VISUALIZING GESTURAL ANNOTATION MADE DURING LEISURE RUNS TO PROMOTE RECALL OF AFFECTIVE EXPERIENCE

by

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ABSTRACT

In this thesis, we present results from a comparative study exploring whether gestural annotations of felt emotion presented on a map-based visualization can support recall of one's affective experience of recreational runs. We compare gestural annotations with audio and video notes and a "mental note" baseline. In our research, 20 runners were asked to record their emotional state at regular intervals while running a familiar route. Each runner used one of the four methods to capture emotion over four separate runs. Five days after the last run, runners interacted with an interactive map-based visualization to review and recall their affective experiences. In addition to the routes run, the visualization presented a set of cues that might support recall: weather, time of the run, running speed, elevation, heart rate, and the location of each annotation. Results indicate that gestural annotation promoted recall of affective experience more effectively than the baseline condition, as measured by confidence in recall and detail provided. Gestural annotation was also comparable to video and audio annotation in terms of time, confidence and detail. Audio annotation supported recall primarily through the runner's spoken annotation, but sound in the background was sometimes used. Video annotation yielded the most detail, much directly related to visual cues in the video, however using video annotations required runners to stop during their runs. Given these results we suggest that background logging (of ambient sounds and video) may supplement gestural annotation.

LIST OF ABBREVIATIONS AND SYMBOLS USED

AM	Autobiographical Memory
CSV	Comma Separated Values
SVG	Scalable Vector Graphics
GPS	Global Positioning System
GEM	Graphics and Experiential Media
HCI	Human Computer Interaction
LSD	Least Significant Difference
PD	Participatory Design

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CHAPTER 1 INTRODUCTION

Digital technology changes everyday practices. From writing in a diary to keeping a blog and from painting on canvas to creating digital images, it has had a profound impact on all aspects of our lives. We can now capture and log many aspects of our daily activities digitally, both implicitly using sensors (e.g. GPS), and explicitly by recording video, recording audio, taking pictures, or even tracking food purchases. These capture technologies are called lifelogging systems. Smith et al. [1], defined lifelogging as “in essence, the collection of data in order to illustrate a person’s life”.

Lifelogging systems and their storage capacity are developing rapidly. Moreover, mobile computing and the advances in sensor networks enable people to log their data beyond their desktop activities; they allow them to capture their data during physical activities such as running and jogging. Lifelogging has great potential for offering beneficial information about users. This encourages researchers to design and visualize lifelogs in order to support memory for personal past events or to monitor daily activities for reasons such as healthcare or manage money and time.

Indeed, visualizing lifelog data that is collected by lifelogging systems and using appropriate data as cues has an important impact on how and what humans remember and helps them better understand themselves. In addition to visualizing lifelogging data for recalling the past experience, it can assist users in self-monitoring. Thus, it gives insight into activities and behaviors, so users become more aware of what can impact their activity and behavior. Moreover, visualizing the data that is generated by lifelog can help users to deal with their health problems, and behaviours and enhance their quality of life by helping them understand their moods, inform their doctor of adverse health events, manage money and time.

Lifelogging systems and visualizing theses logging data are not limited to log only events and daily or physical activities. They are also capable of capturing emotional data like Moodmap [2] and Emotion Map [3] which allow users to tag locations and times with emotions, and present these on a map. This research adds to a growing body of work on logging emotional data.

1.1 RESEARCH PROBLEM

This thesis addresses how to support runners' emotional memory by visualizing the emotion they experienced and running related data such as weather, speed, elevation, heart rate, and location of the emotions along the route on a map. This visualization can trigger runners' memory to reveal what affects their emotions while running and recall more information about specific emotions which enable runners to better choose the time, place, and circumstances of their leisure runs. Furthermore, the research explores how different strategies can impact the ability to recall affective experience over a series of runs. A further objective of this research is to demonstrate that lifelogging visualizations can not only support runners to retrieve their affective experiences, but also help them know what influences their emotion while running. This means that it has the potential to be very useful for people who would like to track their emotions during other physical activity (e.g. Walking, and hiking,) to know such things as which location makes them nervous or happy.

For the purpose of this thesis, we define *emotional state* to be how an individual is feeling at certain point and *affective experience* to be the emotional state plus why an individual is feeling this way, including relevant details about what is going on at that time.

1.2 MOTIVATION

Emotions occur in all areas of human life, including physical activity. This thesis is inspired by the idea that emotions play an important role in recreational physical activity including jogging or running. Most commercial personal fitness informatics systems such as Runkeeper and Fitbit concentrate on performance metrics, but users might understand their performance better if they were more aware of the influence of internal and external factors. Emotion as contextual information can be added to physical information to improve our self-knowledge about physical activity, but this requires empathetic recall of those states. Therefore, research is needed to understand how people use logged emotion to trigger and enhance their memory of past experience. The thesis explores this within the context of recreational running.

Running is a physical activity enjoyed by many. It has low barriers to participation, and for most, running is an active pastime rather than a competitive sport. However not every run is as enjoyable as the next, and personal preferences for runners vary: weather conditions, location, terrain, music, time of day, solo or group running, etc. Without a means of capturing emotion or affective experience during runs, runners don't have a way of tracking and identifying patterns that correlate with a positive running experience. Such a feature would enable runners to better choose the time, place, and circumstances of their leisure runs.

1.3 RESEARCH OBJECTIVE

This thesis investigates how different techniques for capturing emotions affect recall of the affective experience of recreational runs. We compare gestural annotations with audio and video annotations and a "mental note" baseline. By collecting user feedback and having users recall their affective experiences, the study clarifies how the above methods can influence or enhance recall ability. In addition, it aimed to determine the effectiveness of gesture annotation as a trigger for emotional experience. We explore this in two phases: in the first phase, we elicited design feedback on the visual representation of the interface; in the second phase, we investigated recall of affective experience using the map-based visualization interfaces designed in the first phase. Each visualization presents affective experiences and additional data (such as heart rate, speed, elevation, route, and weather). The first visualization interface displays gesture annotations that were captured using a touch gesture capture application. The second visualization interface displays audio annotations that were captured using audio recorder. The third visualization interface displays video annotations that were captured using video recorder. The fourth visualization presents just the supplementary data without any emotion annotation. In a between-subject study, 20 runners were asked to record their emotional state at regular intervals while running a familiar route using one of the four methods, over four separate runs. Five days later, runners interacted with an interactive map-based visualization to review and recall their affective experience. In addition to the routes run, the visualization presented a set of cues that might support recall: weather, running speed, elevation, heart rate, and the location of each annotation.

1.4 CONTRIBUTION OF THE THESIS

As a part of a research effort in the field of Human Computer Interaction (HCI) to create effective personal visualizations, this thesis concentrates on capturing the emotional state of runners, as well as additional information (such as heart rate, speed, elevation, time of run and weather) that could be used to create interactive cues able to trigger human memory for recalling their affective experience. In addition, it introduces a visualization interface to present that data visually.

My strategy in pursuing this goal is to use different lifelogging systems (audio recorder, video recorder , and gesture capture app) to capture emotional state and build visualizations with real runners to assess the value of every emotion collection method, as well as the visualization interface. The main contributions of this thesis can therefore be classified as follows:

1- We explore, through iterative design and a controlled study, ways to integrate annotation of affect experience into a personal visualization of recreational runs.

2- We demonstrate the feasibility of gestural annotation as a low demand modality for capturing emotional state while mobile.

3- We evaluate gestural annotation of emotional state as a trigger for recall of affective experience, comparing it with different strategies for recording emotion (video, audio and mental note).

1.5 STRUCTURE OF THE THESIS

This thesis is divided into seven chapters as follows:

Chapter 2 gives an overview of the human memory and its structure. It also provides a brief introduction to theories pertaining to autobiographical memory. In addition, Chapter 2 highlights the relevant literature on systems that help people to recollect personal data and recall their personal experiences using visualizations.

In Chapter 3, the initial visualization prototype is defined. I describe the participatory design of a map-based visualization system, which supports the viewing of various types of data in an interface.

Chapter 4 addresses the experimental tools used in the study and pilot study.

Chapter 5 discusses the field study design starting with research objectives and the types of techniques that were used to capture emotions, a description of participants, and the analysis process.

In Chapter 6 presents the results and analysis of data collected from the field study.

Chapter 7 includes discussion and limitations of this research, and the next phase as future work.

Finally, Chapter 8 is the conclusion of the thesis

CHAPTER 2 BACKGROUND AND LITERATURE REVIEW

This chapter provides an overview of human memory to introduce basic knowledge of memory structures, process, autobiographical memory and its theories. This chapter also gives an overview of the relevant literature on systems that help people to recollect personal data and recall their personal experiences using visualization systems.

2.1 BACKGROUND

This section provides an overview of human memory and theory on human memories and cues.

2.1.1 Structure and Process of Human Memory

Memory and awareness are important aspect for wellness especially when people have to deal with a vast amount of data. Memory is a part of a brain process in which experience, knowledge, emotions are encoded, stored and retrieved. Human memory is like a record of the experiences, actions, and events of the individual [4]. To understand how memory stores and retrieves memories, Eysenck introduced the process of human memory (Figure 1) which include three stages: encoding is the first phase of creating a memory of experiences that come from input sensors and integrate with existing information, storage is the second phase where some information is committed to memory as a result of the encoding stage, and the third phase is retrieval where the stored information in the human memory is retrieved [5].

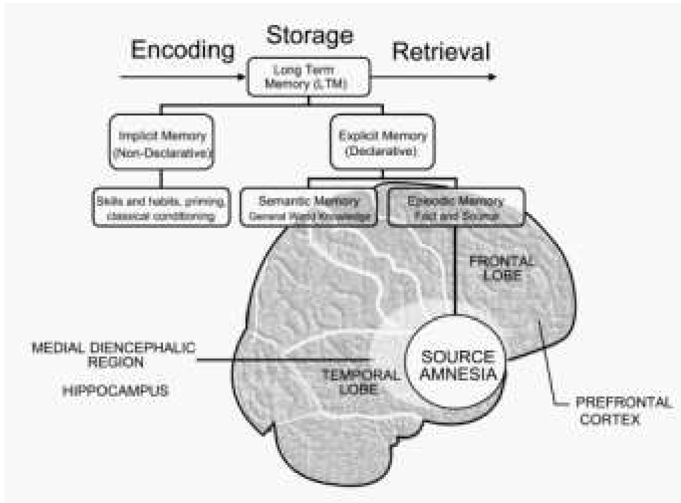


Figure 1: Structure and Process of Human Memory [53]

According to Tulving and Thomson, stored information in human memory can be retrieved but it cannot be accessed without using contextual cues [6]. Data like time, location, people, events, and picture can be important cues to support recalling memory.

2.1.2 Architecture of Human Memory

According to Atkinson and Shiffrin, the basic structure of human memory is divided into three components based on the time span of remaining the information in the memory, these are: sensory, short-term, and long-term [7]. The structure of the multi-store model proposed by Atkinson and Shiffrin is shown in figure 2.

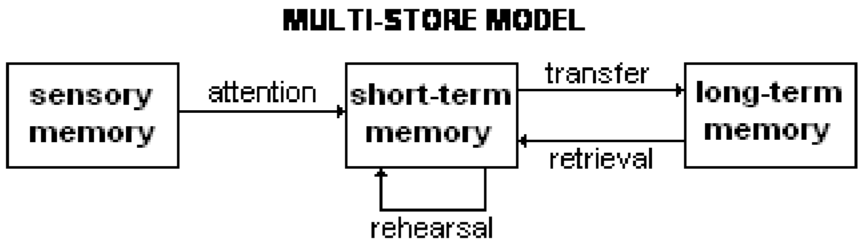


Figure 2: Multi Store Model Purposed by Atkinson and Shiffrin [7]

2.1.2.1. Sensory Memory

Sensory memory is the first component of human memory that holds information for a short period of time and deteriorates very quickly. It also has a limited capacity so new information replaces older information. The outputs of sensory memory are able to be inputs of short-term memory via the process of attention [7].

2.1.2.2. Short-term Memory

Short-term memory is the second stage of human memory. It also has a limited capacity and stores the information temporarily. Rehearsing information using such techniques as repetition, attention, and association might pass the information to the long-term memory [7].

2.1.2.3. Long-term Memory

Long-term memory (Figure 3) is the third level of human memory where the information is stored for a long period of time which can be obtainable for a lifetime and has unlimited capacity [7]. Since the main focus on this thesis is on recollecting personal experiences, the long-term memory is the most relevant memory type to discuss in detail in the following section.

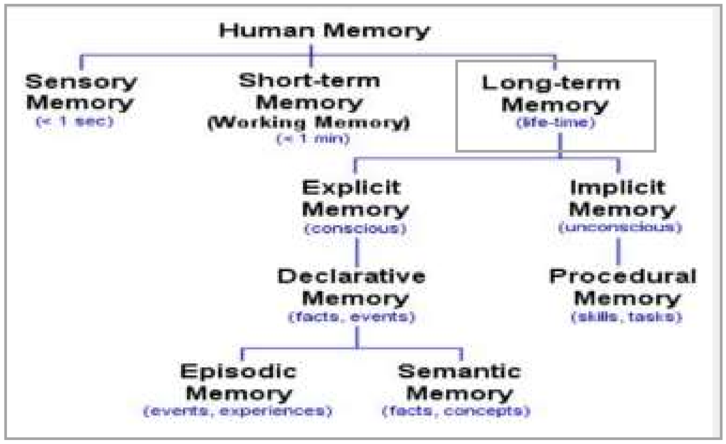


Figure 3: Type of Long-term Memory [8]

- **Explicit Memory and Implicit Memory**

Long-term memory consists of two main categories: explicit and implicit memory. Explicit (known as declarative) memory refers to those memories that are consciously stored. It helps us to recall events that have occurred. For example, what happened at specific party? Implicit (known as procedural) memory refers to the skills and memories that are unconsciously stored in memory such as playing a guitar or riding a bike. These memories are obtained via practice [8].

- **Episodic Memory and Semantic Memory**

Declarative memory is divided into episodic memory and semantic memory. Episodic memory refers to the memory of experiences or specific events, locations, people, and associated emotions [8]. This type of memory allows people to recall their past experience. According to Tulving, episodic memory is a record of individual experiences, and each item in this type of memory represents information that is stored about your experience of events [9]. It also allows people to mentally travel back into their past experiences [10]. So, using some cues (e.g. time, location, and people) can support individuals in recalling their personal past. Moreover, this kind of memory is about the feeling; individuals remember their emotions or how they felt in a specific event more than the event's details. Semantic memory, on the other hand, deals with facts, concepts and general knowledge about the external world [8]. So, we can have knowledge without remembering where and when it was obtained.

2.1.3 Autobiographical Memory

According to Conway and Rubin, the autobiographical memory (AM) is known as "memory of the events of the one's life", which involves all memories of the people. Autobiographical memory is mostly episodic and stores the memory of personal experiences and includes some semantic memory [11]. However, the way these two memory systems (episodic and semantic) are connected to each other is unknown, even though it is certain that they are overlapping in memories [12].

2.1.4 Autobiographical Memory Theory

- **Record-keeping Approach**

The record-keeping approach is the oldest memory storage theory [13]. The main idea behind this theory is based on the metaphor that like books fill in the library, memories fill in the human memory. Each book in the library is considered a memory and every new book is created by a new experience. The process of the retrieval is represented as searching for the book [14]. According to this theory, the more memories that an individual has, the more difficult it is to retrieve the correct memory. There are many projects in HCI that have been designed based on this theory. For example, iFlashBack, is a wearable system which was designed for use in workplace. It contains a sensor, camera, display and RFID tag to record and replay a specific interaction with artifacts to enable the user to know the location of a specific artifact [15]. Moreover, Lamming and Flynn designed the Forget-me-not application, which records a variety of office activities such as using the computer, meeting people, and telephone calls. The stored events in the device can help users remember the location of documents or the name of a colleague in case of forgetting [16]. These projects focus on having a database of facts more than cuing memory.

- **Constructionist Approach**

An adapting memory system can be developed by using the constructionist approach. In these cases, memory recall occurs through reconstruction. For example, if a person tries to remember what he/she did on specific day at specific time, she/he goes back to what he/she did on that day. In fact, this person probably does not recall what he/she did at that specific time but he/she infers it from him/her regular pattern [14]. Due to this reconstruction process, memories alter over a period of time based on current knowledge and beliefs. In addition, when reconstruction is no longer possible because a lot of reconstructions, forgetting happens [14]. An individual reconstructs past experience such as events based on the constructionist approach. An augmented memory system can not store the memory by itself because an individual is required to recreate this memory for every reminiscing. However, the cues that can be used to trigger memories to assist people in reconstructing a memory can be stored in an augmented memory system. Cues can help people to recall the information from long-term memory only if there is link between the cue and sought-after memory. The cue could be anything such as image, text, smell, and person as long as there is a connection between the cue and the remembered events [14].

In general, there are two types of cues: generative, which involve conscious and direct retrieval, which involve unconscious memory cuing [17]. According to Baddeley (1999, as cited in [14]), there are three memory-type categories: context-dependent memory, state-dependent memory, and mood-dependent memory. In the context-dependent memory, the memory is easily recalled if the physical context of both the memory encoding and retrieving are the same. For instance, Godden and Baddeley (1975, as cited in [14]) asked divers to learn words either on the beach or underwater. They found that the number of words remembered correctly was high if both the recalling and encoding contexts were the same.

The state-dependent memory explains the relation between the cue and the resulting retrieval. This category focuses on the internal context. The last category is mood-dependent memory, which means that memory is easily recalled if the mood at retrieving is the same mood at encoding. So, the emotional state of the person such as being happy or upset is a key cue. Sometimes cuing does not assist recall of a specific event which, indicates of forgetting. However, forgetting may not be complete; there is evidence in support of cue-dependent forgetting, which means that memories are not lost but they might be inaccessible temporarily [18].

2.2 RELEVANT HCI RESEARCH

There is a lot of research in HCI on the use of visualization for recalling based on the constructionist approach. This section gives an overview of relevant literature on systems that help people to recollect personal data and recall their personal experiences using certain cues on visualization tools. The literature is divided into four groups: lifelogging system, personal visualization system, visualization for recalling, and visualization for physical activity.

2.2.1 Lifelogging

Using technology to enhance human memory is not new idea. Nowadays, digital sensors or mobile applications make it possible to store a vast amount of personal information and everyday activates either passively, without their intervention (e.g., GPS) or actively (e.g., tracking food purchases).

There is some research that has investigated the use of physical memories and found that collecting physical memories has two significant objects: it can be used as cues to trigger memory recalling about past experience and to motivate conversation about the past event [19] [20]. These findings encouraged the design of lifelogging systems which firstly, enable people to capture their personal memories digitally, through such systems as Living Memory Box, which was designed to store families' memories by capturing audio and video of specific events [21]. Other systems, such as MemoryLane, which was designed to allow people to capture their digital memories such as place, people, objects in their home, and visually arrange these memories in various ways [22].

The main goal of the lifelogging and personal informatics research is to provide tools that help capture and store information about daily activities and personal events that could enhance people's effectiveness, health and lifestyle. Lifelogging software can store a variety of data types such as video/photo information, audio information, biological information (e.g. heart rate, blood pressure, and muscle activity), location information, weather information and more. Lifelogging software aims to track and store information about everyday activities in order to support the human memory about personal past events. SensCam, one of the earliest lifelogging devices, was originally intended to support those with memory impairments [23] both as a day-to-day memory prosthesis and as a repository of meaningful life events. Lifelogging data can be used as cues to trigger people's memory to remember the location of the item, people, place and so on. In addition, it can be used to manage time, share everyday events or experiences with others, help patient with memory problem and regulate the emotions improve health by monitoring and promoting healthy eating habits and weight loss and being physically active [24].

