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Capturing in-situ Feelings and Experiences of Public Transit Riders Using Smartphones

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By

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ABSTRACT

High-density urban environments are susceptible to ever-growing traffic congestion issues, which speaks to the importance of implementing and maintaining effective and sustainable transportation networks. While transit oriented developments offer the potential to help mitigate traffic congestion issues, transit networks ought to be safe and reliable for ideal transit-user communities. As such, it is imperative to capture meaningful data regarding transit experiences, and deduce how transit networks can be enhanced or modified to continually maintain ideal transit experiences. Historically speaking, it has been relatively tricky to measure how people feel whilst using public transportation, without leaning on recall memory to explain such phenomena. Recall memory can be vague and is often less detailed than recording in-situ observations of the transit-user community. This thesis explores the feasibility of using smartphones to capture meaningful in-situ data to leverage the benefits of the Experience Sampling Method (ESM), while also addressing some limitations. Students travelled along Grand River Transit bus routes in Waterloo, Ontario from Wilfrid Laurier University to Conestoga Mall and back using alternate routes. The mobile survey captured qualitative and quantitative data from 145 students to explore variations in wellbeing, and the extent to which environmental variables can influence transit experiences. There were many findings to consider for future research, especially the overall role anxiety played on transit experiences. In addition, the results indicate that the methodology is appropriate for further research, and can be applied to a wide range of research topics. In particular, it is recommended that a similar study be applied to a much larger, and more representative sample of the transit-user community. Future considerations are discussed as key considerations to leverage the benefits of ESM research, and the promise it can bring towards the enhancement of transit experiences and the cohesion of transit-user communities.

1. INTRODUCTION

Traffic congestion has been a notorious issue within the Greater Toronto and Hamilton Area (GTHA) and beyond. Auto-dependence is not sustainable, having grown with population and been problematic for the environment and commuting patterns. As an alternative, public transportation needs to improve both physically and how users perceive it. Intricate networks of public transportation, or mass transportation, can be an effective provision for future economical and environmental health. Based on the philosophy of "If you build, they will come", the Liberal Government has invested billions of dollars into public transportation repairs, improvements and enhancements. This is very promising for a sustainable transportation system. However, public transportation often suffers from negative perceptual issues with respect to reliability, comfort and efficiency.

More research is needed on the user perception of public transportation. The overall goal of this research is to utilize a smartphone app to capture meaningful in-situ qualitative and quantitative feedback from transit users concerning their perceptions, feelings and experiences. In the process, the intent is to explore the feasibility of using smartphones and experience sampling methods to capture and infer the nature and extent of transit experiences in considering situational and demographic explanatory factors. The findings of this research support the notion that the methodology can be applied on a much larger and more representative scale of the transit-user population, along with several interesting situational and demographic quantitative findings regarding the transit experience.

2. LITERATURE REVIEW

In an ever-changing world with population pressures and advances in technology, urban growth management has been challenged socio-politically, economically and environmentally (Handy et al. 2005; Metrolinx 2008; Grizans 2009; Yoo et al. 2010; Cervero 2011; Batty et al. 2012; Metrolinx 2014). Forced to adapt to such pressures for future financial health and environmental responsibility, urban areas have planned and implemented sustainable public transportation infrastructure throughout Southern Ontario

(Metrolinx 2008; Metrolinx 2014). Such projects are particularly imperative for future stability in transportation given the traffic congestion problems in the GTHA that are the worst in Eastern Canada (Potoglou & Kanaroglou 2008; Davies 2013; Gorzelany 2013; McQuigge 2017). Public transit infrastructure investments on the billion-dollar scale have created friction with residents because the short-term pains of road construction inconveniences are seemingly less attractive than the long-term gain of transit users (Metrolinx 2008; Metrolinx 2014).

