm R=swing arm	T=walk on hands R=walk on hands	T=jump on head R=jump on head	T=walk on hands R=walk on hands	T=clap behind R=clap behind	T=jump on head R=jump on head	T=swing arm R=swing arm

APPENDIX E

Effects and interactions for production probe

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Time	Pillai's Trace	.189	6.045[b]	1.000	26.000	.021	.189
Time * MADSCATD	Pillai's Trace	.036	.967[b]	1.000	26.000	.335	.036
Time * Group	Pillai's Trace	.188	6.016[b]	1.000	26.000	.021	.188
Condition	Pillai's Trace	.027	.719[b]	1.000	26.000	.404	.027
Condition * MADSCATD	Pillai's Trace	.039	1.066[b]	1.000	26.000	.311	.039
Condition * Group	Pillai's Trace	.036	.968[b]	1.000	26.000	.334	.036
Time * Condition	Pillai's Trace	.006	.151[b]	1.000	26.000	.701	.006
Time * Condition * MADSCATD	Pillai's Trace	.008	.219[b]	1.000	26.000	.644	.008
Time * Condition * Group	Pillai's Trace	.004	.098[b]	1.000	26.000	.756	.004

Effects and Interactions for comprehension probe

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Time	Pillai's Trace	.063	1.744[b]	1.000	26.000	.198	.063
Time * MADSCATD	Pillai's Trace	.019	.506[b]	1.000	26.000	.483	.019
Time * Group	Pillai's Trace	.070	1.967[b]	1.000	26.000	.173	.070
Condition	Pillai's Trace	.049	1.347[b]	1.000	26.000	.256	.049
Condition * MADSCATD	Pillai's Trace	.026	.689[b]	1.000	26.000	.414	.026
Condition * Group	Pillai's Trace	.039	1.061[b]	1.000	26.000	.312	.039
Time * Condition	Pillai's Trace	.023	.622[b]	1.000	26.000	.437	.023
Time * Condition * MADSCATD	Pillai's Trace	.029	.783[b]	1.000	26.000	.384	.029
Time * Condition * Group	Pillai's Trace	.001	.017[b]	1.000	26.000	.898	.001

PPVT and immediate probe correlations- Group with DS

Correlations

		PPVTae	Immediate Production Elicited imitation	Immediate comprehension elicited imitation	Immediate production no imitation	Immediate comprehension no imitation
PPVTae	Pearson Correlation	1	.147	.419	.130	.328
	Sig. (2-tailed)		.617	.136	.657	.252
	N	14	14	14	14	14
Immediate Production Elicited imitation	Pearson Correlation	.147	1	.554*	.588*	.636*
	Sig. (2-tailed)	.617		.040	.027	.015
	N	14	14	14	14	14
Immediate comprehension elicited imitation	Pearson Correlation	.419	.554*	1	.791**	.890**
	Sig. (2-tailed)	.136	.040		.001	.000
	N	14	14	14	14	14
Immediate production no imitation	Pearson Correlation	.130	.588*	.791**	1	.663**
	Sig. (2-tailed)	.657	.027	.001		.010
	N	14	14	14	14	14
Immediate comprehension no imitation	Pearson Correlation	.328	.636*	.890**	.663**	1
	Sig. (2-tailed)	.252	.015	.000	.010	
	N	14	14	14	14	14

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

PPVT and delayed probes correlations- Group with DS

Correlations

		PPVTae	Delayed production elicited imitation	Delayed comprehension elicited imitation	Delayed production no imitation	Delayed comprehension no imitation
PPVTae	Pearson Correlation	1	.670**	.348	-.080	.454
	Sig. (2-tailed)		.009	.223	.785	.103
	N	14	14	14	14	14
Delayed production elicited imitation	Pearson Correlation	.670**	1	.404	-.138	.301
	Sig. (2-tailed)	.009		.153	.638	.296
	N	14	14	14	14	14
Delayed comprehension elicited imitation	Pearson Correlation	.348	.404	1	.225	.801**
	Sig. (2-tailed)	.223	.153		.439	.001
	N	14	14	14	14	14
Delayed production no imitation	Pearson Correlation	-.080	-.138	.225	1	.210
	Sig. (2-tailed)	.785	.638	.439		.472
	N	14	14	14	14	14
Delayed comprehension no imitation	Pearson Correlation	.454	.301	.801**	.210	1
	Sig. (2-tailed)	.103	.296	.001	.472	
	N	14	14	14	14	14

**. Correlation is significant at the 0.01 level (2-tailed).

WISC and Immediate probes correlations- Group with DS

Correlations

		WISCraw	immediate production elicited imitation	Immediate comprehension elicited imitation	Immediate production no imitation	Immediate comprehension no imitation
WISCraw	Pearson Correlation	1	.218	.345	.402	.414
	Sig. (2-tailed)		.454	.227	.154	.141
	N	14	14	14	14	14
immediate production elicited imitation	Pearson Correlation	.218	1	.554*	.588*	.636*
	Sig. (2-tailed)	.454		.040	.027	.015
	N	14	14	14	14	14
Immediate comprehension elicited imitation	Pearson Correlation	.345	.554*	1	.791**	.890**
	Sig. (2-tailed)	.227	.040		.001	.000
	N	14	14	14	14	14
Immediate production no imitation	Pearson Correlation	.402	.588*	.791**	1	.663**
	Sig. (2-tailed)	.154	.027	.001		.010
	N	14	14	14	14	14
Immediate comprehension no imitation	Pearson Correlation	.414	.636*	.890**	.663**	1
	Sig. (2-tailed)	.141	.015	.000	.010	
	N	14	14	14	14	14