Lifelogging systems have utilized manual input from users, automatic input from sensors, or a combination of manual and automatic input. The systems designed to support physical activity use sensors to record data automatically. For example, TripleBeat, a mobile phone based system that helps runners to achieve predefined exercise aims. The design of Triple Beat is based on the MPTrain which monitors heart rate through a monitor and movement through a 3-axis accelerometer. Then, the music is selected to motivate the user to speed up, slow down, or keep the pace based on the heart rate and pace data [25]. Similarly, Houston was designed to encourage physical activity by tracking every day's step count and sharing it with friends [26]. Most of these systems also require the user to use the sensor system (such as a heart rate monitor) during their activities. Other systems that are designed to track data, which is difficult to detect, rely entirely on the users to manually input the data.

Many applications that collect emotion or affect fall under this category. For instance, in Mood Map [2], the user has to capture their mood using a two-dimensional colour coded representation. The MoodMap app allows the user to record their mood during the meeting by clicking at the appropriate area of the mood map and to add an annotation to the current mood. In addition, Huang at el. [3] designed a location-based mobile app called Emotion Map that can help people to track their emotions at various places over a period of time. In particular, Emotion Map enables users to record emotions with location, activity information and time, and then displays the emotions on a map. Matassa and Rapp [27] developed a mobile application that is able to record contextual information such as time, position and weather automatically, allowing users to manually add additional information, such as feeling, picture or video related to specific event.

Gesture holds promise as a mechanism for active capture while mobile. In a lab experiment Bin Hannan et al. [28] showed that people can express the intensity of emotion using attributes of a gesture (e.g. pressure, length) in a consistent way, and they can recognize intensity when the gestures are played back. Other work has also illustrated that the manner continuous gestures are made on a mobile phone can encode additional information, such as placing emphasis on words in a text message [29].

2.2.2 Personal Visualization

Information visualization systems have often focused on supporting deep insights for expert users. Recently, there has been some research done that highlights new subdomains of visualization: casual visualization and personal visualizations, which are easy to use for non-expert users. Pousman et al. [30] defines casual information visualization (Casual Infovis), which utilizes computer mediated tools to describe meaningful information in a visual way to help people in everyday work and life. Personal visualization involves interactive visualization data for use in personal contexts which can be internal such as goals, skills, and experiences, or external such as physical environment, and social impact [31]. The way people perceive the visualization and interpret data are affected by people's memories, skills, knowledge and cultures. Most personal visualization and personal visualization analytics were built to assist people to explore and gain insight into their own data. People utilize a personal visualization tool for different reasons: satisfying their curiosity, reminiscing about past experience or sharing with friends [32].

Hung et al. [31]provide a survey that covers a variety of personal visualization systems that address most aspects of everyday life. These systems present personal data which is obtained from a wide variety of sources and covering many areas of an individual's life such as health, changing behaviours, and social life. Personal visualization of this different data has two different usage modes [31]. The first is to inform changing behaviours which can improve people's lives via analysis. For example, Eye tracking was designed to record massive amounts of data about spatiotemporal information of eye gazes and video recordings of the individual's environment in order to understand how user interacts with others and the environment [33]. The second is to support personal reflection in the context of recalling, which is discussed in the next section. In fact, personal visualization systems were designed to inform users of their behavior, but users may better understand their status and enhance or change their behavior if these systems also allow the user to remember past experiences that affect their behavior or emotions.

2.2.3 Visualization for Recall

Visualization systems to support recalling or reminiscing has been used in many aspects of our life. There is some research interested in tracking personal data throughout workday activates to support recall. For example, Mcduff et al. [34] developed AffectAura visualization to log audio, visual, physiological and contextual data related to users' workday activities (such as desktop activities, meetings, and locations) and predict users' affective states using a classification scheme. They compared each participant's survey responses from the beginning of the week to interview responses provided at the end of the week and found that participants retrieved the general emotion two days before the interview day compared to the beginning of the week. However, when presenting the data using AffectAura visualization, participants were able to reconstruct a 'story' about their workday activities and recall at least one event that they had forgotten about during the interview. In addition, Hailpern et al. [35] designed YouPivot which is a contextual history based search tool, to support recall of digital information. The YouPivot tool logs all the contextual data related to the user's computer usage with a time mark (such as open file, listen to music, meeting, physical location etc.) and provides a visualization interface to display the user's activities. They compared the YouPivot with the traditional history tool and found that the participant recalled YouPivot contextual history faster than traditional history and they were more satisfied with YouPivot. Similarly, the AppInsight visualization tool was designed to display the computer usage logs such as the application's name, URL and window title as contextual cues for reminiscing. AppInsight allows users to recall their past events, be aware of their lifestyle and reflect on their activity [36].

Mobile computing and the advances in sensor networks enable people to log personal data beyond desktop activities. For instance, Mathur et al. [37] designed a visualization tool (LifeView) that can convert lifelog data into a cartoon strip and make contextual hyperlinks between the various events in the lifelogs. Participants' data was collected passively using android applications such as SMS, call logs, photos/videos taken from the camera. They also could record their events manually. Each participant used three different interfaces (No-Cartoon, Cartoon-Linear and Cartoon-Hyperlinked) to present their lifelog data in order to decide which interface provided better sentimental recall. The study shows that the cartoonized interface provides better sentimental recall due to its visual appeal as compared to text. Also, contextual hyperlinks were helpful for participants setting goals with reference to their lifelogs. Furthermore, Kalnikaitė et al. [38] provided participants with a SensCam and GPS to capture images and location data of their daily life for two weeks. After that their memories were tested using three type of visualizations: Snap (visual image), Track (location data) and SnapsTrack (a combination of visual and location data). The result shows that Snap supported more recall of details than Track, while SnapsTrack promoted inferences about an individual's habitual patterns. Similarly, Sellen et al. [39] investigated how the photographic image that was taken using the SensCam can be an efficient cue to trigger memory of personal events. They tested at a short and long period and found that these images assisted people to recollect their events as well as helped people to know what occurred in the absence of recollection. Moreover, they found that using images to support recalling the past event was not affected by the passage of time.

There is also a visualization system that was designed not only for the purpose of recall but also for sharing memories with others. Thudt et al. [32] designed and deployed a visualization tool (visual mementos) for the web that allow users to load, present and share their personal data from a variety of sources and lifelogging systems. Visual mementos are developed from data that directly record an individual's history. Personal data could be picture, events, status update from a social network, GPS location history, activity logs, or listening history. Users stated that the visual mementos were able to trigger their memories and helped them to reflect on their trips and share their past experience with others.

Moreover, visualizations for the purpose of emotional recall can be created by using or interacting with a mobile device. For example, Niforatos and Karapanos [40] designed EmoSnaps Application that allows participants to capture their facial expressions and express their emotion at specific moment. In the first session of this study, participants were given a mobile device which has EmoSnaps app and asked to capture their facial expressions each time they unlock the screen of their mobile device. They were also encouraged to report their psychological well-being. In the second session of this study, researchers asked participants to capture their facial expression during a wider variety of interactions such as unlock screen, SMS sent/read, call answer/end, application launches, and system actions. The researchers found that one week following their capture phase, participants were able to infer their feeling from their face pictures and that the selfie was an effective cue to support emotional recall.

LastHistory was developed for reminiscing and analysis of listening history. The visualization tool presents music and metadata of music such as timestamp, artist name, and song title. The listening history and music metadata are obtained from last.fm server. Digital photos and a calendar also presented contextual information. The visualization of LastHistory has two buttons in the upper left corner of the interface: analysis (listening history and personal modes (contextual information). The result of this study included that 72% participants agreed that LastHistory helped them with reminiscing. 68.8% users who had photos and 75.8% users who had photos and calendar found it useful. Moreover, in some cases, listening history by itself was enough to trigger user's memory [41].

2.2.4 Visualizations for Physical Activity

Most physical activity log systems were designed to collect information about physical activity (such as heart rate and step counts) to improve the awareness of physical activity. There is also research on novel visualizations for physical activity awareness. For example, The Shakra system [42] utilized GSM signal strength to reveal time spent involved in physical activity and presented cartoon visualizations of the activity on a mobile device. So the Shakra system was built to confirm whether a user is active or inactive, accumulated daily totals, and allowed users to share their data with others.

Additionally, UbiFit Garden system [43] was built using on-body sensing, activity inference, and a novel personal, mobile display to infer users' activities throughout everyday life. UbiFit Garden presented the levels of physical activity utilizing a garden metaphor in a glanceable display on mobile devices to prompt physical activity. The size of butterflies in the UbiFit Garden indicate achieving the goal and the absence of flowers indicate no activity this week. Moreover, "Fish'n'Steps" [44] is a software application that was built to support physical activity awareness by utilizing a visualization of fish in a tank. The growth and activity of an animated fish in a fish tank is connected to a user's daily foot step count.

All physical activity systems and commercial personal fitness informatics systems such as Runkeeper and Fitbit provide information about physical activity rather than information about factors that influence physical activity which might be needed for self-reflection. An exception is Li et al. [45], who designed two prototypes, IMPACT 1.0 and 2.0, which supported reflection on physical activity and contextual information. IMPACT 1.0 allowed users to collect their data manually using paper booklets and the IMPACT 2.0 collected the data semi-automatically using a mobile phone. Moreover, they developed the IMPACT website that allow users to see visualizations of their step counts and the association between their steps and contextual factors. The result included that users became aware of those factors that influence their physical activity when their physical activity is associated with contextual information such as events, people, and places. Also, the user's awareness was increased because of the reflection on physical activity and contextual information.

2.3 Relationship to Other Work

The research in this thesis builds on prior work that has been done in this area in the Graphics and Experiential Media (GEM) lab (Figure 4).

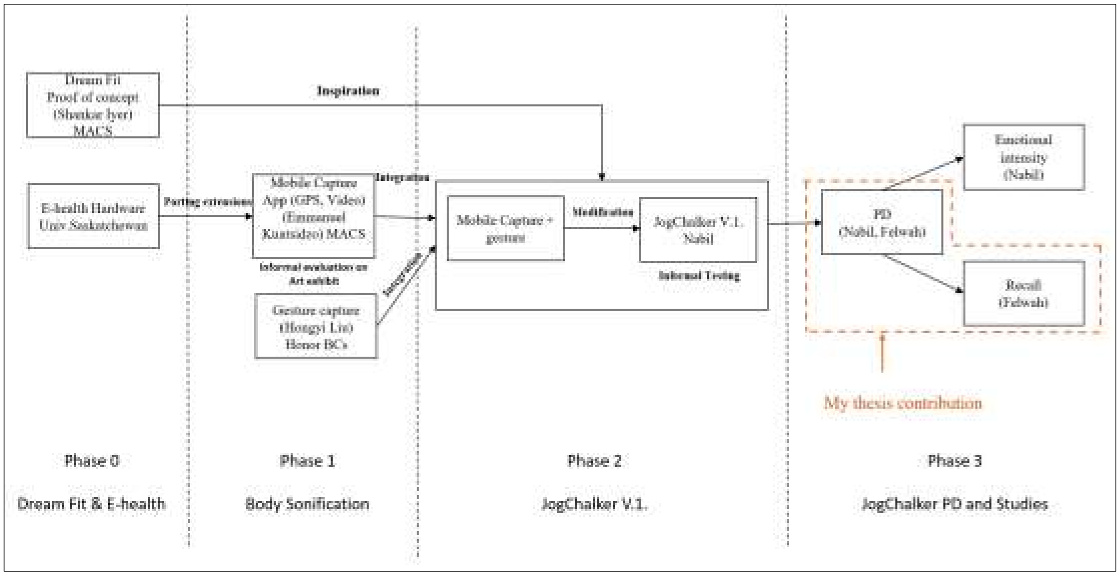


Figure 4. Prior work done in the GEM lab

Phase 0, DreamFit: DreamFit was a project by Shankar Iyer [46] that involved the development of a set of proof of concept iOS apps. The apps served to allow a runner to capture location, time, current song, and touch coordinates with each touch of the phone screen. Iyer also proposed an architecture for capture applications like DreamFit.

Phase 1, Body Sonification: In a subsequent project, Kuatsidzo [47] built on the E-health hardware prototype, an Arduino-based EKG and gait capture prototype developed at the University of Saskatchewa. He built an Android mobile application that read the biometric data from the Arduino device, GPS, and orientation sensor readings, and enabled the user to record short high quality video recordings during the data collection process. All the collected data was transmitted wirelessly to a server (computer) running Max/MSP to produce multimedia (sound and video) output of the data. Liu [48] then developed an additional Android gesture capture app. The app recorded and recognized gestures, learned new gestures, and generated an SVG-based output representation of each gesture recorded. This was then integrated into Kuatsidzo's app.

Phase 2, JogChalker v1: lab colleague Bin Hannan iteratively tested and refined the Phase 1 prototype with inspiration from DreamFit, to produce JogChalker V.1. JogChalker kept the video, GPS, and gesture recording components, removing connectivity with the E-health hardware as it was not suited to runners.

Phase 3, Participatory Design and Controlled Studies: After that, four sessions of participatory design (PD) was ran on the JogChalker application and visualization interface [49] (See preliminary work chapter 3). Bin Hannan conducted a controlled study [28] that demonstrated that people can express the intensity of emotion using attributes of a gesture (e.g. pressure, length) in a consistent way, and they can recognize intensity when the gestures are played back. In order to evaluate the ability of gestural annotation to trigger user's memory, we used different lifelogging systems (touch based gestuer app, video recorder, and audio recorder) to capture emotions and build visualizations with real runners to assess the value of every emotion recollection method, as well as the visualization interface.

2.4 RESEARCH GAP

Previous studies have primarily concentrated on visualization systems that support recalling and reminiscing for daily activities such as computer usage [35], special events [37], trips [32] and mobile device interaction [34].

Moreover, most physical activity systems were developed to track and provide visualization about physical activity information. These systems were designed to focus to make users active and aware about physical activity [43] [44]. One study investigated the combination of physical activity and contextual factors in everyday life to improve the awareness of factors that influence physical activity but not for the purpose of recalling [45]. So, researchers' aim was to improve awareness using location, activities and people as contextual information. They found that participants became more aware of the factors influencing their physical activity, and suggested that capturing mood and weather would also be useful.

All visualization systems that support recalling were in daily activities and physical activity systems were designed to encourage physical activity without showing the impact of internal and external factors that affect the physical activities. Therefore, the aim of this research is to track the emotional state of runners and then visualize both the annotation of emotion and running related data (speed, heart rate, elevation and weather) on a map-based visualization in order to support affective experience recall.

CHAPTER 3 PRELIMINARY DESIGN WORK

This chapter provides a detailed overview of the visualization design process. The outcome of this process was a map-based visualization system that supports the viewing of various types of data in an interface. I contributed to preliminary design work. I conducted the JogChalker's visualization sessions and my lab colleague, Nabil, ran JogChalker's capture sessions.

3.1 VISUALIZATION DESIGN

We used a participatory design (PD) method and paper prototypes to achieve the final visualization used to represent runners' data in the main study. Participatory design is a method that includes all stakeholders such as user and employee in the design process to come up with a result that meets their needs and is usable (see section 1.2). We developed a capture and visualization tool called JogChalker [49], refined through a four-week participatory design process. We describe in detail the process and outcomes here.

3.1.1 Prototype

We started our PD process with existing prototypes for both the JogChalker mobile app and JogChalker visualization application (our map interface and Runkeeper visualization) because we wanted to improve the design of the functionality of JogChalker mobile application and add a visualization for the interface. We also thought that showing existing prototypes could inspire the participants to bring new ideas during the design sessions and improve the existing prototypes.

The capture component was written in Java for the Android platform. It provides a simple touchscreen interface for making gestures. Gesture data (touch location/trajectory, width, pressure) are encoded into Scalable Vector Graphics (SVG) image format. The app also passively captures GPS coordinates and time.

Two researchers from our lab informally tested the capture application. They went out for a run for 25- 30 minutes and expressed their feelings by gesturing on the screen. Initial testing showed that the researchers were drawing gestures based on something they saw on their running route. Some of these drawings were random shapes and objects i.e., clouds, kitten, flowers. We then made the gestures more relevant to the running scenario (adding the geo-coordinates of the place where the gestures were drawn) and concentrated on selecting some of the emotions that runners generally feel during their runs. Based on the two researchers' suggestions and mental states that they felt during their run, we chose five running-related emotional states i.e., bored, tired, mellow, euphoric, and exhilarated. Furthermore, we developed simple candidate gestures related to each emotional state for evaluation (Figure 5).

Figure 5: gestures for five running-related emotional states.

The visualization component was written in JavaScript and built using Mapbox [50] (Figure 6). The SVG gesture image was merged with the route data based on the timestamp of the captured SVG image. The initial prototype of the visualization was divided into two sections; The first section displays a single running route with teardrop markers where the emotion occurred and the second section presents a list of the gestural annotations made during the run, from the first emotion until the last. These are also hyperlinked to teardrop markers that are marked on the route. Specific location was

Figure 6: initial map-based visualization

identified below the listed emotion. Basically, clicking on the emotion in the list will display SVG gesture images.

3.1.2 Participatory Design

We employed a participatory design approach with recreational runners. In the beginning, we did a pilot study with two colleagues who ran twice with our application and "Runkeeper" operating in the background. At the end of the run they provided feedback about the sessions for both the capture application and visualization interface. This helped us improve the feedback questionnaire and tools used for PD sessions. After pilot testing, we arrived at the methodology.

3.1.3 Participants

We recruited four recreational runners (one female and three males, aged 25-35), who each participated in four study sessions over 4-week period.

3.1.4 Procedure

After first receiving training on making the 5 gestures (for bored, mellow, tired, euphoric, exhilarated), participants ran for 30-60 mins using the capture tool prior to each session. Participants were simply asked to run a familiar route. They used an Android smartphone with a pressure-sensitive screen worn on an armband (Figure 7(a)) and a Mio heart rate wristband (Figure 7(c)). Gestures were displayed on the side of the armband for quick reference (Figure 7(b)). The mobile device would vibrate if no gesture was recorded over a 10-minute interval; otherwise participants were not prompted to record gestures. The Runkeeper application was also launched on the phone, and we preloaded the phone with a personal playlist if they preferred to listen to music while running. Participants also wore a GoPro camera while running (Figure 7(d)). This was to generate a video stream as a potential element to include in the visualization interface.

a b c d

Figure 7:(a) Mobile screen for gesture application (b) Armband with gesture list (c) Mio heartrate wristband (d) GoPro camera setup

We held four PD sessions for both JogChalker mobile app and JogChalker visualization application. The first two PD sessions were done individually and the last two sessions were conducted as a group.

In the First Session:

JogChalker mobile app session: Participants answered a couple of feedback questions about the usability of the touch gesture application, then sketched potential modifications to the capture application using pen and paper and a set of paper widgets.