Public transportation offers a range of economic, environmental and health benefits. Economically speaking, public transportation is much more affordable than owning a vehicle and can serve as a long-term investment opportunity (Metrolinx 2008; Yoo et al. 2010; Cervero 2011; Ferarri et al. 2014). From an environmental standpoint, public transportation helps mitigate carbon footprints and the impacts contributing to climate change (Handy et al. 2005; Eboli & Mazulla 2007; Agrawal et al. 2008; Metrolinx 2008; Sunitiyoso et al. 2010; Cervero 2011; Avineri 2012). In addition, using public transportation on a regular basis has proved to be a healthier (Agrawal et al. 2008; Badland et al. 2008; Bean et al. 2008; Metrolinx 2008; Yoo et al. 2010; Morency et al. 2011) and safer option than operating a vehicle (Geiger & Dissanayake 2009; Cervero 2011). Also, Agrawal et al. (2008) and Morency et al. (2011) indicate how a single transit trip can account for approximately 25% of the recommended daily physical activity for adults just from the walk to and from transit (Morency et al. 2011).

A range of research and observation of urban growth suggests that the built environment strongly influences transit use. That is, the idea of wide walkable sidewalks with a large carrying capacity and sufficient space for greenery to create a welcoming and appealing environment for transit-users (Cervero & Kockelman 1997). Physical environment characteristics that positively influence transit use includes: density, land-use diversity and pedestrian-oriented designs. These "3Ds" can help policy makers and urban planners shape urban environments into remarkable transit communities which induce transit-use.

Despite the benefits of transit to users and the built environment, persuading individuals to drift from auto-dependence to a lifestyle that leans on transit-use remains as a considerable challenge. There is much to learn from those who use public transit on an on-going basis, especially their experience of the benefits and limitations. Actual in-situ experiences whilst taking transit are of particular interest because they enable researchers to make connections and inferences to help explain transit-related phenomena based on realistic data (Casello et al. 2009; Steinfeld 2010; Yoo et al. 2010; Steinfeld et al. 2011; Zimmerman et al. 2011; Said 2013; Tomasic et al. 2014). This review will focus on transit experiences and factors that influence the use of public transportation; empirical measures of transit experiences; and behaviour modelling of transit experiences that seek answers to understand the total cost of using public transportation.

2.1. Transit Experience

Transit experiences are those that pertain to how one feels, thinks and behaves whilst using public transportation. Transit experiences can be influenced by many variables, which may have different weights between individuals – from how we feel physiologically or emotionally during the use of public transportation (via bus, train, streetcar, subway, light rail transit, etc.) to transportation infrastructure that contributes to a more efficient onboarding process that may enhance such experiences. Transit experiences can also be influenced by the reflections of transit trips from the past. In addition, psychological factors are key to helping explain and understand the "transit experience" (Li 2003). Implicit memory, or memory based off emotion, can have a significant weight on transit-user decision-making (Hamann 2001). For example, initial transit experiences can manifest within new transit-users that can create a norm or some presumption of what to expect. If the norm or expectation is that the bus will likely be late, the perceived transit experience can deviate from the truth – some studies even suggest that perceived wait time is longer than actual wait time (Li 2003; Caulfield & O'Mahony 2009; Casello et al. 2009; Iseki & Taylor 2010; Nour et al. 2010; Bick 2011; Psarros et al. 2011; Cats & Loutos 2016).

Quinlan Cutler and Carmichael (2010) devise a conceptual model that builds from previous literature (Figure 1). The tourist experience conceptual model advises that the tourist experience is beyond the destination, which includes the anticipation and recollection of the tourist experience. The influential and personal realms of the concept model are strikingly similar to major influencers of using public transit. For example, the physical aspects of a transit system within the influential realm can refer to the built environment; the social aspects can refer to the inevitable interactions whilst using public transit; and the products/services can refer to the performance of the transit system (i.e. transit reliability, cost, etc.). In addition, the personal realm confines the key cognitive processes that encompass the transit experience. Such cognitive processes are imperative to measure to further understand transit experiences, especially how one feels using public transportation. Furthermore, the tourist experience component of the concept model echoes what one may typically experience whilst using (and planning to use) public transit. For example, the anticipation of using public transit; the travel to access transit; the on-site activity of using transit (i.e. the destination); the return trip from the destination; and the reflection of using public transit. Such a comprehensive concept model lends itself to the transit experience as the willingness to use public transit can be governed by past experience, which creates some expectation for future experiences.