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

WISC and Delayed probes correlations- Group with DS

Correlations

		WISCraw	Delayed Production Elicited imitation	Delayed comprehension elicited imitation	Deylayed production no imitation	Delayed comprehension no imitation
WISCraw	Pearson Correlation	1	.626*	.295	-.080	.036
	Sig. (2-tailed)		.017	.305	.786	.902
	N	14	14	14	14	14
Delayed Production Elicited imitation	Pearson Correlation	.626*	1	.404	-.138	.301
	Sig. (2-tailed)	.017		.153	.638	.296
	N	14	14	14	14	14
Delayed comprehension elicited imitation	Pearson Correlation	.295	.404	1	.225	.801**
	Sig. (2-tailed)	.305	.153		.439	.001
	N	14	14	14	14	14
Deylayed production no imitation	Pearson Correlation	-.080	-.138	.225	1	.210
	Sig. (2-tailed)	.786	.638	.439		.472
	N	14	14	14	14	14
Delayed comprehension no imitation	Pearson Correlation	.036	.301	.801**	.210	1
	Sig. (2-tailed)	.902	.296	.001	.472	
	N	14	14	14	14	14

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

PPVT and immediate probe correlations- TD group

Correlations

		PPVTae	Immediate production elicited imitation	Immediate comprehension elicited imitation	Immediate production no imitation	Immediate comprehension no imitation
PPVTae	Pearson Correlation	1	.460	.200	.341	.707**
	Sig. (2-tailed)		.113	.512	.254	.007
	N	13	13	13	13	13
Immediate production elicited imitation	Pearson Correlation	.460	1	.351	.149	.234
	Sig. (2-tailed)	.113		.200	.596	.401
	N	13	15	15	15	15
Immediate comprehension elicited imitation	Pearson Correlation	.200	.351	1	-.119	.522*
	Sig. (2-tailed)	.512	.200		.674	.046
	N	13	15	15	15	15
Immediate production no imitation	Pearson Correlation	.341	.149	-.119	1	.063
	Sig. (2-tailed)	.254	.596	.674		.824
	N	13	15	15	15	15
Immediate comprehension no imitation	Pearson Correlation	.707**	.234	.522*	.063	1
	Sig. (2-tailed)	.007	.401	.046	.824	
	N	13	15	15	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

PPVT and delayed probe correlations- TD group

Correlations

		PPVTae	Delayed production elicited imitation	Delayed comprehension elicited imitation	Delayed production no imitation	Delayed comprehension no imitation
PPVTae	Pearson Correlation	1	.492	.423	.165	.207
	Sig. (2-tailed)		.087	.150	.591	.497
	N	13	13	13	13	13
Delayed production elicited imitation	Pearson Correlation	.492	1	.337	-.068	.322
	Sig. (2-tailed)	.087		.219	.809	.242
	N	13	15	15	15	15
Delayed comprehension elicited imitation	Pearson Correlation	.423	.337	1	.284	.375
	Sig. (2-tailed)	.150	.219		.304	.168
	N	13	15	15	15	15
Delayed production no imitation	Pearson Correlation	.165	-.068	.284	1	-.493
	Sig. (2-tailed)	.591	.809	.304		.062
	N	13	15	15	15	15
Delayed comprehension no imitation	Pearson Correlation	.207	.322	.375	-.493	1
	Sig. (2-tailed)	.497	.242	.168	.062	
	N	13	15	15	15	15

WISC and Immediate probes correlations- TD Group

Correlations

		WISCraw	Immediate production elicited imitation	Immediate comprehension elicited imitation	Immediate production no imitation	Immediate comprehension no imitation
WISCraw	Pearson Correlation	1	.451	.112	.327	-.036
	Sig. (2-tailed)		.092	.690	.235	.899
	N	15	15	15	15	15
Immediate production elicited imitation	Pearson Correlation	.451	1	.351	.149	.234
	Sig. (2-tailed)	.092		.200	.596	.401
	N	15	15	15	15	15
Immediate comprehension elicited imitation	Pearson Correlation	.112	.351	1	-.119	.522*
	Sig. (2-tailed)	.690	.200		.674	.046
	N	15	15	15	15	15
Immediate production no imitation	Pearson Correlation	.327	.149	-.119	1	.063
	Sig. (2-tailed)	.235	.596	.674		.824
	N	15	15	15	15	15
Immediate comprehension no imitation	Pearson Correlation	-.036	.234	.522*	.063	1
	Sig. (2-tailed)	.899	.401	.046	.824	
	N	15	15	15	15	15

*. Correlation is significant at the 0.05 level (2-tailed).

WISC and Delayed probes correlations- TD Group

Correlations

		WISCraw	Delayed production elicited imitation	Delayed comprehension elicited imitation	Delayed production no imitation	Delayed comprehension no imitation
WISCraw	Pearson Correlation	1	.137	.039	.173	-.266
	Sig. (2-tailed)		.628	.889	.538	.338
	N	15	15	15	15	15
Delayed production elicited imitation	Pearson Correlation	.137	1	.337	-.068	.322
	Sig. (2-tailed)	.628		.219	.809	.242
	N	15	15	15	15	15
Delayed production elicited imitation	Pearson Correlation	.039	.337	1	.284	.375
	Sig. (2-tailed)	.889	.219		.304	.168
	N	15	15	15	15	15
Delayed production no imitation	Pearson Correlation	.173	-.068	.284	1	-.493
	Sig. (2-tailed)	.538	.809	.304		.062
	N	15	15	15	15	15
Delayed comprehension no imitation	Pearson Correlation	-.266	.322	.375	-.493	1
	Sig. (2-tailed)	.338	.242	.168	.062	
	N	15	15	15	15	15

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