JogChalker visualization session: Participants were shown the visualization prototype (Figure 6), RunKeeper's visualization interface (Figure 8), and the GoPro video feed (Figure 9) side by side on the same display. They interacted with the visualization prototype and were asked a list of questions about the visualization and whether or not it was easy to use. They were provided with pen, paper, and a set of paper widgets (including elements from the two visualizations and others not presented on either visualization including video, music, and weather data) and they were asked to integrate them in a single interface and assumed that they were creating interface for a computer (laptop/ desktop). Then they sketched a single visualization interface that would integrate the captured gestures with other data they deemed relevant for visualizing their experience.

In the Second Session:

JogChalker mobile app session: we expanded the ideas from the sketches of design session 1 and used the RunKeeper app as a base to integrate our touch gesture application. The main purpose was to come up with a new application design which would help the users to record their emotion and also collect all the related data. Participants used the same tools to envision how to integrate gesture capture into Runkeeper. At the end of this session, participants were also asked about all the possible methods to record their emotion while running.

JogChalker visualization session: Each participant was presented with their own prototype as an overview of his or her ideas. We then showed every participant the other participants' prototypes one by one to understand all prototype's features. Participants modified their visualization design using the same tools after viewing the designs created by the other runners.

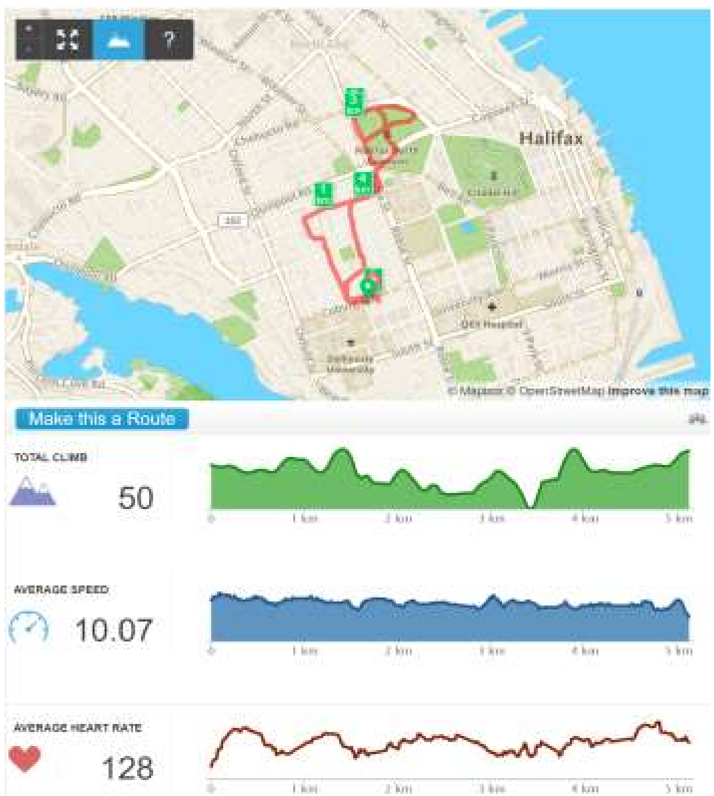


Figure 8. RunKeeper's visualization interface used in PD sessions

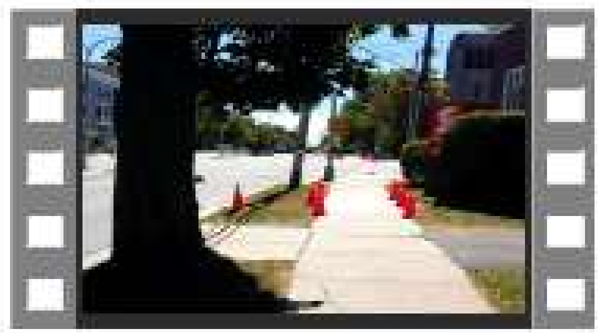


Figure 9:GoPro video feed used in PD sessions

In the Third Session:

The group met at the Mona Campbell building at Dalhousie University in a controlled lab environment (see Figure 10). The same procedure was conducted in both JogChalker app session and JogChalker visualization session. Participants presented and discussed their own and other member's designs in sequence. Discussion lasted for half an hour and was focused on the positive and negative aspects of keeping or removing a set of proposed features. participants were asked to identify all the features that they felt must be provided in the final version of the application. They were also asked to consider the tradeoffs between functionality and simplicity. As a group, they were asked to sketch out the basic interface using pen, paper, and a set of paper widgets for both JogChalker app and visualization and afterwards. Then they worked together to create a single integrated JogChalker app design mockup and a single visualization interface. We additionally gave them a list of scenarios to consider when refining their mockup design (running on a rainy day, running on a cold day with your gloves on, running with a group of people, running in a race, running on a wooded trail, running in a busy downtown area, running in a new town, leisure cycling, and going for a walk).

Figure 10: setup of Group designs session

In the Fourth Session:

Session 4 was conducted in the style of a Future Technology Workshop [51] for both touch gesture capture application and visualization interface. The Future Technology Workshop defined as "a method whereby people with everyday knowledge or experience in a specific area of the use of technology envision and design the interactions between current and future technology and activity" [56]. The group brainstormed alternative methods that could use to capture and visualize emotional state. Our goal was to have an overview of what type of data would be collected while running and how can we use a future technology to collect it. Moreover, it also covers what type of visualization can be used to effectively visualize your run history and improve insights and decision-making for your later runs.

There were 2 phases in this session. In the first phase, we asked participants what type of future data (data that is not collected currently by any running application) that would be collected during the runs using a future technology. In the second phase, participants were asked to think how the current data (data that is collected currently by running application) could be collected using a future technology.

3.1.5 Results

Through the four design sessions of the visualization interface, we were able to identify themes by observing how the individual designs changed over the first three design sessions. Participant feedback is illustrated in Table 1. For the first design session, participants had different ideas for visualization even though they were presented with different components of the visualization. However, in the second design session their ideas of visualization became similar to each other and we were able to expect the final design of the visualization because reviewing other participants' paper prototype design narrowed their thinking instead motivated them to generate new ideas (this is a drawback of the method in the second session). In the final design session, participants agreed to have these features due to the influence of the second session.

e 1. Visualization themes followed by participants throughout the first 3

Design Sessions		Session 1				Session 2				Session 3			
Participants		P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4
Map themes	M.T1	*											
	M.T2		*			*							
	M.T3			*			*	*	*	*	*	*	*
	M.T4				*								
Emotion themes	E.T1	*											
	E.T2		*	*	*	*	*	*	*	*	*	*	*
Collected data themes	B.T1	*	*			*		*		*	*	*	*
	B.T2		*			*	*	*		*	*	*	*
	B.T3								*				
	B.T4			*									
	B.T5				*								
Video themes	V.T1	*											
	V.T2		*										
	V.T3			*		*	*	*	*	*	*	*	*
	V.T4				*								
Music themes	Mu.T1	*											
	Mu.T2		*	*	*	*	*	*	*	*	*	*	*

M.T1: A small map on the top left corner of the interface.
M.T2: A big map on the right side of the interface.
M.T3: A big map on the top of the interface.
M.T4: A big map cover the whole interface.

Emotions themes:

E.T1: Presenting the emotions as button. If the user clicks on it, all related data will be shown.
E.T2: Presenting the emotions on the pop-up windows if the users click on the locations of the emotions.

Collected data themes:

B.T1: Biometrics graphs for the whole run presents on the interface.
B.T2: The value of each biometrics data for specific emotion will be display on the pop-up window.
B.T3 the average of the biometrics data can shows in the text box.
B.T4: biometrics graphs will be displayed if the user clicks on the value of the data.
B.T5: all biometrics graphics can be shown on the summary button on the interface

Video themes:

V.T1: related video will be shown on the left down side of the interface.
V.T2: the whole video of the run will be shown on the left down corner of the interface.
V.T3: Each video that is related to emotion will be displayed on slider-bar. If the user clicks on the video icon on the popup window, the related video will play.
V.T4: video icon in the popup window to display the video that is related to the emotion.

Music Theme:

Mu.T1: and music that related to emotion will display on the interface under the video and play if the user click on it.
Mu.T2: music button in the pop-up window.

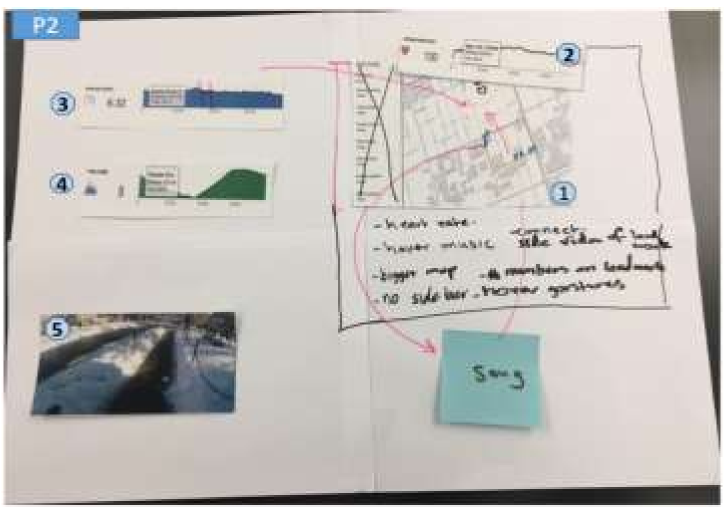
Throughout the design phase, our visualization interface designs maintained a simple map-based run plot; most debate centered around whether data other than route and gesture location should always be visible or only after a selection interaction. There was also discussion around whether their running data should be presented only in the pop up window or both in the pop up window and as a chart.

First design session: P1 and P2 preferred a map with all related data visible, i.e. video, music, speed, and elevation and had the full video of the whole run (see Figures 11 and 12). However, P3 and P4 preferred a simple map showing only emotions, with related data visible only after a selection interaction (see Figures 13 and 14). P3 wanted to have a slide-bar showing all the video in sequence so the user could click easily through the video, while P4 wanted to click a video button on the pop up window. None of the participants offered any explanation for their choices and we did not ask the participants the reasons they chose specific design. Since we provided the participants with all elements and asked them to integrate them, the outcomes of the paper prototypes were heavily influence by the session setup.

Second design session: P2, P3, and P4 wanted to visualize a simple map to display the captured gestures and related data at specific points on the map (Figure 16, 17, 18). P1, and P3 preferred also to have running related data for the whole run as a graph (Figure 15, 17). All the participants liked the idea of a slider-bar as a second way of presenting the video. The slider-bar shows multiple videos in sequence and allows the user can easily go back and fourth to view different parts of the video. Because we showed every participant the other participants' prototypes one by one, participants' ideas converged on presenting a simple map and captured data (emotion, video, music and biometric data) as well as having multiple videos in a slider-bar.

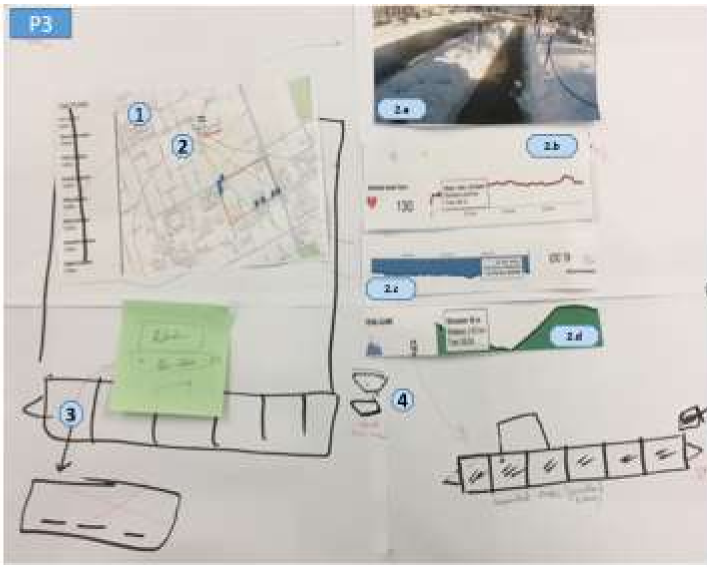
1- Map shows the route and location of the emotions.
2- Displays all the gestures of the emotions. If the users click on a gesture button, the other data related to the emotion in the other section will be shown.
3- Speed data of the whole run, displayed as a graph.
4- Climb data of the whole run, displayed as a graph.
5- Heartrate of the whole run, displayed as a graph.
6- Full video of the whole run.
7- Music the runners listened to.

Figure 11:First participant's sketch visualization after session 1



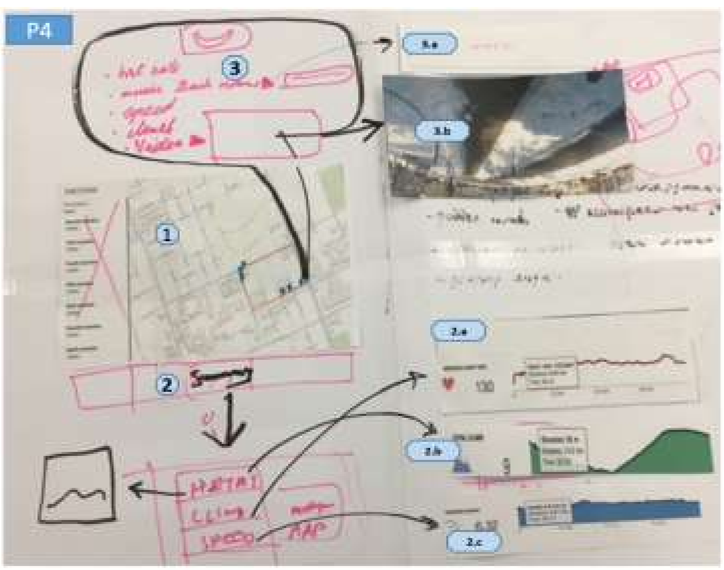
1. 1-Map shows the route and the location of the emotions
2. 2-The pop-up window displays the music and the heartrate of specific emotions.
3. - Speed data of the whole run, displayed as a graph.
4. Climb data of the whole run, displayed as a graph.
5. Full video of the whole run.

Figure 12: second participant's sketch of visualization after session1



1. Map shows the route and the location of the emotions.
2. The pop-up window has all biometric data, emotion and video button. If users click on any specific data, it will pop up as 2.a, 2.b, 2.c and 2.d.
   2.a. Video of the surrounding area at specific point.
   2.b. Heartrate of the whole run, displayed as a graph.
   2.c. Speed of the whole run, displayed as a graph.
   2.d. Climb data of the whole run, displayed as a graph.
3. Slide-bar: contains multiple videos related to the total run. The video shows if the users click on it.
4. "Sort by" button: sorts the multiple videos by speed, heartrate or climb.

Figure 13. Third participant's sketch of visualization after session1



1. Map shows the route and the location of the emotions.
2. Summary button to show the biometric data for the whole run.
   2.a. If the users click on the heartrate, the heartrate of the whole run displays as a graph.
   2.b. If the users click on the climb, the climb of the whole run displays as a graph.
   2.c. If the users click on the speed, the speed of the whole run displays as a graph.
3. The pop-up window has all biometric data, emotion and both the video and music button. If users click on the video button, it will pop up as 3.b. If they click on the music button, it will play as 3.a.

Figure 14: fourth participant's sketch of visualization after session 1

Third design session. All participants agreed to using a simple map to display all captured data in a pop-up window, a slider-bar showing the videos in sequence. Also, it was decided that the additional data (heartrate, speed, and elevation) would be presented as a chart. When a gesture location is selected in the group design, a synchronized video stream would play in the corresponding segment, and additional data (heart rate, elevation, speed, and music), and the gesture itself would be displayed in a popup (Figure 19).

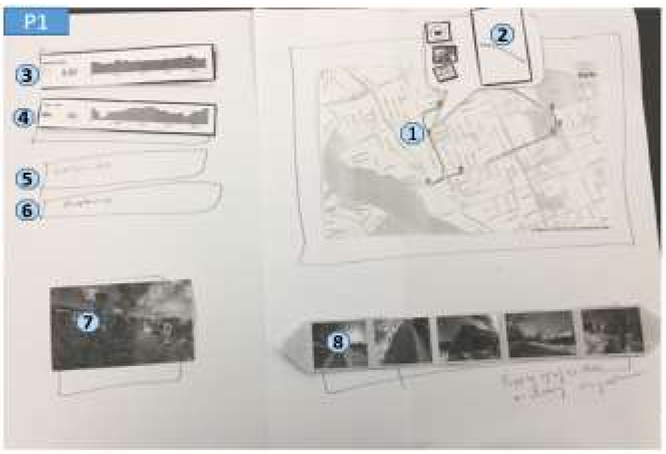
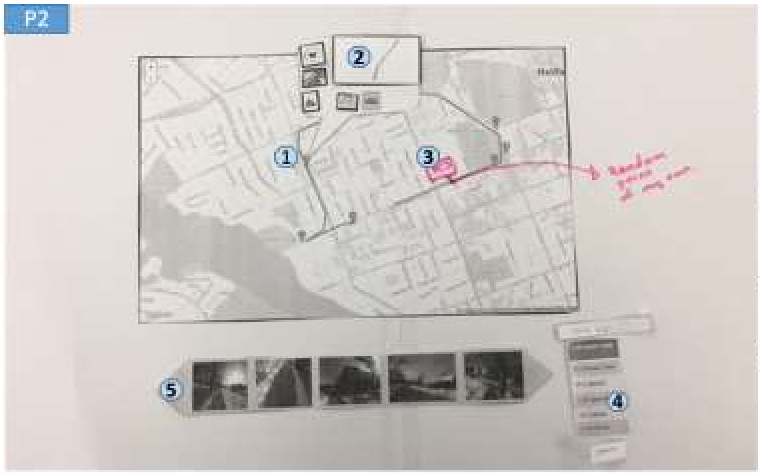
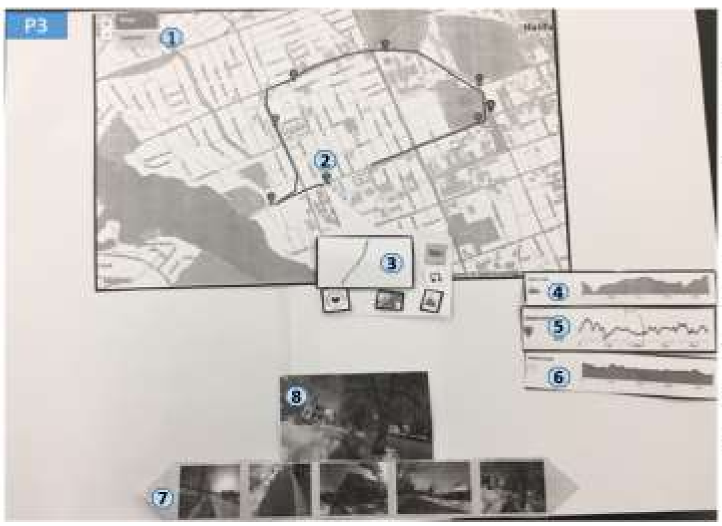


Figure 15: First participant's sketch of visualization after session 2



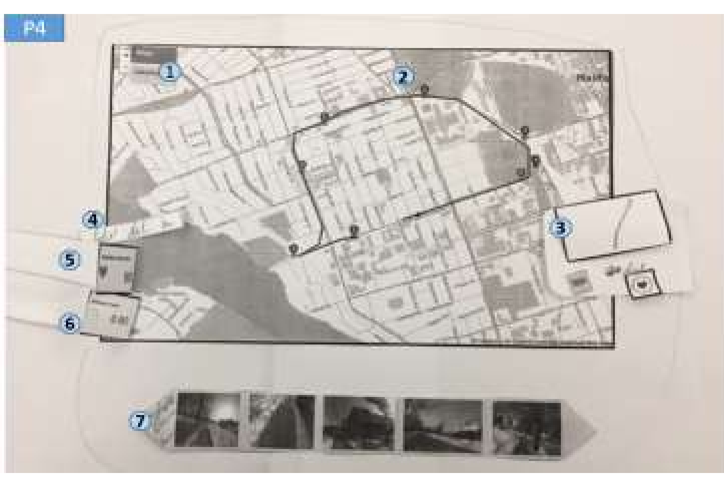
1. Location of the emotion: if a user clicks on it, the pop-up window is displayed.
2. Pop-up window: runner's data and gesture of the emotions at specific points. It also contains the video and music button.
3. If a user clicks on any random point on the route, the video of that point is displayed.
4. "Sort by" button: sort the videos by speed, heartrate, climb or gesture.
5. Slide-bar: contains multiple videos related to the emotions. The video is displayed if a user clicks on the video button in the pop-up window.