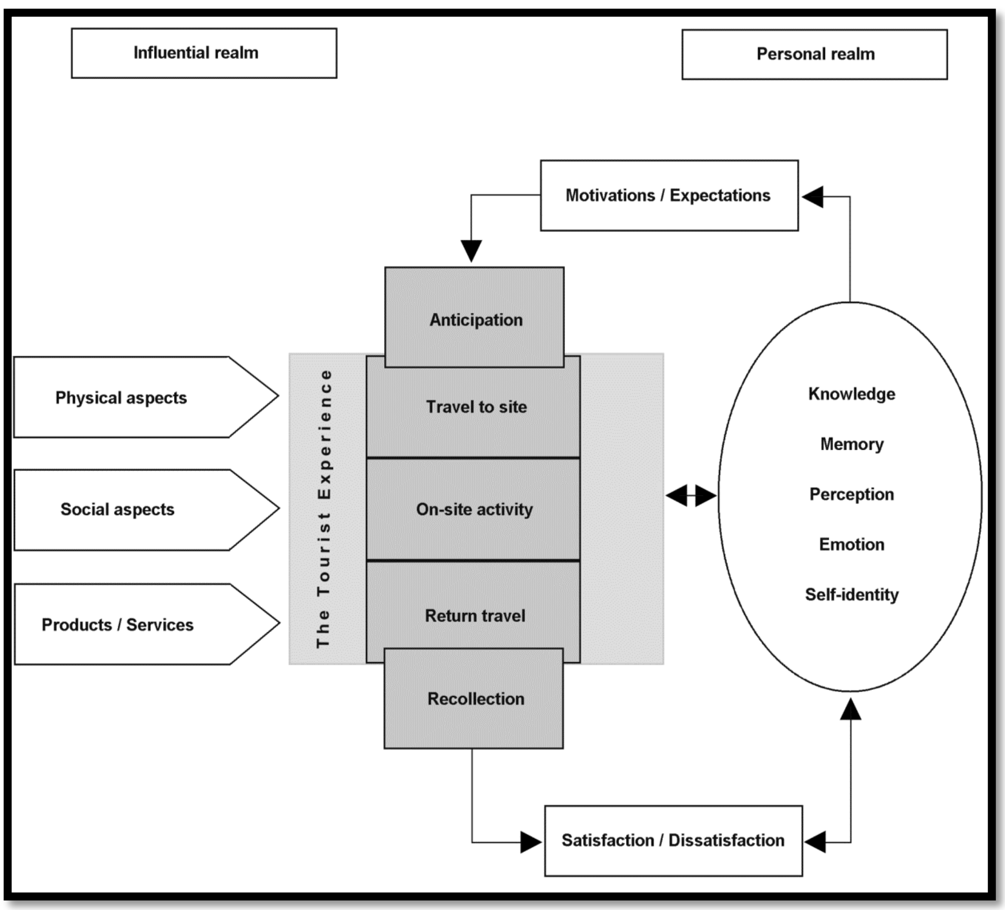

Figure 1: Tourist Experience Conceptual Model of Influences and Outcomes (Quinlan Cutler & Carmichael 2010)

It can be argued that the perceptions of using public transit are equally as important as the reality. Such perceptions are detrimental to the vision of a transit-dependent community for future (and current) high-density areas, because such perceptions can add to the cost of using transit, and if these issues can be addressed, transit-user permanency is catchable. For example, Lai and Chen's (2011) study highlight the factors influencing transit-user permanency, or long-term transit-user loyalty. The study finds public transit to be viewed as a service product, and not just a "means to get by". The paper argues that transit satisfaction is one of the main incentives of transit-user loyalty; therefore, the cost of travel needs to be reasonable and travel conditions need to be safe to encourage a growth in transit-usage.