Figure 18: second participant's sketch of visualization after session 2



1. Two options view (map, satellite): changes the view of the map.
2. Location of the emotion: if a user clicks on it, the pop-up window is displayed.
3. Pop-up window : has runner's data and gesture of the emotions at specific points. Also it contains both the video and music buttons
4. Climb data of the whole run, displayed as a graph.
5. Heartrate data of the whole run, displayed as a graph.
6. Speed data of the whole run, displayed as a graph.
7. Slide-bar: contains multiple videos related to the emotions.
8. The video is displayed if a user clicks on the video button in the pop-up window.

Figure 17: Third participant's sketch of visualization after session 2



1. Two options view (map, satellite): changes the view of the map.
2. Location of the emotion: if a user clicks on it , the pop-up window is displayed.
3. Pop-up window: displays the heartrate, distance, and gesture of the emotions at specific points. Also, it contains the video button.
4. Text box on the map to display the total distance of the run.
5. Text box on the map to display the average heartrate.
6. Text box on the map to display the average speed.
7. Slide-bar: contains pictures that were taken during run and not related to the emotions.

Figure 16. Fourth participant's sketch of visualization after session 2

Future technology workshop. Participants wanted a visualization that replicated a 3D model of themselves and integrate their data to create the model. The model would display the person's current body structure, condition of muscles, blood flow. For the capture application, runners liked that the gesture capture was always on, and wanted to be able to define their own gestures. They wanted to record voice annotations, instead of or in addition to gestures.

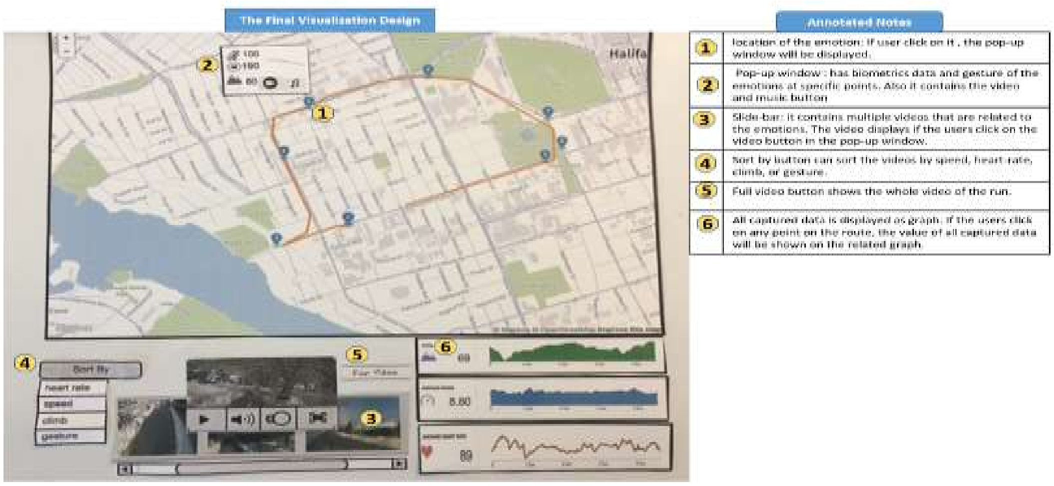


Figure 19: the final visualization interface prototype after group design session 3

These outcomes motivated us to consider gesture, audio, and video as methods to capture emotion in a comparative study. We also used the final visualization that resulted from the group design session in this thesis

CHAPTER 4 IMPLEMENTATION

In this brief chapter, we outline the experimental tools and the pilot study. The experimental tools include devices, capture apps and visualization interfaces that were used during the study.

4.1 EXPERIMENTAL TOOLS

In this section, we describe the experimental tools used for data capture. The ways in which these tools were utilized is discussed in the study design chapter.

4.1.1 Devices

- **Android device**

We used an Android smartphone (Samsung Galaxy) since JogChalker app runs on the Android smartphone.

- **Mio heart rate wristband.**

Since we were interested in displaying biometric data such as heart rate, we used Mio heart rate wristband that track and transmit runners' heart rates to the smartphone. Figure 7(c) shows the Mio heart rate wristband used during the runs.

4.1.2 Capture Apparatus

We used a variety of lifelogging capture apps (JogChalker app, video recorder, and audio recorder) on the Samsung Galaxy smartphone to capture runner emotions and Runkeeper app to capture physical information such as heart rate, speed, and elevation.

- **Gestural annotation**

we used the JogChalker capture application used in the PD sessions (Figure 20) for capturing gesture [49]. We used five running-related emotional states (bored, tired, mellow, euphoric, exhilarated) (Figure 20), recorded using simple gestures used in the PD sessions and in related work [28]. The gestures were listed on the bottom of the phone for easy reference. Recorded gestures were timestamped and geocoded.

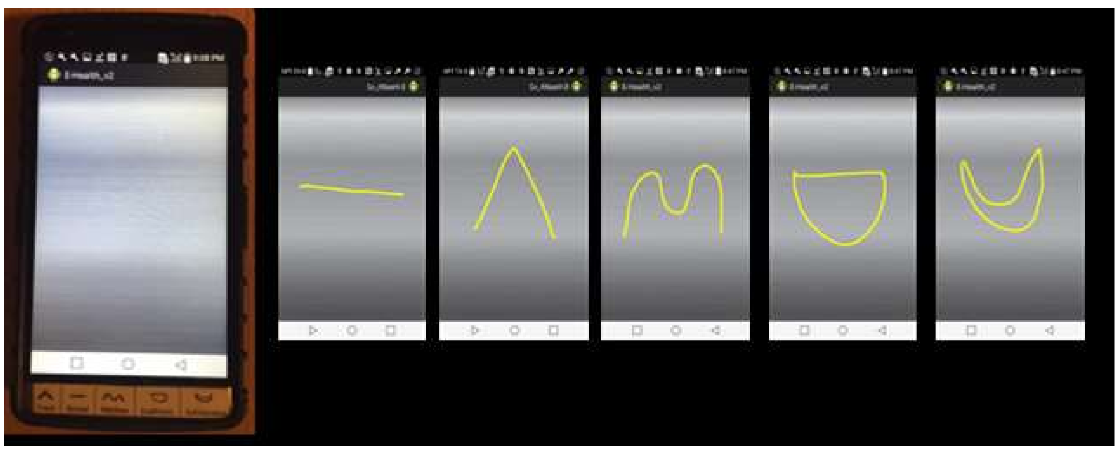


Figure 20: Gesture/Emotion set used in the JogChalker app

- **Video annotation**

In the visualization design, participants stated that using the GoPro camera during their run made them embarrassed. We therefore decided to use a video recorder embedded in the JogChalker application to record the surrounding environment and emotional state while running (Figure 21). Participants were able to press the start button to begin recording and press again to stop recording. In addition to the video recordings, we captured the time of the video recording (Figure 22) to allow us to integrate the video on the map-based visualization.

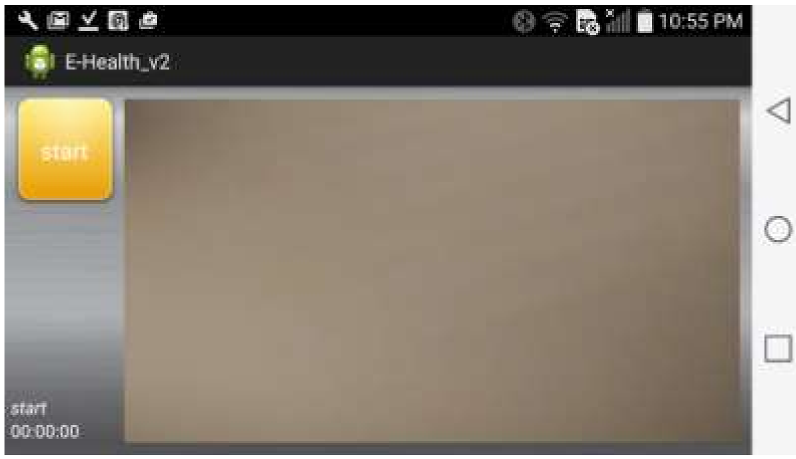
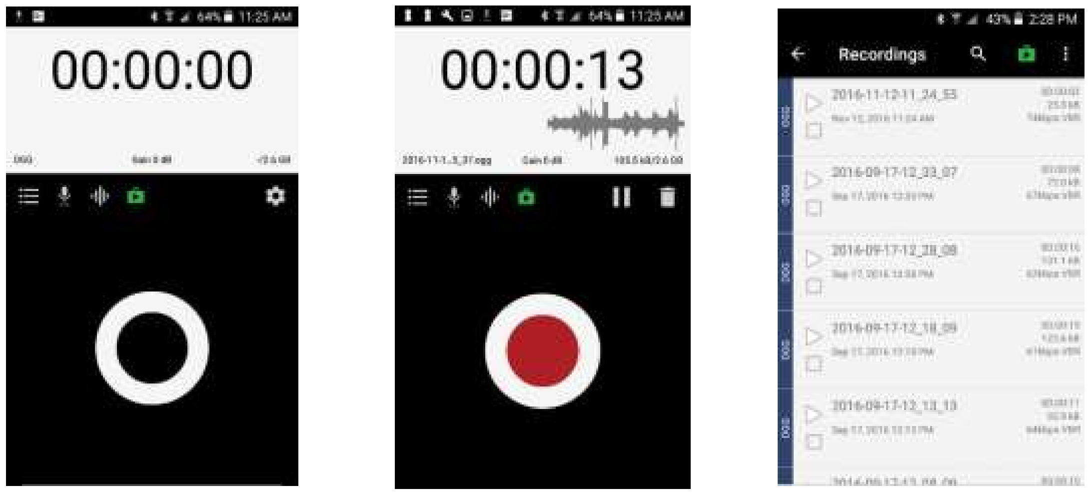


Figure 21: The video recorder embedded in JogChalker. The button toggles recording, and a preview window appears on the right.

Figure 22: video annotations were timestamped

- **Audio annotation**

We used ASR [57], a voice and audio recorder app to record participants describing their emotional state of the run at prescribed points (Figure 23). The app also provides the timestamp in which the audio is generated to integrate the audio on the map-based visualization. Moreover, ASR provides a large button which makes it easy to record audio so runners only need to press the button when they want to record and press again to stop recording. Then the audio will be saved automatically with a timestamp (Figure 23(c)).



(a) *(b)* *(c)*

Figure 23: ASR recorder [57], (a) before recoding, (b) during recording, (c) timestamp with audio recordings

- **Runkeeper application**

We used the RunKeeper application (Figure 24) on the android device to collect physical activity information such as GPS data, heart rate, speed, elevation and time of the run.

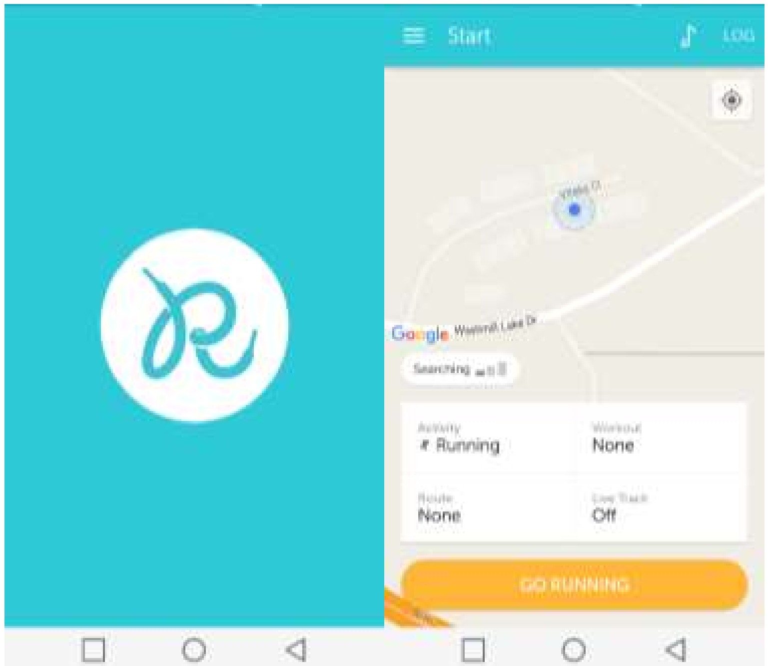


Figure 24: RunKeeper Application

- **Data merging**

Since we used a variety of lifelogging capture apps on the smartphone to capture runner emotions and physical information files such as GPS, heart rate, speed, and elevation, these lifelogging apps generated data in separate. A lab colleague built a script in Python that combined the Runkeeper output with the annotation files. The resulting data is a CSV file (Appendix H) that contain the following data:

1- latitude column (contains latitude values)

2- longitude column (contains longitude values),

3- Elevation column (contains elevation values)

4- Speed column (km/h) (contains speed values)

5- Heading column (contains heading values)

6- Leg length (m) column (contains leg length values)

7- Elapsed time column (contains elapsed time values)

8- Heart rate column (contains heartrate values)

9- File Name column (file name values)

The CSV file must be on the same domain as the page (interface) that requests it as remote file access was not implemented for this purpose. The interface requests the CSV file behind the scenes and analyzes it. After that, the data for each teardrop marker can be presented using the name of the column in the CSV file (Figure 25)

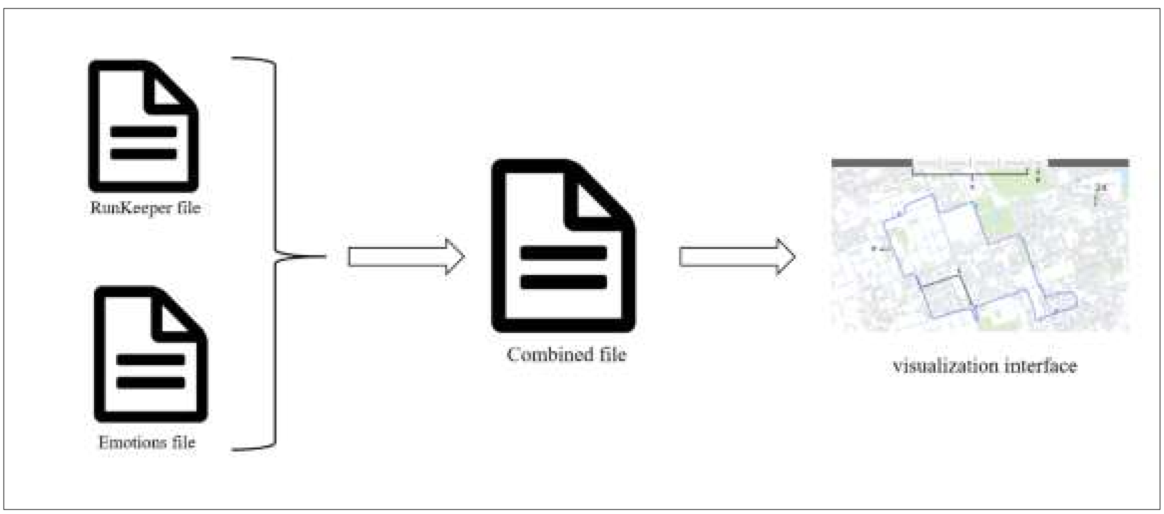


Figure 25: data collection and merging process

4.1.3 Visualization Interfaces

Building on the preliminary design work, we developed four variations of the visualization interface for a desktop/ laptop: a gestural annotation interface, a video annotation interface, an audio annotation interface and one without any annotation, in order to compare each method in our study. The interface has a tab for each run and a “report” tab presenting the data across all the runs. Along the route teardrop markers indicate annotation locations; clicking these causes corresponding emotion annotation to be displayed alongside running data (speed, heartrate, and elevation). The day and weather are always visible in a small box in the upper right corner of the interface (Figure 26).

Figure 26: The main visualization interface, (A) Presenting the captured data for each run individually, (B) showing all the data combined, (C) The day, time and weather, (D)

The gestural annotation interface presents the gesture annotation of emotional state as an animation (Figure 27). This replayed the gesture at the same rate as it was recorded. Stroke width matched touch area and pen colour was matched to gesture pressure. This was done as related work indicates that the way a gesture is made can express emotional intensity [4].

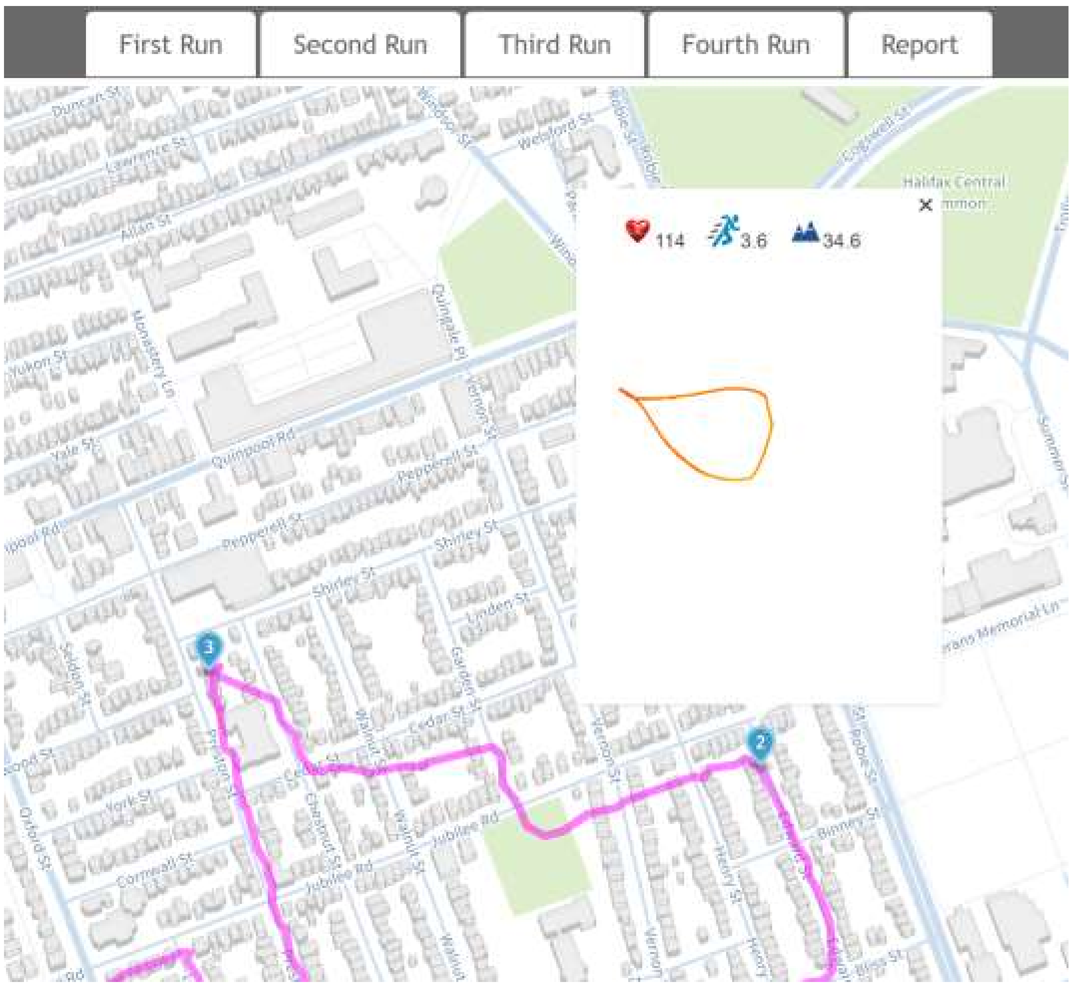


Figure 27: The gesture annotation interface

The video annotation interface plays the video annotation alongside the running data (Figure 28).

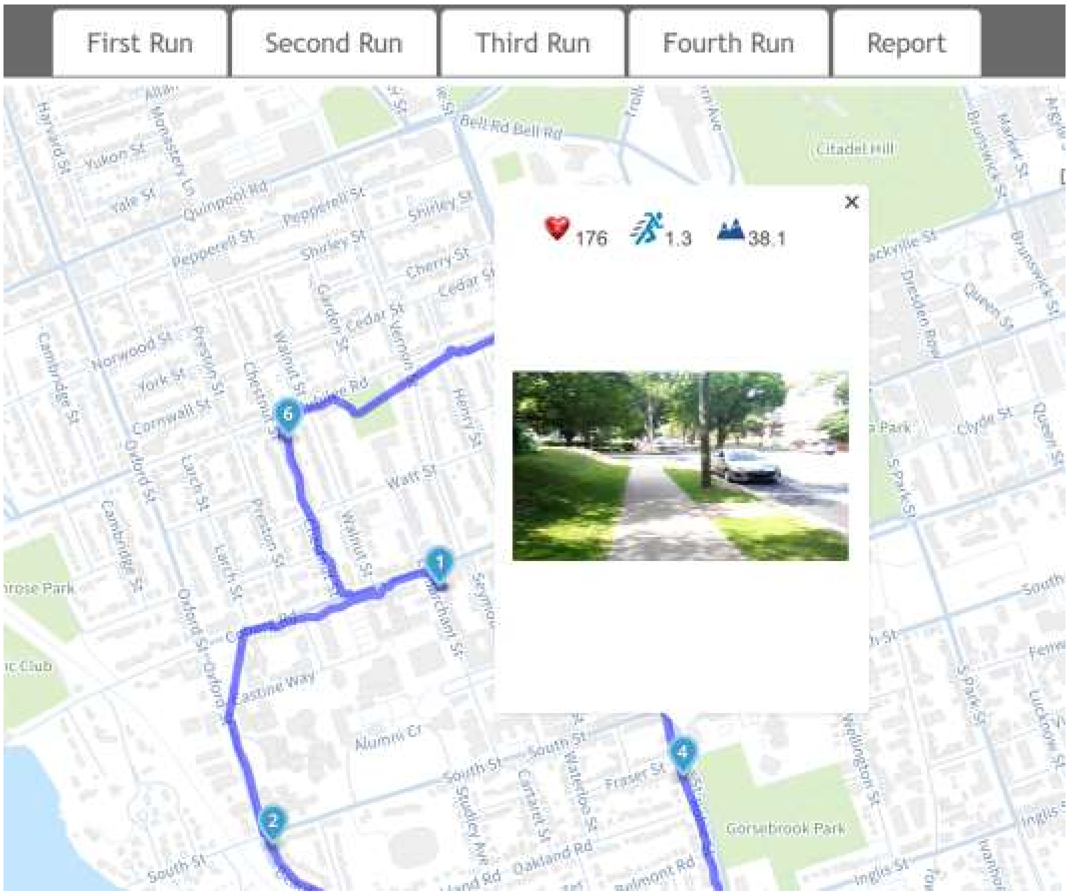


Figure 28. The video annotation interface

The audio annotation interface plays the audio annotation while displaying running data (Figure 29).

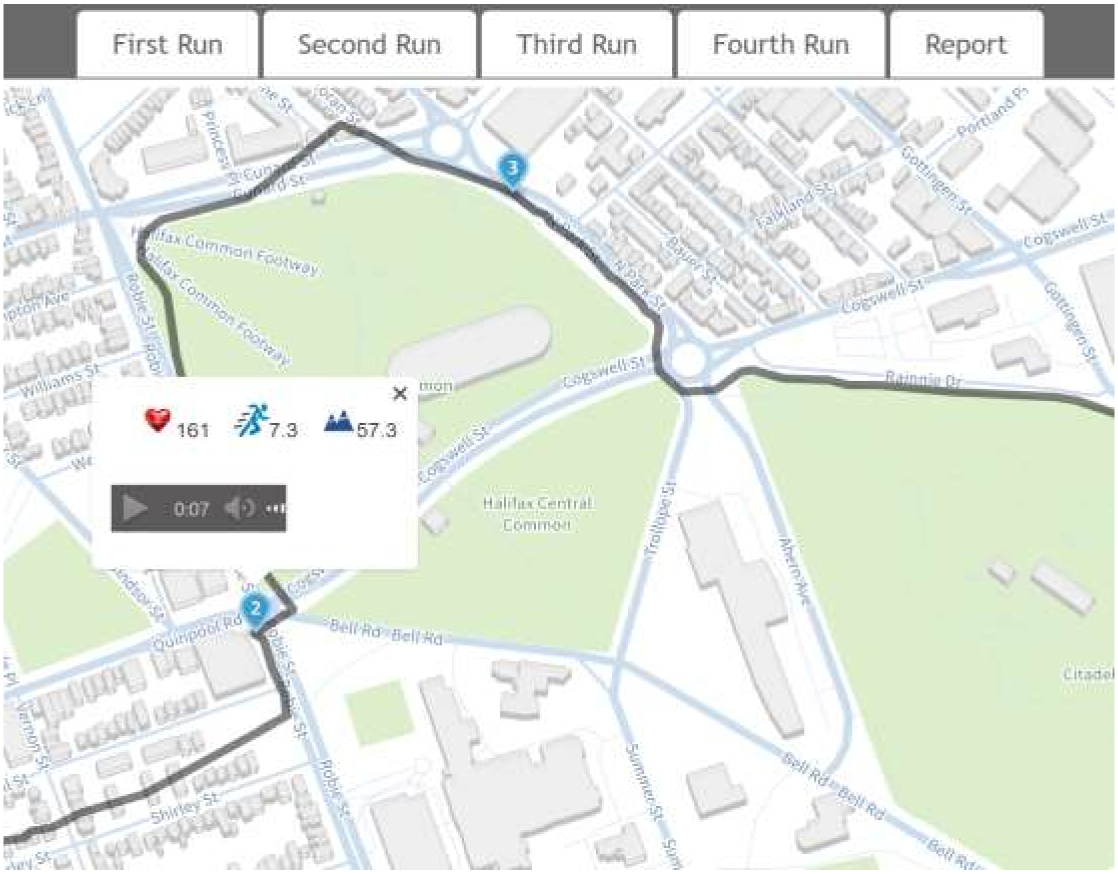


Figure 29. The audio annotation interface

The interface without any annotation, only the running data is displayed such as speed, heart rate, and elevation (Figure 30).

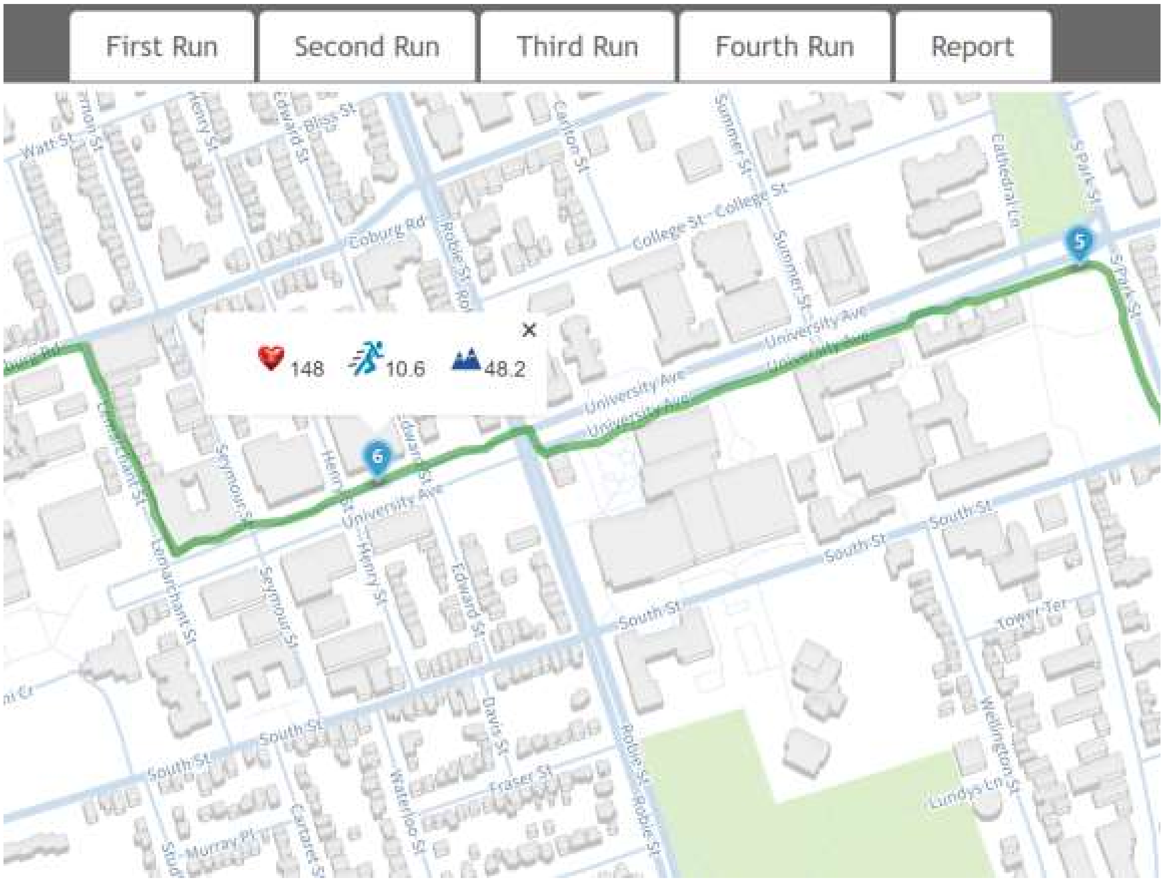


Figure 30. interface for presenting heart rate, speed, elevation

Clicking the Report tab displays all the data together (Figure 31). The left side of the interface shows the routes that were chosen, which were displayed in different colours to distinguish between runs. We also displayed average speed for different runs, average heart rate for different runs, distance and differing annotation data during the different runs (annotation data was presented for all three conditions except the mental note).

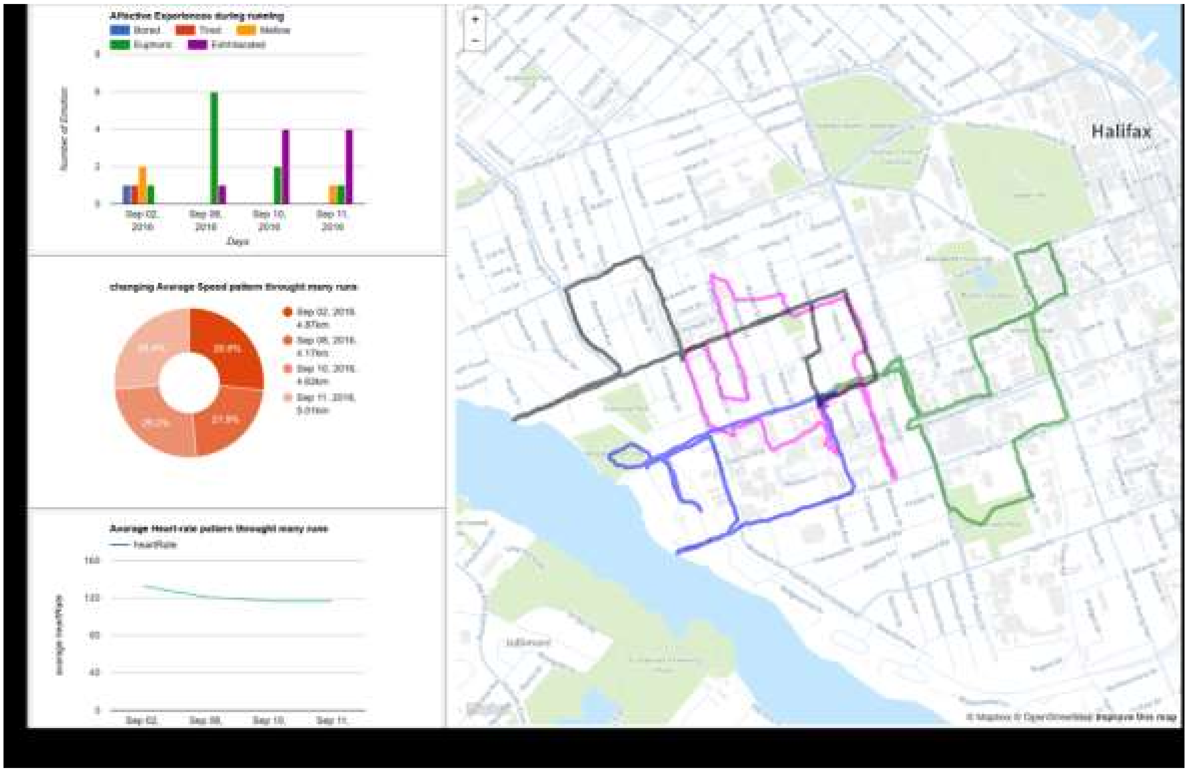


Figure 31. The Report interface

4.2 Pilot Study

We conducted a pilot study with lab peers to evaluate the tools and refine the study design presented in the next chapter.

4.2.1 Procedure

We recruited four recreational runners (all of them males). The pilot study was conducted over one week and was divided into two phases: The capture session allowed runners to record their emotional state using one method (capture app, audio record, video record or mental note) based on the condition assigned to them. Additional data was also recorded automatically (speed, elevation, and heart rate). After explaining the study, participants were assigned a condition and underwent a training session on how to express emotions using the JogChalker capture application, ASR audio application, JogChalker for video, or making a mental note (in this condition they were asked to think about their emotion without recording it). I showed the participants using the capture application how the touch gesture system works and asked them to use the system by drawing each emotion gesture twice. I also showed the relevant participants how to use the video recorder or audio recorder. I then asked the participant who used the audio recorder to record what they were feeling when the mobile device vibrated by clicking the start button once to start and a second time to stop recording. The participant using video was asked to record what they were feeling and the surrounding environment when the mobile device vibrated by clicking the start button once and again to stop recording. I had them practice twice before they went for a run. The mental note participant was asked to just think about what they were feeling without recording when the mobile device vibrated. In the capture session, we asked runners to run twice in a week and record their emotional state while running using one of these methods starting and ending at the same point, which was the Mona Campbell building. Participants annotated at prescribed times, spaced in 5-minute intervals. The device vibrated when it was time to create an annotation. We provided them with an Android phone that has the app to capture their emotional state and RunKeeper was launched on the phone to collect the additional data (heart rate, speed, and elevation as well as the GPS) for each run. They used a Mio heart rate wristband (Figure 7(c)) and gestures were displayed on the armband for quick reference (Figure 7(b)). We also gave them an option to have music but none of them used it. We met the participants before each run to setup all devices and apps and to make sure they worked properly, and met them again after each run to collect the data and devices.

After finishing all their runs, participants were given three days before the visualization session. In this part of the study, participants used the map-based visualization to recall their affective experience. We asked the participants to describe in as much detail as possible how they felt at each annotation point, and why they felt that way, starting with the first run and moving to the fourth. For each run, participants selected each annotation in sequence and attempted to give detailed descriptions of their affective experience at that moment. A semi-structured interview was conducted (Appendix F) in which they answered questions related to aspects of their annotation condition that did and did not help them recall their affective experience.

4.2.2 Result

Our goals were to get a sense of how runners use existing methods (capture app, audio record, video record, or mental note) that are available on smartphones for capturing emotions and to find any issue with our study design and tools.

Although we gave the option to listen to music, none of the participants used it because two of them did not listen to music while running and the other two had privacy or technical issues involved with exporting music from their phones to our device in the pilot study. For that reason, we decided to recruit runners who tended not to listen to music while running in the main study. Moreover, runners did not like the idea of recording an emotional state after each five-minute interval; they preferred to record emotional states as they wished. We did not change this in the study protocol, however, as we found that participatory design participants—who were given freedom to annotate when they wished—varied widely in annotation frequency, and in the study we wanted to assess recall using annotation data, not annotation behaviour *per se*.

The gesture condition participant missed out on recording some emotional states since the vibration was not strong enough to capture his attention when the phone was attached to his arm. For that reason, we decided to ask runners in the main study to hold the phone in their hand so they would not miss any vibration alert. This participant could recall his affective experience using locations alone, however the gesture made him more confident of his recollection. He said the gesture could be very helpful after a longer period to support recall.

The video condition participant recorded his emotional state along with an explanation of why he felt that way. He relied on his explanation for recall and did not add more details. For that reason, we decided to ask runners in the main study to just record how they were feeling. He stated that providing the video without audio annotation would not help him to recall his affective experience.

The audio condition participant also recorded his emotional state with an explanation of why he felt that way. However, when recalling he provided more details which were not on the audio recording using some cues such as weather, speed, and elevation. Also, in some points, he was able to connect the elevation value, speed and heart-rate value with his emotions at specific points and explained how that affected his run.

The mental note condition participant was able to recall his emotions for the first run more than second run. He said he was running with a partner which made him more engaged during the first run. Since running with a partner could affect the affective experience recall we made sure in the main study that each participant ran individually. As with the audio notes participant he said the weather and location helped him to recall some emotional states.

We validated that our tools would work for the large study and found no obvious issue with the capture tool and visualization tool.

CHAPTER 5 USER STUDY

This chapter describes the design of the comparative study. It first outlines the research objectives (section 5.1). Then, it describes the study design (section 5.2) including data collection, location, participants, recruitment, informed consent, compensation, and analysis. The goal of this study was to examine the differences in recalling affective experience when different annotation techniques are used (gesture, audio, video, and mental notes), and to explore the suitability of each technique for annotation while running.

5.1 RESEARCH QUESTIONS

The central research questions that guided the study are:

1) Does using gesture annotations of emotional states on a map-based visualization support affective experience recall?

2) How does using different techniques to capture emotional states during runs change the ability to recall their affective experience?

3) Which is the convenient method for recording emotional states during the run, the capturing touch gesture application, the audio recorder or the video recorder?