A body of literature suggests that the three most important facets of the transit experience that are within a reasonable control of planning authorities are: transit schedule reliability (O'Sullivan & Morrall 1996; Li 2003; Currie & Wallis 2008; Iseki & Taylor 2010; Li et al. 2010; Bick 2011; Psarros et al. 2011), transit-stop safety (Agrawal et al. 2008; Iseki & Taylor 2010) and the distance required to walk to transit (O'Sullivan & Morrall 1996; Agrawal et al. 2008), with an emphasis on the former. This is attributed to the growing frustration of an unpredictable transit schedule for individuals who depend on public transit to get to work. As a result, such transit users are left feeling like they have little control over their trip, which can ultimately lead to increased levels of frustration and anxiety (Iseki & Taylor 2010; Bick 2011; Psarros et al. 2011; Cats & Loutos 2016). Thus, improving transit reliability, safe transit stops, and service quality would seem to have the potential to produce transit-user loyalty and attract more users. In addition, all of these factors can contribute to lessening the total cost (which includes perceived wait time) of travel, and ultimately, a less anxious transit experience.

Recent research devoted to understanding transit experiences has proved useful, practical and promising for policy makers to leverage for effective and encouraging transit systems (Caulfield & O'Mahony 2009; Chen et al. 2010; Yoo et al. 2010; Jariyasunant et al. 2011; Lai & Chen 2011; Psarros et al. 2011; Zimmerman et al. 2011; Ferrari et al. 2014; Tomasic et al. 2014; Cats & Loutos 2016). In the case of enhancing transit experiences by providing real-time data, there has been much research to support such improvements (Caulfield & O'Mahony 2007; Caulfield & O'Mahony 2009;

Jariyasunant et al. 2011; Cats & Loutos 2016; Watkins & Brakewood 2016). In the study conducted by Caulfield & O'Mahony (2009), participants received real-time transit information from either a transit agency, text message (via mobile phone), or from real-time information displays. The authors suggest that passengers benefit greatly when real-time information is provided, especially from real-time transit information displays at bus stops. Participants of this research echoed the benefits of providing real-time information as they claimed to have felt safer knowing when their bus was going to arrive. Locations that did not provide real-time information displays left the participants feeling frustrated and uncertain if their bus or train had already arrived.

Taking real-time bus arrival information further, Jariyasunant et al. (2011) capitalized on GPS utility by using GPS traces of the transit user (via mobile device) and the transit provider (on-bus GPS tracing) in tandem to find a solution to enhance transit experiences (Figure 2).