5.2 STUDY DESIGN

We employed a between-subject study design because we wanted to see how participants used a method over a series of runs, to reduce any novelty effect, to build familiarity with the annotation technique, and to capture fluctuations in runner experience from one run to the next. A future goal of the work is to see whether individuals are able to detect patterns in affective experience across runs using the visualization interface, and the between-subjects design additionally allowed us to get some initial feedback regarding this from our participants. The study was divided to two phases:

Capture: each participant ran 4 times in 10 days, capturing his/her emotions using the method assigned to them. The participants assign to the conditions were randomly.

Visualization: five days after the last run, runners interacted with an interactive map-based visualization to review and recall their affective experience. We chose 5 days as short time of period to evaluate the recalling.

5.2.1 Participants and Recruitment

Our study population was drawn from recreational runners in Halifax area. We recruited primarily through the Dalhousie University community but also advertised on Facebook. We recruited 20 runners for the study (10 males, 10 females, aged 18-64). Thirteen participants had run recreationally for more than 3 years; five had 1-3 years of running experience, and two had run for less than one year. One participant regularly ran >10k per run, eight ran 5-10k, nine 2-5k, and one <2k. Due to privacy and technical issues involved with exporting music from runners' phones to our device, we decided to recruit runners who never or rarely listened to music while running. Seven of 20 participants had at least some prior experience using personal informatics apps/devices for running such as Runkeeper, Strava, Fitbit, or Garmin connect. Participants received $30 for taking part in the study. Table 2 shows number of males, females, and prior experience of using personal informatics app taking them separately in four groups: video, audio, gesture, and mental note.

Table 2. Participant Demographics

	All participant number (n= 20)	Prior experience using personal informatics apps	Video condition	Audio condition	Gesture condition	mental Note condition
Number of meal	10	3	4	2	3	1
Number of female	10	4	1	3	2	4

All participants were recruited by email announcements through Notice Digest (notice.digest@dal.ca) and a departmental mailing list (csall@dal.ca. In the recruitment notice, participants were asked to email their interest in participating to me, the principal investigator. The participant and researcher then communicated to find an appropriate time for the participant to do the study**.** The email recruitment script is shown in Appendix A. In addition, I posted the study details on my Facebook page to inform people of the study (Appendix B).

5.2.2 Procedure

The study was conducted in the Graphics and Experiential Media (GEM) Lab, Mona Campbell Building, Dalhousie University. At the beginning of the study participants met with me in the Mona Campbell building, where the study was explained and the informed consent was given by the participant (Appendix C). They then completed the background questionnaire (Appendix D), which took about 10 to 15 minutes. As well, participants underwent a training session on how to express emotions using the JogChalker capture application, ASR audio application, JogChalker for video or making a mental note (in this condition they were asked to think about their emotion without recording it) based on the condition assigned to him/her. I showed the participants who used the capture application how the touch gesture system works and asked them to use the system by drawing 10 gestures (each of the 5 customized emotion gestures twice) for approximately 15 minutes. I also showed the relevant participants how to use the video recorder or audio recorder. I then asked the participant who used the audio recorder to record what they were feeling when the mobile device vibrated by clicking the start button once to start and a second time to stop recording. The participant using video was asked to record what they were feeling and the surrounding environment when the mobile device vibrated by clicking the start button once and again to stop recording. I had them practice twice before they went for a run. The mental note participant was asked to just think about what they were feeling without recording when the mobile device vibrated. The study was conducted for two weeks and it was divided into two phases: the capture phase and visualization phase.

In the capture phase, each runner used one method to capture emotion over four runs. Participants went out for a run four times in 10 days for 30 minutes on any route they chose starting from the same starting and ending point which is Mona Campbell building (to facilitate equipment dropoff). Participants annotated at prescribed times, spaced in 5-minute intervals. The device vibrated when it was time to create an annotation. We did this to avoid wide variation in annotation frequency between participants, something we observed in the preliminary design work. Prompting for annotation follows the Experience Sampling method [49], asking participants to reflect on their current emotional state rather than capturing annotations when the participant feels compelled to do so. We felt this was important as different participants may be more compelled to express different emotional states, potentially impacting comparison of annotation conditions, and also because we wanted to sample affective experience over the duration of each run. Additional data was collected during the run using RunKeeper app. Participants used an Android smartphone and a Mio heart rate wristband (Figure 7(a and c)). Gestures were displayed on the bottom of the phone for quick reference (Figure 20). We met the participants before each run to setup all devices and apps and to make sure they worked properly, and met them again after each run to collect the data and devices. After finishing all their runs, participants had a five-day break before the visualization phase.

In the visualization phase, participants returned to the GEM lab for a final meeting, where they interacted with the visualization interface corresponding to their annotation condition. Each run is presented in a separate tab, and a synthesis is presented in a report tab. After participants finished familiarizing themselves with the interface, we asked the participants to describe in as much detail as possible, how they felt at each annotation point, and why they felt that way, starting with the first run and moving to the fourth. For each run, participants selected each annotation in sequence and attempted to give detailed descriptions of their affective experience at that moment. Specifically, they were asked to explain how they were feeling and why they felt that way. After each recollection, we asked participants what they used to help them remember and how confident they were about their recollection on a scale from 1 (not at all confident) to 5 (very confident). After they finished the recall phase, they opened the report tab. They were then asked if they could see any patterns in their affective experiences. Participants completed a post-study questionnaire (Appendix E) and semi-structured interview was conducted (Appendix F) in which they answered questions related to aspects of their annotation condition that did and did not help them recall their affective experience. During the interview, a video recorder was used to aid me in analyzing the data. The participant then completed the payment form (Appendix G) and was compensated.

5.2.3 Data collection

We used different data collection tools and methods during this study:

1- JogChalker capture app was used to store the position of the gesture drawn on the mobile device, the width of the gesture, the time of drawing, and the amount of pressure imposed on the device while drawing the gesture.

2- ASR audio recorder app was used to log emotional state using voice annotation.

3- JogChalker video recorder was used during the run to record emotional state and the surrounding environment.

4- RunKeeper was launched on the phone to collect physical information such as heart rate, speed, and elevation as well as the GPS.

4- A video recorder was used during the recollection phase and the interview to help understand the user's feedback and opinions.

5- A background questionnaire (Appendix D) collected basic demographic data, such as age, gender, and more detail about participants' affective experiences.

6- A post-study questionnaire (Appendix E) was utilized to identify what in the interface tool triggered the participants' memory and to determine whether tracking the emotions helps them later in the recall phase.

7- A semi-structured interview (Appendix F) was conducted to understand participants' views about how seeing their emotional state on a map-based visualization interface affected their recall.

5.2.4 Informed consent

All participants involved in the study signed a consent form (see Appendix C). This was administered by me, the lead researcher, at the initial meeting. I distributed it to all participants, asking for their written consent. The consent form outlined the purpose of my research, the risks and benefits associated with participation, and the conditions involved. These include what they were required to do and also that they were able to withdraw from the study at any time without loss of compensation, should they want to.

5.2.5 Compensation

Participants were compensated $30 at the end of the visualization session for participating in the study (whether they were able to finish or not). Participants signed the Participant Payment Receipt (Appendix G) upon receipt of payment.

5.3 ANALYSIS

During the visualization session, we set up a camera to record participants' recollections while exploring their emotions on the visualization interface. We also took observational notes during the interview. The video record and observational notes taken during the sessions helped us understand the impact of having gesture annotation, video annotation, audio annotation, or mental notes on the ability to recall their effective experience. We started our analysis phase by transcribing all videos including recalling and interview sessions. In addition to qualitative analysis of participant recollections and of feedback given in the questionnaire and interview, we considered the time taken to recall affective experience associated with each annotation, the amount of detail recalled for each annotation, and a self-reported measure of confidence in the recollection provided for each annotation.

When calculating *number of details* for each recollection, participants were given one point for each emotion described, and one point for each reason provided. For example, ‘I was feeling tired, because I was running uphill and the weather was hot’ would be assigned 3 points. No points were awarded for no emotion described or commentary not relevant to affective experience (e.g., “I just started running at this street and I was thinking about my work”).

Time to recall was calculated as the time from the point the annotation is reviewed up to the end of the participant’s verbal explanation, including any time spent thinking.

Confidence: the participants indicated their confidence for each recollection on a scale from 1-5, where 1 is not confident at all, and 5 is very confident

We used a multivariate ANOVA in SPSS to analyze:

1- Time taken to recall affective experience associated with each annotation.

2- The amount of detail recalled for each annotation.

3- Confidence to assess the success of gesture annotation in prompting emotional recall.

Moreover, we coded the interviews and questionnaires to find the advantages and disadvantages for each method used in the capture and visualization phases.

CHAPTER 6 RESULTS

The goal of this thesis was to determine if the gesture annotation is a useful aide in emotional memory recall and, in particular, to examine the differences in recalling affective experience using different techniques (gesture annotation, audio annotation, video annotation, mental note). We used a variety of methods to meet the study's objectives. In addition to the qualitative data generated through the recall phase, the post-study questionnaires and interviews, we also collected quantitative data including the time taken to recall the affective experience associated with specific emotion, the number of details recalled for each emotion in each run and whether or not runners were confident about their recollection.

6.1 USE THE TECHNIQUES

The JogChalker app was used in the same way by all gesture condition participants to capture the five running related emotions. However, the other techniques (e.g. video and audio) were used to capture emotion sometime with more details and sometime without during runs.

All Video condition participants recorded more details (e.g. emotional state, weather, or the reason of the emotion) along with the visual cues in the video. For example, VP1 recorded "South street, I feel very good, very excited and a little mellowness. I am a little tired. It is very humid today. It is getting hard to breathe but it is nice, clear and sunny". VP2: "I am running down the hill feeling very good and running is nice and cool day today". While VP3 stated "I am feeling good today. Some clouds came by so it is not hot right now. Wishing I run a little fast but that is not unusual". VP4 reported that "I am feeling a little heavy maybe I am running very fast than my capacity to complete half an hour". VP5 recorded "I am not tired right now. I think I can run more but I feel thirsty my mouth is dry but I feel good it is very sunny day and breath."

The three Audio condition participants recorded most of their feelings with more details such as their emotion and the reason for that emotion. For instance, AP5 said "still running… feeling very tired and my legs are cramping". AP2 stated, "I feel a bit self conscious running in crowded street and a bit scared because there is fire engine outside the medical building....", and AP3 noted, "I am on Quinpool street and it is cloudy but I am still bored". In addition, one participant recorded her emotion briefly in all runs. For example, AP4 stated "Happy but tired". Another participant recorded her emotions sometimes briefly and sometimes with details. For instance, when AP1 recorded briefly, she stated "I feel a little better but still sad" but when she recorded with details, she recorded "I am feeling happy and the cramp is gone. I do not feel tired but I feel I am running kind of slowly".

We used a multivariate ANOVA in SPSS to analyze the data. There were three dependent variables (DVs): Number of Details (Details), Time to Recall (Time) and Confidence, with annotation type as the independent variable (Gesture, Audio, Video, Mental Note). The main analysis for the three DV indicated that there was a significant difference between the groups with $F (2,48) = 2.241$ ($p < .035$, $\eta^2 = .296$). This indicates that the best linear combination of the three DV is different as a function of group. So, each DV was analyzed separately using a simple BS-ANOVA, followed by Fisher's Least Significant Difference post-hoc test, because we had specific predictions about how the annotation conditions would impact performance.

The collected data showed that there were some runners did not capture their six emotion points as required or they skipped some emotion while recalling phase. So, by design, the pattern of missing emotion point values would be the same for all three DVs. This means that if it was missing for Details, it was also missing for Time and Confidence. The collected data also showed that seven participants (3, 4, 5, 9, 10, 14 and 20) were missing one single emotion value, two participants (11 and 15) were missing two, one participant (18) was missing three, and one participant (12) was missing 10. The analysis of data indicated that missing emotion values were not all in a single condition, were not all in a single emotion point, or run). As such, replacing missing values was feasible.

The missing values could be replaced using the combination of mean for run and mean for emotion point. so, a missing value for emotion 1 in run 1 would be replaced using:

$$\text{missing} = \text{mean (run1)} + \text{mean (emotion1)} - \text{Grand Mean}$$

Table 3 presents the data for the mean number of details recalled of condition. Each mean is the average for four runs in each condition for each participant.

Table 3.The mean number of details recalled for each participant

Condition	participants					Mean for condition	Std. Deviation
Video	P1	P2	P3	P4	P5	3.4593	1.20296
	5.6209	2.6667	2.9203	2.8735	3.3333		
Audio	P1	P2	P3	P4	P5	2.4582	1.29111
	4.75	1.9167	1.6775	2.0833	1.9286		
Gesture	P1	P2	P3	P4	P5	2.5594	0.64232
	3	2.7071	3.2308	2.1844	1.6667		
Mental Note	P1	P2	P3	P4	P5	1.6918	1.37626
	3.1864	0	2.244	1.875	0.6163		

For number of details, the conditions were not significantly different, with $F(3,16) = 1.933$ ($p < .165$). The mean number of details recalled per annotation for each participant, by annotation condition is presented graphically in Figure 32. Post hoc analysis indicated that there was a significant difference in Detail between Video and Mental Note ($p < .029$), but not between any other two conditions.

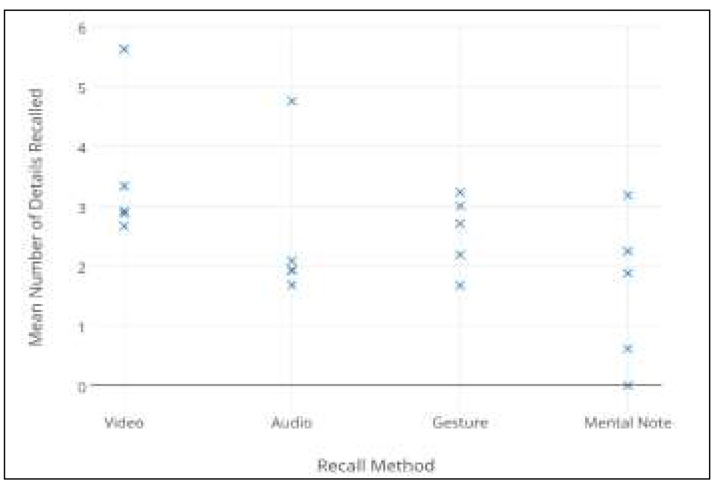


Figure 32: The mean number of details recalled for each participant in each condition

Table 4 presents the data for the mean total time taken in recall (sec) of each participant in each condition. Each mean is the average for four runs in each condition.

Table 4. The mean total time taken in recall(sec) of each participant in each condition

Condition	Participants					Mean for condition	Std. Deviation
Video	P1	P2	P3	P4	P5	28.0509	6.85034
	33.0023	21.125	25.7614	23.5515	37.7083		
Audio	P1	P2	P3	P4	P5	21.9943	10.31329
	39.875	15.2917	14.3449	20.4583	19.1698		
Gesture	P1	P2	P3	P4	P5	32.8862	12.81585
	33.6667	33.8721	41.5279	41.5327	11.4167		
Mental Note	P1	P2	P3	P4	P5	10.716	7.77037
	14.2738	0.75	16.0357	15.8333	4.2353		

For total time to recall, the conditions were significantly different with $F(3,16) = 1.933$ ($p < .014$, $\eta 2 = .476$). Figure 33 presents the mean time to recall per annotation for each participant, by annotation condition. Post hoc analysis indicates that there was a significant difference between Gesture and Mental Note ($p < .012$) and between Video and Mental Note ($p < .009$).

We looked at the correlations between number of details and the total time to recall within each group. Note that this analysis was based on a sample size of just 5 per group, so while we report significance we cannot rule out the influence of individual differences on results between groups. For the Video group, number of details recalled was not significantly correlated with total time to recall, at $r = .558$ ($p < .328$). For the Audio group, number of details recalled was positively correlated with total time to recall at $r = .987$ ($p < .002$). For the Gesture group, number of details recalled was not significantly correlated with total time to recall, at $r = .710$ ($p < .179$). for the Mental Note group, number of details recalled was positively correlated with total time to recall at $r = .890$ ($p < .043$).

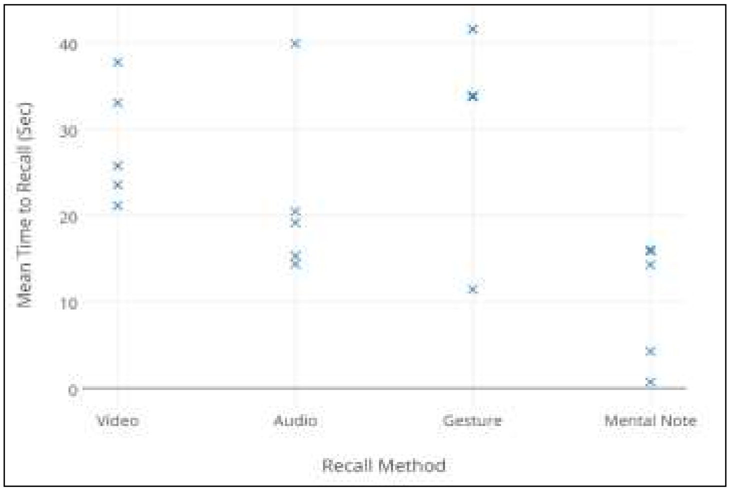


Figure 33: The mean total time to recall for each participant in each condition

Table 5 presents the data for the mean time taken in recall (sec) after removing the initial time spent thinking for each participant in each condition. Each mean is the average for four runs in each condition.

Table 5. The mean recall time for each participant in each condition, after removing initial time spent thinking.

Condition	Participants					Mean for condition	Std. Deviation
Video	P1	P2	P3	P4	P5	23.73334	7.249769891
	26.75	15.9167	22.125	19.2917	34.5833		
Audio	P1	P2	P3	P4	P5	19.833360	10.3283613
	37.875	14.2917	14.0417	13.7917	19.1667		
Gesture	P1	P2	P3	P4	P5	25.624980	9.4364747
	30.25	29.5833	31.75	27.5833	8.9583		
Mental Note	P1	P2	P3	P4	P5	7.700000	6.7343996
	12.75	0	15.6667	8.125	1.9583		

For recall time after removing the initial time spent thinking, the conditions were significantly different with $F(3,16) = 4.145$ ($p < .019$). Figure 34 presents the mean time to recall per annotation for each participant, by annotation condition. Post hoc analysis indicates that there was a significant difference between Gesture and Mental Note ($p < .004$), between Audio and Mental Note ($p <.040$), and between Video and Mental Note ($p < .009$). We see that after removing the initial thinking from the total time, Audio became significantly different from Mental Note.

We also looked at the correlations between number of details and the time spent relaying details ("talking time") within each group and we found approximately the same correlations between number of details and the total time presented above (i.e. without thinking time removed). For the Video group, number of details recalled was not significantly correlated with talking time, at $r = .419$($p < .482$). For the Audio group, number of details recalled was correlated positively with talking time at $r = .972$ ($p < .006$). For the Gesture group, number of details recalled was positively correlated with talking time with marginal significance, at $r = .873$ ($p < .053$). For the Mental Note group, the number of details recalled was positively correlated with talking time at $r = .907$ ($p < .034$). This result highlights the qualitative difference between video annotations and the others: participants often presented richer detail in the video condition, but the detail was not always directly tied to affective experience.

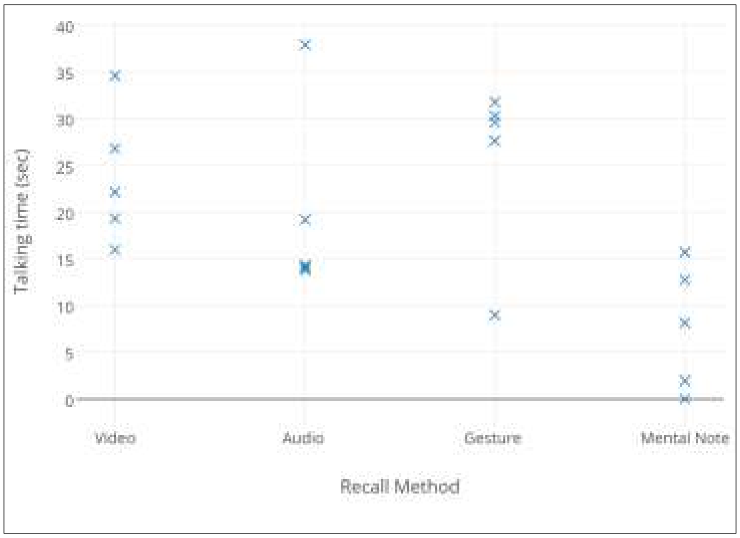


Figure 34. The mean talking time for each participant in each condition

Table 6 shows the mean of total time divided by number of details for each participant in each condition.

Table 6: The mean of total time divided by number of details

Condition	Participants					Mean for condition	Std. Deviation
Video	P1	P2	P3	P4	P5	6.603660	1.6885355
	5.0550	5.7222	6.1502	6.6551	9.4358		
Audio	P1	P2	P3	P4	P5	6.771860	1.8389490
	8.5263	5.3069	5.1042	8.9729	5.9490		
Gesture	P1	P2	P3	P4	P5	9.655760	3.8722014
	8.4747	11.3262	9.4779	14.7778	4.2222		
Mental Note	P1	P2	P3	P4	P5	3.264400	1.9891712
	3.2666	0.7500	5.1257	5.2970	1.8827		

After dividing the total time by number of details, we found that the conditions were significantly different with $F(3,16) = 5.424$ ($p < .009$). Figure 35 presents the mean total time divided by number of details per annotation for each participant, by annotation condition. Post hoc analysis indicates that there was a significant difference between Gesture and Mental Note ($p < .001$) and between Audio and Mental Note ($p < .042$). however, there was no significant difference between Video and Mental Note ($p < .053$). While acknowledging the potential for individual difference effects, we note the higher overall mean for the Gesture condition. In this condition, 4 of 5 participants are near or higher than the highest time/details values for the Video and Audio conditions. This suggests that Gesture provided an efficient means of encoding emotional state in a manner that promoted recall of affective experience.

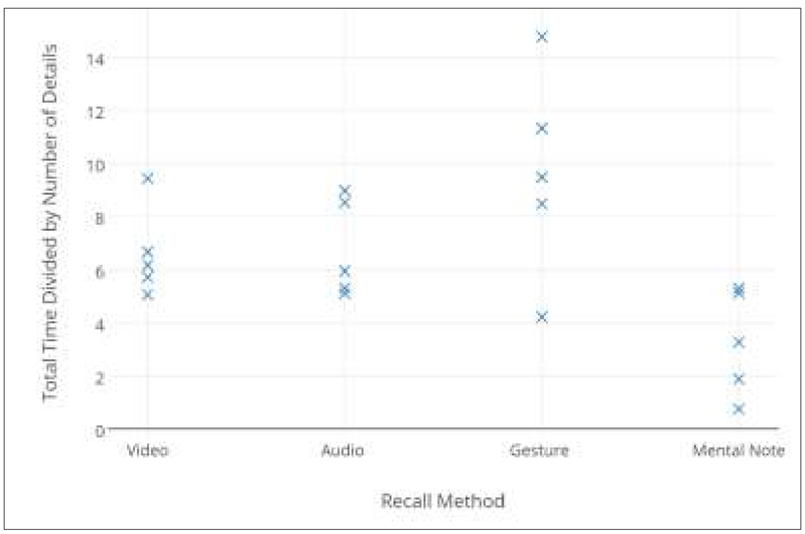


Figure 35. The mean of total time divided by number of details for each participant in each condition

Table 7 presents the data for the mean confidence of each participant in each condition. Each data point is the average for four runs in each condition.

Table 7. The mean of confidence of each participant in each condition

Condition	Participants					Mean for condition	Std. Deviation
Video	P1	P2	P3	P4	P5	4.7439	0.2206112
	4.7785	5.0000	4.9036	4.4959	4.5417		
Audio	P1	P2	P3	P4	P5	4.1579	0.6618912
	4.5833	4.9091	3.8448	3.2083	4.2437		
Gesture	P1	P2	P3	P4	P5	4.4818	0.3902054
	4.9167	4.6534	3.8572	4.4819	4.5000		
Mental Note	P1	P2	P3	P4	P5	3.0330	1.2878300
	3.4127	1.0000	4.5595	3.0000	3.1926		

For confidence, the conditions were significantly different with F (3,16) = 1.933 (p <.015, η2= .469). Figure 36 presents the mean confidence score per annotation for each participant, by annotation condition. As might be expected, confidence was generally lowest in the Mental Note condition. Post hoc analysis shows a significant difference between Gesture and Mental Note (p < .004), Audio and Mental Note (p < .036), and Video and Mental Note (p < .002).

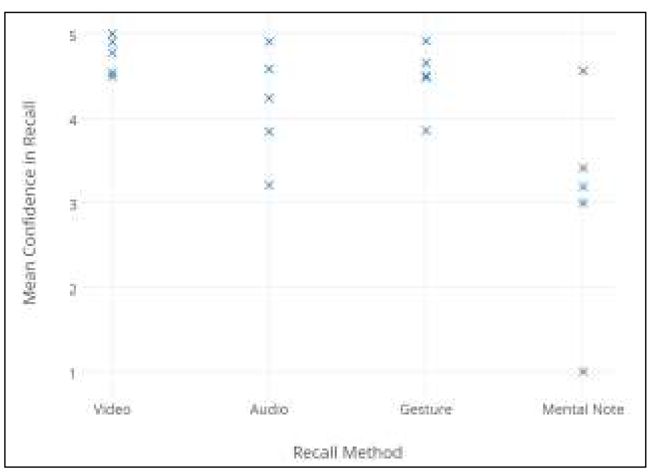


Figure 36: The mean confidence in recall for each condition.

6.2 DETAILS RECALLED

6.2.1 Use of annotation

In the Video condition, details recalled were often closely tied to what was visually evident in the video recording. For example, VP1 noted “At that point I had been on the flat street for a while so I was not feeling tired any more…”. While, VP2 stated “Yeah I remember where I was still feeling kind of determined to finish and happy because I would almost be done and the rain had stopped”. VP3 said, “I was feeling good. It is easy to run around soccer field. I do not have to look for a car or think of what is happening”. VP4 stated, “I can see I went down. I was tired but better because I was going down so I felt better”. VP5 explained, “I was happy because I saw a lot of trees along this route and it was beautiful area and more clean”.

Building on these visual elements, participants’ descriptions of affective experience provided a broader narrative than the emotional states participants noted in the video annotation. For example, VP4 reported in the video annotation that he was feeling “very heavy”, but in his recollection, he stated that “I was getting better … because I was in the flat (sic) and I was running slow and the elevation did not change.” VP1, after reviewing a video annotation commented that it “is interesting to report mellowness I know I was going uphill so I was working harder at that point but it might be the nice neighbourhood and the little park that contributed to the mellowness.” And VP3 reported that she was feeling good and she was walking because of the traffic light, but after reviewing the video she stated that “ I remember I was kind of bored so that’s why I tried to think about something that I need to work on it”. If video was blurry or jostled, participants relied on the audio description and other cues like annotation location. For example, VP2 recorded video while running such that the video itself was angled toward the road. However, his route was very familiar to him and he recalled his affective experience in detail based on annotation location and his statements in the audio.

In the Audio condition, participants' recollections largely mirrored the detail provided in the audio annotations, provided that those annotations were sufficiently detailed. For example, AP3 reported in the audio recording he was thirsty because he did not drink water before running and after listing to the audio recording he stated that "I did not have water before running and after I starting running, I was feeling thirsty". When annotations provided little detail, participants relied on memory or other cues (location, weather, time) to explain how they were feeling. For example, AP4 recorded her emotion briefly in all runs. She could remember the emotions that related to aspects of the physical landscape that she knew could affect her emotion, or if an event occurred such as bumping into a friend; otherwise she could not recall her affective experience.

In the Gesture condition, recollections often included detail not evident in the gesture itself. This and the time taken for recollection suggest that participants really thought about their affective experience and that the gesture prompted their memory. For example, GP1stated that "I was feeling annoyed because there were some kids on my way. There should be a [gesture] for annoyed." GP4 said, "I felt euphoric because I saw about five people who were swimming and the sun was in the west and the sea was very beautiful so I felt happy at that time." GP5 noted, "I was not feeling very well at that day and my legs were sore." GP3 explained "I think I was more expos[ed] to the sun and there was a lot of people. I was tired because of the crowd and the heat. I can picture myself running around the people so I was tired."

In the Mental Note condition participants provided very few details about their emotions, tending to focus instead on their running progress and performance. Participants described their general feelings at the start and end of each run, but they encountered difficulty remembering specific emotions at the prescribed points. For example, MP2 stated that "I just started walking because I cannot run more than 20 mins continually but after my run I have beautiful feeling I like that feeling." MP3 noted that "When I first started I felt stronger than I had for other one. and I remember this one was a harder than the day before and I think because the humidity oh that is right that was on my Saturday morning….".

6.2.2 Use of passively captured data

Video condition participants did not use other data such as speed, elevation, weather, and heart rate to help them during recall. The plotted location was helpful for them to contextualize the video clips, however.

In the Audio condition, participants generally did not use passively captured data beyond location. AP3 and AP5 did look at heart rate to see how it might be related to a recorded emotion. AP4 used weather and the date of the run to explain some emotions.

All participants in the Gesture condition used location to contextualize each annotation, and 4/5 used weather and time information at least once in their descriptions. Participants did not use other data, except for GP5, who connected his emotion with his speed, stating “when I ran fast I knew I was happy but when I ran slower I knew I was tired”.

Three participants in the Mental Note condition used the location and/or weather when recalling their emotions, but provided few details and expressed low confidence in their recollection. Participants did not use other data for recall of affective experience. MP2 used speed to provide more information about her performance only.

6.3 Time to Recall

Recollection for participants in the Video and Audio conditions did not generally involve long pauses or explicit efforts to remember. Instead, the video or audio recording was played and participants reflected on what was stated or shown. Video and audio annotations were generally played once, unless there was an issue with audio quality.

In the Mental Note condition some participants did take a little time to think, but generally provided short observations of their running progress or performance. Any recollections of affective experience were high level descriptions of how they felt before and after the run.

Recollection was a more effortful process for participants in the Gesture condition overall. Unexpected emotions tended to generate particularly thoughtful recall. For example, GP3 usually did not feel good at the beginning of her run, so she took time to recollect her experience, saying “Ooh now I can remember, I remember when I started off, I was surprised that I was feeling as good as I was because I thought I should be tired because of a long run in Prince Edward Island but I actually felt ok so that is why I was mellow, yes I do remember that.” GP1 normally feels good at the beginning of her run, so she took time to consider why she had made a “bored” gesture in one instance, then recalled “I did not sleep very well the day before so I am just feeling down I am not really bored in the sense of being bored. I am more depressed”. At other times participants, could not recollect. For example, GP2 stated that “I usually start my run bored. I do not really remember this one”. GP5 noted, “I was sick at that day. I do not know why I was happy after I was tired”.

When Gesture condition participants recorded the same gesture annotation consecutively, they generally took time to think about and discuss the first instance, and spent less time thinking about and discussing subsequent instances, instead indicating that they felt the same way. This contrasts with the Audio and Video condition participants, who consecutively played each annotation and provided an explanation for each.

6.4 Recall and the Act of Annotation

All Video condition participants stated that video annotation helped them to recall many aspects of their affective experience.

VP1 stated “Capturing the video particularly helped me remember my emotional states, the thoughts I had while recording, and the particular details of the day (weather, sleep the night before, other factors contributing to mood or exhaustion).” VP2: “I think it helped me pinpoint how I was feeling at specific points during the run. Using video and audio recordings allowed me to understand the what/when/why in my emotions. Without recordings, I feel like me recalling my emotions would be a much more abstract experience.”. while, VP3 said “I think I was able to give more details about my particular feelings and experiences during the run than I would have been able to if I had just noted, for example, 'ran 4k yesterday'." VP4: "The audio helps us recall our emotions because we can understand our gestures and our tone. The video helps because we can figure out where we were which eventually helps us guess better." And VP5 stated that "I think my memory is connected to my emotions strongly. I can remember very clearly when I have some special emotions, like angry or very happy."

Most (4 of 5) Audio condition participants felt that audio annotation helped them to recall their affective experience. Despite largely mirroring audio description details in their recollections, participants also felt the act of annotation serves as a marker for recall, and the recording itself (the sound of one's voice, ambient noise) serves to trigger memory. AP1 stated "… I think that actually having the recording of my voice triggers those memories, however just the act of recording creates an experience to base memories around. So even if I did not get to hear the recordings again, I have a vivid memory of doing the recording at certain places during the run because I did an activity that was outside the norm of my normal run. I remember making the recording itself." AP2 said "My voice reminds me of how exhausted, how tired I was, etc., during that moment in time.", while AP3 noted that "Usually when I run I do not record my emotions while running but after hearing the emotions after running help me remember what exactly happened at that particular moment.". AP5 noted "…it helps me remember the environment I was in... For example, the car who never stopped for me in my third run.". However, the audio recording did not help one participant, who recorded only emotion without any details, to recall her/his affective experience.

AP4: “I think the route mapping helps me vs the emotions, as other emotions occur in between the 5min lapse between emotions that may also help in run recollection.”

4 of 5 Gesture condition participants indicated that gestural annotations supported recall of their affective experience. Participants cited the act of annotation itself as an event that could be remembered, leading to recall of more detail about the run at that moment. GP3 stated “It helped with the internal visualization of where I was in the city at the moment that the emotion was recorded. It allowed me to picture in my mind where I was at that moment, and allowed me to recall how I felt while I looked at whatever scenery was around me at that time.” GP2 said “I think recording these instances makes each individual moment more unique. I think memories need to stick out in some way for them to be easily recalled. I don't find running or exercise particularly exciting or fun and if I wasn't recording my emotions at the time, or tracking my location using a GPS I would not be able to recall any specifics about the run other than how I feel in general about running or very generic details like my route or an extreme temperature/weather.” GP5 pointed out that “Usually I would not be able to recall my emotions from a run a week ago, but being able to look back at my emotions I was able to remember why I had chosen each emotion.” GP4 noted that “the gesture combined with the route, time and weather can increase my recall”.

Only one participant did not think capturing the emotion helped her to recall. GP1explained, “I’m more of a cerebral runner, thinking analytically about what I'm doing or where I'm going, and being very aware of my surroundings. I usually remember my runs based on either what I'm thinking or what I am seeing.”

Mental Note condition participants felt that the reminders to make a mental note while running served to increase mindfulness and to remember details about their run, but not necessarily their affective experience. MP2 stated "It kind of keeps me alert at the time of running and my mind remains active and remembers what I was thinking at that moment." MP1 said "I remember where I was when I thought about certain things. For example, when I was close to my work place I started to think about work". MP3: "I was determined to remember because it was a study. Hearing the beeps made me more aware of my feelings at that moment; normally I would be more 'in the zone' for a run and not as aware of my emotions until a finish point or obstacle such as a hill." MP5 noted "while you are running mostly you think about different things and even negative thoughts, and pay attention to my running." While, MP4: "When I'm deliberately thinking about my emotional state at each five minute interval, it caused my brain to remember that approximate moment, however not always in detail.

6.5 EASE OF USE AND EFFECTIVENESS

Three Video condition participants stopped running to make a video annotation. Of these, two felt it wasn't possible to use the interface without stopping, while the third wanted to ensure a good quality image. Another participant stopped in the first run but ran while annotating after that because he felt stopping distracted from his run. All participants felt the video aided in recall.

All Audio condition participants felt audio annotations were easy to make while running. However, three participants felt embarrassed or self-conscious when recording their emotion around other people. For example, AP1 noted that "I did not record my emotion immediately [when notified] because there was a person coming at me … so I said wait until we passed each other so I do not look crazy. Participants also stated that they felt challenged during recall if the annotation was short or if there was a lot of environmental noise.

All Gesture condition participants stated that that making gesture annotations was easy and did not interfere with their run. However, three participants said that they needed to look at the interface to make sure the gesture was drawn properly, which sometimes made them slow down. Two participants indicated that the annotations, by only recording an emotion, made it challenging to differentiate specific instances. As GP1 stated, “the good thing [is] the application is easy to use and fast but it does not capture what’s actually going on”.

6.6 SHARING EMOTIONAL DATA

As other physical activity applications offer a feature for sharing biometrics data, we asked the runners how they felt about sharing the emotional data. There were some privacy concerns about sharing their emotional data with others. All Gesture condition participants did not mind sharing their emotional data with friends and other people. However, only 2 of 5 Audio condition participants did not have privacy concerns about sharing their emotional data with both friends and other runners, and other 2 like to share their emotional data with their friends only. Only one participant had a privacy issue with sharing her/his emotions with anyone, especially if it contained more details that related to personal life. 4 out of 5 Video condition participants did not have any privacy concerns about sharing their emotions and just one runner preferred to share his/her emotion with friends only. Moreover, 2 out of 5 made mental note participants have privacy concerns whereas the others runners in this group had none. Overall, 14 runners did not have privacy concerns about sharing their emotional data with anyone, 3 runners did not worry about sharing their emotional data with just their friends or the group they run with. However, 3 runners would prefer to keep their emotional data completely private. Most of participants (13 out of 20) stated that seeing others' emotional data could help them to enhance their run. However, other participants did not see that other emotional data could help them since emotion is individual feeling.

6.7 ADVANTAGES OF THE VISUALIZATION

All participants liked the idea of revisiting how they were feeling and why, and enjoyed recalling the various factors that affect their running experience. Providing the emotions in the visualization made participants aware about what positively and negatively affected their run and would enhance the way they run. Showing them the location of each of their recorded emotions and weather helped to trigger their memory. In addition, the statistical data such as heart rate, speed, and elevation increased their confidence in their recollection. The visualization was simple to use and included many details. In addition, the visualization helped all participants regardless of the condition to reflect on their enjoyment during the run and what can influence their enjoyment and performance during runs. Moreover, most participants (17 out of 20) felt that using the visualization long term might help them make better choices and have more fulfilling runs.

6.8 VISUALIZATION IMPROVEMENT

All runners in each of the four condition groups suggested some improvements in the visualization to make it more effective for emotional recall:

1) Changing the view of the map to satellite view or topography map

2) Showing the physical information like speed, heart-rate, and elevation as continuous values in a chart next to each run. This was consistent with the final design from the participatory design sessions.

3) Having an option to cluster data together so the user can look at this information to see how they were feeling related that to the time of day or distance to be able to get a general sense of how they were feeling related to different aspect of their run.

4) Showing the daily activity before the run (such as food intake).

To summarise, these results suggest that gesture annotation supports a runner's ability to recall their affective experience from their past runs. Gesture annotation tends to trigger recollection of the running experience related to emotion, with details that were not in the gesture itself. Also, more time was taken to think about the causes of the emotion and participants had high confidence in the recollection. Moreover, the different techniques for capturing emotional states during runs were used in different ways during capture phase and variously affect the recollection in the recall phase. There are many factors that impact the ability of recall such as the details in recording, visual cues in the video, knowledge of the routes, and other details such as wind, rain, events in one's personal life or something notable happening during a run.