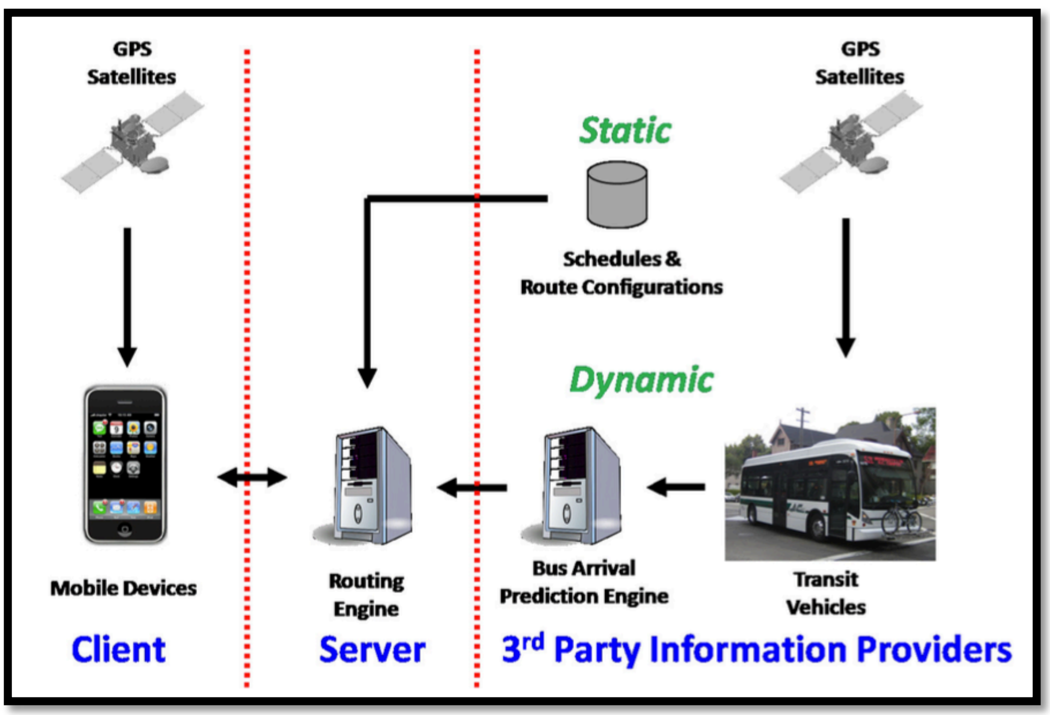

Figure 2: Architecture and System Implementation of Transitr (Jariyasunant et al. 2011)

In practice, one will essentially use the coordinates of their mobile device and input their destination. From there, the transit trip planner – Transitr – will calculate the shortest path to the destination whilst considering real-time information provided by a dynamic third-party bus arrival prediction system. The third party – NextBus – uses time-of-day historical averages and real-time GPS information to calculate bus arrival times. The results of the study echo the promise in literature that real-time information can yield better transit experiences overall. The biggest contribution is perhaps that Transitr has the potential “to serve any transit agency that provides both static schedule information along with an interface to real-time bus arrival information” (Jariyasunant et al. 2011). Such methods can be employed where transit agencies provide a static schedule, but also have GPS devices tracing their busses, which is promising and has utility in many American cities.

Real-time bus arrival information has come a long way to reach the point it has in the United States and a few places in Canada (Watkins & Brakewood 2016). OneBusAway is an open-source application that was developed at the University of Washington. It enables “transit agencies to adapt the code to their own systems” in efforts to settle the score with real-time bus arrival information and create better transit experiences. As such, the open-source nature of the application has led many urban areas to adopt the code for future prosperity. The solution is also providing real-time transportation arrival displays in conjunction with the application in attempts to cater to individuals who do not have a mobile device. The end result is obvious – to provide an easier, more confident transit trip that enables transit-users to more accurately plan activities and travel, and ultimately, to make public transit more appealing. Similar to the findings of Caulfield and O’Mahony (2009), the research conducted by OneBusAway found that 92% of riders had increased feelings of satisfaction, and interestingly, felt safer knowing when their bus was arriving (Watkins & Brakewood 2016). Overall, OneBusAway has many positive outcomes – from decreased wait times to increased ridership – that show promise towards widespread change, as long as more urban areas continue to adapt to such strategies (Watkins & Brakewood 2016).

Given that the transit experience plays a key role in ridership, it would seem important to further explore sources of anxiety or other negative experiences/situations that exist in transit settings that contribute to transit-related frustration. Whilst most of the research to date focuses on anxiety experienced due to unreliable transit schedules and safety, Nour et al. (2010) recommends more specific research on transit user anxiety levels *on* transit. They found anxiety levels to be highest when the in-vehicle trip is longer than anticipated. Nour et al. also made several recommendations in exploring the transit experience further by using GPS-enabled smartphones in tandem with static bus schedules to measure variations in anxiety when in-vehicle trips are longer than scheduled. Such efforts can more accurately measure anxiety over time and space, specific to transit schedule (un)reliability.