CHAPTER 7 DISCUSSION

The purpose of this study was to see whether or not the gesture annotation of captured emotions could improve a person's ability to recall their affective experience related to particular emotions, comparing various methods of recalling such as video, gesture, audio and no-aid condition. We therefore wanted to see how different strategies of capturing emotion during runs affects emotional recall over many runs and to identify the convenient methods to capture emotion while running.

Overall the results indicate that gesture annotations of emotions presented in a map-based visualization did trigger recollection of affective experience for our runners. Each strategy to capture emotions influenced recall of affective experience in particular ways, depending in part on the way they were used during runs, and on innate characteristics of the annotation medium itself.

Using the visualization interfaces made our participant runners aware about what positively and negatively affected their running experience. Over time, such an interface could enhance the way they run, and lead to better choices about when and where to run. Participants in the participatory design sessions and the controlled study liked the idea of revisiting how they were feeling and why, and enjoyed recalling the various factors that affected their running experience over a span of time.

Sharing the emotional data using gesture annotation made participants less concerned about the privacy issue since the gesture annotations shows the emotional state without explanation what cause of that emotion. However, sharing emotional data using audio and video annotations varied from participant to participant. Some of participants had privacy concerns and some of them did not. So, it was based on the individual personality and the number of details provided about the emotion in the recording.

Moreover, most runners thought that seeing others' emotional data would not help them since the emotion was based on individual feelings. However, a few runners thought that seeing others' emotional data would increase their performance and might motivate them to run in the same place.

Analysis of collected data shows that gestural annotations prompted runners to remember details of captured emotion that were not evident in the gesture itself. The gesture animations triggered recollection, especially when the emotion expressed in the gesture was out of the ordinary. Gestural annotations seemed to encourage thinking, about when they made that gesture and why they felt that way, while the act of making the gesture itself acted as a marker around which to frame recall. Confidence in the details recalled for gestural annotation was also very high (as high as video). This came at a cost, however: the average time taken to recall details was higher with gesture annotations compared to mental notes, and while the time was comparable to that for audio and video, in those conditions participants spent more time playing the annotation vs. trying to remember.

Participants in the Gesture condition were restricted to five running related emotions (tired, mellow, euphoric, exhilarated, and bored). This sometimes did not allow them to capture what they felt, and so they chose the closest emotion, which may have made it more difficult to recollect affective experience. It is possible that more gestures may promote greater differentiation and better recall, however at the expense of needing to learn a larger gesture vocabulary.

Unlike audio and gesture, video annotations allowed participants to refer to visually evident details and discuss why and in what way they affected their running experience. These results agreed with Eldridge et al. [8], which indicate that video has valuable cues that increase recall. Our participants used visual cues not only to explain why they were feeling the way they stated in the video, but to connect that emotion to a larger narrative that included how they were feeling leading up to, or after, the moment of annotation. This could sometimes diverge from the stated emotion (e.g., I stated I was tired, but I was starting to feel better).

Sometimes, runners who used gesture annotation or recorded brief audio annotations could not recollect their affective experiences, which is indicative of forgetting the circumstances in which the annotation was made. However, according to Tulving, forgetting may not be complete; there is evidence in support of cue-dependent forgetting, which means that memories are not lost but they might be inaccessible temporarily [18]. More research is required to determine what makes an annotation act salient vs. forgettable. Indeed, it may be that continued use of an annotation aid reduces the power of annotation itself as a memory cue. Additional contextual data, specifically snapshots or video, may serve as a backup cue or reinforcement in cases where the gesture or audio is insufficient.

Runners who made a mental note encountered difficulty remembering their emotional experience because there was no sign of the emotion type on the map. Even if some participants could remember or infer how they felt based on the location, their confidence in recall was very low. In addition, runners tended to remember their running behaviour more than their emotional state. For example, MP5 noted that "I was thinking about my physical body…what is going on while I am running", while, MP1 stated, "I decided that since I was running slower than normal I should take that route instead". According to Tulving, episodic memory is a record of individual experiences, and each item in this type of memory represents information that is stored about your experience of events [9]. So, using some cues can support individuals to recall their personal past. However, for the Mental Note condition, runners did not have emotional cues in the interface which did not allow them to remember their affective experience.

Most participants did not use heart rate, speed, or elevation values as cues to recall their running experience since there is no strong link between the values of these cues and emotional state. According to van den Hoven and Eggen [14], an augmented memory system can not store the memory by itself because an individual is required to recreate this memory for every reminiscing. However, the cues that can be used to trigger memories to assist people reconstruct a memory can be stored in an augmented memory system. Cues can help people to recall the information from long-term memory only if there is link between the cue and sought-after memory. The cue could be anything such as image, text, smell, and person as long as there is a connection between the cue and the remembered events. So the heart rate, speed, or elevation values did not have a strong link with emotional state. Consequently, they were not used to recall the affective experience.

In terms of capturing emotion while running, touch-based gesture is convenient since it does not interfere with a run like video recording can, and it is more private than audio recording. With repeated use, it is likely that the need to look at the screen while performing a gesture will be reduced.

All runners in each of the four condition groups suggested some improvements in the visualization to make it more effective for affective experience recall. These include changing the view of the map to a satellite view or topographical map, and showing the passively capture data like speed, heart rate, and elevation as continuous values in a chart next to each run. Participants also suggested hybrid capture approaches, using video or snapshots to supplement gestural or audio annotations.

7.1 Limitations

Perhaps the most notable limitation of the current study is the small sample size: with only five participants in each condition, the potential impact of individual differences is high. While we partially address this through mixed quantitative and qualitative analysis, a study with more runners would help solidify our findings.

Despite positive indications given by the quality of recollections and stated confidence in the Gesture condition, we could not objectively assess the accuracy of recall from gestural annotation in our study. In future work we may ask participants to explain their reason for each gesture annotation after making it, and use this to assess a subsequent interpretation of the annotation.

Given the limited timeframe of our study, we do not know if observation of patterns in annotation of emotion is feasible or useful. While we hypothesize that gesture has advantages over audio and video when visualizing trends, more research is required to determine how best to accomplish this. A longer study is required to determine the utility of visualizing such trends, and to explore whether passively captured data becomes more relevant for understanding emotion over the long term.

7.2 FUTURE WORK

Prior work suggests that gesture modifiers [29] and intensity [28] can be expressed in the manner in which a gesture is made. Future work could explore how this might permit more flexible gestural annotation without a large increase in vocabulary. To further assess the relationship between the gesture itself and recollection, an animation of the gesture could be compared with a snapshot of the completed gesture and an iconic representation.

A longitudinal study of gestural annotation possibly with added ambient audio/video snapshots) to see how this data is interpreted to gain insight into what impacts an individual's running experience, and how this might in turn shape running behavior.

Finally, while our study involved recreational runners and actual running experiences, a field study is needed to characterize actual annotation behaviour, and show how this data is interpreted to gain insight into what impacts an individual's running experience, and how this might in turn shape running behaviour.

There is a need for future work to improve the visualization of the affective experience to be more effective use of the passive captured data (heart rate, speed, and elevation) in recalling the affective experience. This could be done by showing the emotion and other factors such as speed, elevation, and heart rate in chart view for the whole run and showing the daily activity before the run (such as food intake or sleeping pattern).

CHAPTER 8 CONCLUSION

This thesis explored how presenting gestural annotations of emotional state on a map based visualization was able to support recall of affective experience and more generally how capturing emotion while running using different methods can enhance recall in a manner influenced by the features of each method and the way they are used. We also explored how passive captured data cues like weather, time, speed, elevation and heart rate could be used to supplement annotation, and how they could be effectively integrated on a map-based visualization to spark runners' memories.

Gestural annotation promoted recall of affective experience more effectively than the baseline condition, as measured by confidence in recall and detail provided. Gestural annotation was also comparable to video and audio annotation in terms of time, confidence and detail. Participants in the Gesture condition expressed that the act of annotation was itself an anchor for recall. While participants required time to think about gestural annotations, their recollections involved detail not embedded in the gesture itself. Audio annotation supported recall primarily through the runner's spoken annotation, but background noise was sometimes used. Participants felt self-conscious annotating how they were feeling in public, however. Video annotation yielded the most detail, much directly related to visual cues in the video, however using video annotations required runners to stop during their runs. The used of passively captured data (weather, time, location, heart rate, elevation, and speed) varied between runners, with location being an important cue for many annotations, and weather information an indicator that helped some participants explain how they felt.

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Appendix A – Recruitment Notice

We are recruiting participants who sometimes or always do not listen to music while running to take part in a study on the impact of using touch gestures (swiping) to recall emotions, and to identify the benefits of using gesture annotation on smartphones to record emotional states while running. No specific expertise is required. Participants need to run outdoors four times in 10 days for 30 minutes per run without listening to music and on any route they choose starting from Mona Campbell building. Participants must also be comfortable running with their smartphone and 18 years of age or older.

The study will consist of **two sessions**. In the first session, you will meet with the researcher at the Graphics and Experiential Media (GEM) Lab, on the 4th floor of the Mona Campbell building, Dalhousie University. In this session, the researcher will explain the study, get consent and give Smartphone that will be used to collect data while you are running. The researcher will show you how to use the app. This should take about half an hour. Over a period of 10 days you will be asked to run four times for 30 minutes while using the touch-based gesture capture app, an audio recorder app or video recorder app to capture your emotional experience during your run or nothing (based on the method that is assigned to you). You will meet the researcher before and after each run so she can collect the data. You will then meet the researcher again for the second session, where you will be shown your data on a map-based visualization and you will be asked some questions about your emotions on the run. Compensation is $15 cash for each session (total $30 cash for two sessions paid after finishing the second session) in the study. If you are interested in participating, please contact Felwah Alqahtani (fl823899@dal.ca).

Appendix B – Post on my Facebook page

"We are recruiting runners for a study that will examine whether recording gesture annotations, audio notes or video recorder about your emotions on a mobile device during your run can later help you recall good/bad parts of your runs. We are recruiting participants who did not listen to music and run four times in 10 days for at least 30 minutes using one method to record your emotions during the run (touch-based gesture and video app audio app, or nothing. In addition to recording your emotions while you run over 4 runs, you will meet with a researcher at Dalhousie before each run to get you set up with the devices and after each run to collect the data. you will also meet the researcher at the end of the study to get feedback on the different interfaces and for an interview. The study will take place over 2 weeks. Compensation is $30. If you would like to participate, please send me a private message and I'll send you all the details of the study. We will not control for other demographic factors such as gender, or experience using touchscreen devices in particular"

Appendix C – Informed Consent

Principal Investigators: Felwah Alqahtani, a graduate student at Faculty of Computer Science, fl823899@dal.ca

Contact Person: Felwah Alqahtani, Faculty of Computer Science, fl823899@dal.ca

Supervisor: Dr. Derek Reilly, Faculty of Computer Science, reilly@cs.dal.ca

We invite you to take part in a research study being conducted by Felwah Alqahtani at Dalhousie University. You may withdraw from the study at any time. Your academic (or employment) performance evaluation will not be affected by whether or not you participate. To participate in this study, you are supposed to regularly run for 30 minutes or more at least two to three times per week outdoors and have used Smartphone while running. The study is described below. This description tells you about the risks, inconvenience, or discomfort which you might experience. Participating in the study might not benefit you, but we might learn things that will benefit others. You should discuss any questions you have about this study with Felwah Alqahtani.

The study will be conducted for two weeks and it is divided into two phases: the capture phase and visualization phase. The purpose of the study is to investigate the impact of having using gestures annotation (swiping on mobile phone) to show emotions on a map-based visualization, as well as the ability to recall your emotional experience while on a 30-minute run. This will allow me to identify the benefits and drawbacks of using (gesture annotation, audio annotation, or video annotation) to recall your running experiences. In the capture phase, the study will be explained and you will be asked to complete the background questionnaire and give your consent to participate. Later, you will go out for a run four times in 10 days for 30 minutes on any route you choose starting from Mona Campbell building and capture your emotions during each run by using one of these methods (a touch based gesture capture app, recording voice using audio recorder app, video recorder or without any capture app depending on the method assigned to you). You will also be holding the smartphone or wearing a smartphone strapped to your arm during each run based on your comfort. At the end of each run, you will meet the researcher so she can collect the data. Approximately four days later, after finishing all four of your runs, and you will return to Mona Campbell Building for the visualization phase study.

You will then meet researcher for the visualization phase. At this time, you will be asked to review different maps of your runs and to complete a post-study questionnaire. You will then participate in an interview about your running experience. With your permission, this will be recorded with a video camera.

A low risk is associated with the study in that your attention may be divided when you are using the capture application while running. We will attach the mobile device on your arm so that the device is unobtrusive, and the application is designed to allow you to draw gestures without looking at the screen. If you feel uncomfortable you can stop, draw your gesture, and continue your run.

All personal and identifying data will be kept confidential. The informed consent form and all research data will be kept in a secure location in accordance with Dalhousie University policy for 5 years post publication.

In the event that you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director, Office of Research Ethics Administration at Dalhousie University's Office of Human Research Ethics for assistance: phone: (902) 494-1462, email: Catherine.connors@dal.ca.

"*I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time.*"

Participant

Name: ________________________________

Signature: ____________________________

Date: ________________________________

Researcher

Name: ________________________________

Signature: ____________________________

Date: ________________________________

"*I agree that participation in the experiments will be video recorded for the purpose of analysis. I understand that this is a condition of participation in the study, and I understand that this video record may be used in publication or presentation of results, after being anonymized by blurring faces.*"

Participant Researcher

Name: ________________________________ Name: ________________________________

Signature: ____________________________ Signature: ______________________________

Date: ________________________________ Date: __________________________________

Please select **one** of the options below:

☐ *"I agree to let you directly quote any comments or statements made in any written reports without viewing the quotes prior to their use and I understand that the anonymity of textual data will be protected by using pseudonyms."*

Participant Researcher

Name: ____________________________Name: ____________________________

Signature: __________________________Signature: __________________________

Date: ___________________________***Date:*** ____________________________

Or

☐ *"I want to read direct quotes prior to their use in reports and I understand that the anonymity of textual data will be preserved by using pseudonyms."*

[if this option is chosen, please include a contact email address: _________________________]

Participant Researcher

Name: ____________________________ Name: ____________________________

Signature: __________________________ Signature: __________________________

Date: ____________________________ Date: ______________________________

If you are interested in seeing the results of this study, please check below and provide your email address. We will contact you with publication details that describe the results.

☐ "I would like to be notified by email when results are available via a publication."

if this option is chosen, please include a contact email address: _________________________

Appendix D - Background Questionnaire

PLEASE FILL IN THE FOLLOWING INFORMATION:

1. Age: _________
   1-
2. Sex: ☐ Male ☐ Female

   8

3. *If attending university*
   2-
   Faculty/department: ________________________________

9 4. How many times do you run a week? (check one)

10 ☐ Once a week

11 ☐ Twice a week

12 ☐ Three time per week

13 ☐ More than three time per week

14

5. How much running experience do you have? (check one)

15 ☐ None ☐ Less than one year ☐ 1-3 years ☐ more than 3 years

16

6. How long is your typical run? (check one)

17 ☐ 2k or less ☐ 2k-5k ☐ 5k- 10k ☐ more than 10k

7. Do you prefer to run alone or with a partner? (check one)

18 ☐ alone ☐ partner

8. What is your motivation to run? (check all that apply)

19 ☐ general fitness ☐ health ☐ lose weight ☐ other --------------

9. How do you usually feel before the run?
10. How do you usually feel after your run?
11. What time do you prefer to run? (check all that apply)

20 ☐ morning ☐ afternoon ☐ evening

12. In which weather do you like to run? (check all that apply)

☐ sunny ☐ fog ☐ rainy ☐ cloudy ☐ others ------------

13- Do you have any prior experience with personal informatics/ life-logging system? (such as an application that logs your step count)?

a. Yes
b. no

Appendix E - Post-Study Questionnaire

1- Do you think capturing emotions during your runs enhances your recall of your running experience?
   a. Yes
   b. No
   Explain how??

Appendix F - Post-Study Semi-Structured Interview

1- In general, what did you like about recalling emotion using map-based visualization?
2- What other cues did you take to help you recall your running experience, when you had to recall your emotion with this visualization? Which ones were especially helpful? How these cues help you to recall?
3- What challenging did you encounter while you were recalling using this visualization?
4- What cues did you like? Why?
5- List some alternative cues that you think can be added to trigger your emotional recall.
6- Do you think this visualization will help you make better choices for future runs?
7- Do you have any privacy concerns about sharing your emotions and data with your friends?
8- Does showing others runner's data motivate you to run? How?
9- Does this visualization help you understand your performance during your run and what can influence your runs?
10- If you had an opportunity to change the presented data, how would you like to present the collected data?
11- Do you find the visualization sufficient for representing a personal interpretation of your past running experience? Why or Why not?
12- As you look at this visualization, what's one thing that you would like to do to improve the visualization and make it more effective for recalling your run?

Appendix G - Participant Payment Receipt

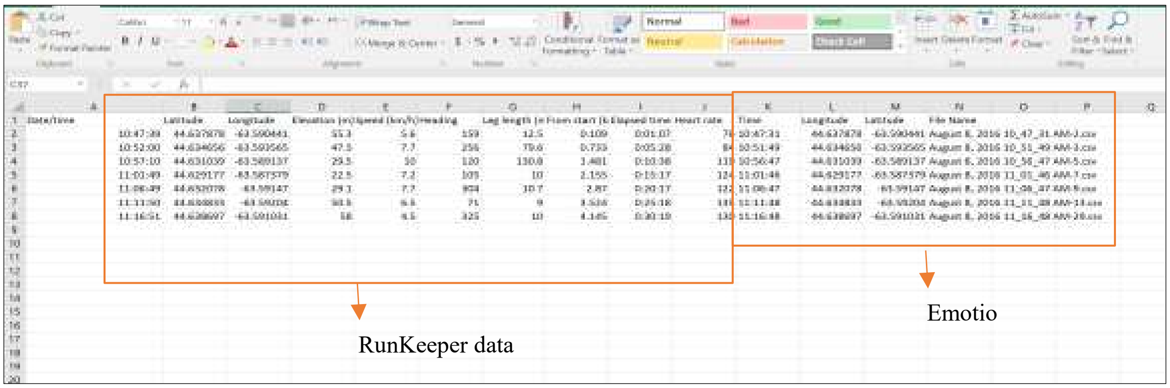
My signature below confirms that I received $30 (CDN) from Felwah Alqahtani as an honorarium payment for participating in the "Visualizing gestures annotation of affective experiences during leisure runs to promote emotional recall" research project.

Name (please print): ______________________________

Signature: ______________________________

Date: ______________________________

Appendix H – Resulting File



Appendix I – Social Sciences & Humanities Research Ethics Board Letter of Approval

DALHOUSIE UNIVERSITY

Research Services

Sciences & Humanities Research Ethics Board
Letter of Approval

February 16, 2016

Felwah Alqahtani

Computer Science

Dear Felwah,

REB #: 2016-3766

Project Title: Visualizing gesture annotations of affective experiences during leisure runs to promote emotional recall

Effective Date: February 12, 2016

Expiry Date: February 12, 2017

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans. This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Karen Beazley, Chair