2.2. Methods for Capturing Transit Experience

A variety of methods have been used to capture transit experiences over the past decade, contributing to an improved understanding of how transit-users behave and feel about using public transportation (Ahern & Tapley 2008; Caulfield & O'Mahony 2009; Russell et al. 2011; Zimmerman et al. 2011; Jariyasunant et al. 2011; Cats & Loutos 2016; Watkins & Brakewood 2016). Surveys or questionnaire have proved useful (Baltes 2003; Hensher et al. 2003; Ahern & Tapley 2008), especially on-board surveys. On-board surveys can be time-efficient in collecting mass data from captive transit users; however, low response rates are typical, usable data can be elusive (Baltes 2003; Hensher et al. 2003; Ahern & Tapley 2008), and they are often perceived as burdensome or an inconvenience for transit-users, which in itself can contribute to questionable data quality and usability (Ahern & Tapley 2008).

Collecting data about transit experiences in the form of a survey or questionnaire post-trip has proved useful as well. Typically, there are four main modes of questionnaire distribution, which include: mail, online, telephone and face-to-face surveys (McGuirk & O'Neill 2016). Mailed surveys have a cost-savings advantage, and the surveys can be completed at the pace of the participant – little stress and less obligation or feelings of being burdened by a stranger (Ahern & Tapley 2008; McGuirk & O'Neill 2016). However, the major limitations of mailed questionnaires are that they are often less detailed, less complex, and there is little control over who completes the questionnaires (McGuirk & O'Neill 2016). Electronically mailed questionnaires can be even more cost-effective and have a wider range of participants. While the range of participants may be heightened, the questionnaire is also at the mercy of those who do not have internet access (i.e. low income groups) or understand how to complete an online questionnaire (i.e. elderly peoples more likely to prefer mailed-in questionnaires)

(McGuirk & O'Neill 2016). Perhaps the major limitation to both mailed-in and electronically sent questionnaires is that they have "lower response rates than conventionally distributed questionnaires" (McGuirk & O'Neill 2016).

Surveys conducted over the telephone have an advantage that they can seem less invasive than being approached by a stranger on the bus or at ones' doorstep (McGuirk & O'Neill 2016). Telephone questionnaires can: enable participants to provide in-depth answers to questions, be relatively cost-effective, and be easily administered, especially through computer-assisted telephone interviewing (CATI), which has highlighted great potential. However, an obvious limitation is that telephone questionnaires depend on the sampling frame of a phone directory, which can introduce several biases (class and gender bias). Another consideration is the growing use and dependence of cellphones, which can work against the sampling frame of the telephone directory (McGuirk & O'Neill 2016).

Surveys conducted face-to-face offer many benefits compared to the aforementioned modes of questionnaire distribution. For example, face-to-face surveys can offer participants ample opportunity to elaborate on open-ended questions with fine detail, especially because of interviewer presence (McGuirk & O'Neill 2016). The presence of the interviewer has the added benefit of being able to make notes of body language and add related contexts that can enhance data quality. In addition, the interviewer can provide some sway or encouragement or clarify questions if need be. Participants also tend to offer longer responses *orally* versus than in writing, and provide significantly higher response rates (McGuirk & O'Neill 2016). Limitations of face-to-face questionnaires include potential influence or shaping of responses by interviewer presence, including filtering responses "through a sense of social expectation" (McGuirk & O'Neill 2016), and their relative expense compared to other methods when considering time and labour costs.

Beyond these advantages/limitations of post-trip surveys or questionnaire, such methods all share another major limitation – they depend on recall memory – which is typically generalized and offers less detail (Stone et al. 2004; Ebner-Priemer et al. 2006). By definition, recall bias is an ongoing cognitive reconstruction process that can distort past experiences (Stone et al. 2004; Ebner-Priemer et al. 2006). This highlights the major advantages of collecting in-situ data – that is, data collected as it is happening.

There are several methods for capturing in-situ transit experiences, the simplest being direct observations of passengers. For example, Russell et al. (2011) investigated what passengers do during their travels on bus and train using structured observation. While their findings give a valuable insight into what transit-users do with their time, it fails to capture how passengers are feeling and what they are thinking. The structured observation method also suffers from observer fatigue or "drift" (Russell et al. 2011).

The Experience Sampling Method (ESM) is a promising research procedure for studying what people do, feel, and think during their daily lives, consisting of asking individuals to provide systematic in-situ self-reports at set intervals (Larson & Csikszentmihalyi 2014). Depending on the survey design, ESM can adhere to the limitations of traditional on-board surveys and post-transit surveys by offering both open- and closed-ended questions, without having to provide data depending on recall memory, and for a relatively low cost. If deployed on a smartphone, ESM offers considerable additional potential in enabling qualitative data collection in the form of voice notes, text notes, pictures and videos, while also being able to trigger responses based on set time intervals, random times and/or user locations (Hektner et al. 2007; Doherty et al. 2014).

Theoretically, ESM can be applied to an array of research topics related to day-to-day living in efforts to more accurately understand what, why and how people are thinking under differing environments. For example, Doherty et al. (2014) leverage the benefits of the ESM on smartphones to investigate the extent to which the natural environment can enhance wellbeing. They found that the method was not perceived as burdensome, with the exception of those participants that were prompted to complete a survey several times at the same location, which speaks to the promise of location-based ESM designs. Similarly, Quinlan Cutler et al. (2016) found success in utilizing ESM with a survey completion rate of 84%, and of the difference, 10% of surveys missed just one element. Such research displays the promise in leveraging ESM to capture real-world activity patterns that can be applied to a variety of environments on a fine spatial-temporal scale (Doherty et al. 2014; Quinlan Cutler et al. 2016).

While ESM has tremendous upside, it too does have its limitations. For example, depending on the nature of the study, the researcher may have little knowledge about the context or the setting in which the data is provided, and participants may not follow instructions in the absence of the researcher. In addition, participants of ESM research can be privy to the self-selection bias (Green et al. 2006). Some research even suggests that repeated surveys can be taxing on participants, and their willingness to cooperate and provide data can decline (Doherty et al. 2014; van der Krieke et al. 2016). Also, it can be difficult to recruit research given how ESM can interfere with the day-to-day lives of participants. It can be perceived as burdensome for participants to be prompted several times throughout the day to provide data, on top of their day-to-day responsibilities. Further, survey prompts can be anticipated by participants, so participants can predetermine what data they will provide, *before* the survey asks the question (van der Krieke et al. 2016).

The ESM concept has gained some traction in measuring in-situ transit experience, such as bus fullness, anomalies with the transit infrastructure (i.e. bus, bus shelter, etc.) and arrival times. For example, users of the Tiramisu smartphone app (see Figure 3) can report problems pertaining to specific bus routes, document (positive or negative) experiences, append images to reports and can geotag locations to reports using GPS on their smartphones (Steinfeld et al. 2010; Steinfeld et al. 2011; Zimmerman et al. 2011). This information can be used by local transit agencies to mitigate uncertainties in using public transit by enabling users to know arrival times or bus conditions such as fullness and access to historical arrival information (Figure 4). The Tiramisu app also creates a sense of community for transit-users, as they depend on one another to provide real-time data on a continuous basis to enrich the dataset and enrich transit experiences (Steinfeld et al. 2011). As a leader in its design, the Tiramisu concept holds potential to be applied to urban environments worldwide. Also, according to Russell et al. (2011), Tiramisu give transit-users something to do on their transit trip, which typically consists of nothing more than looking/gazing out the window or listening to music.

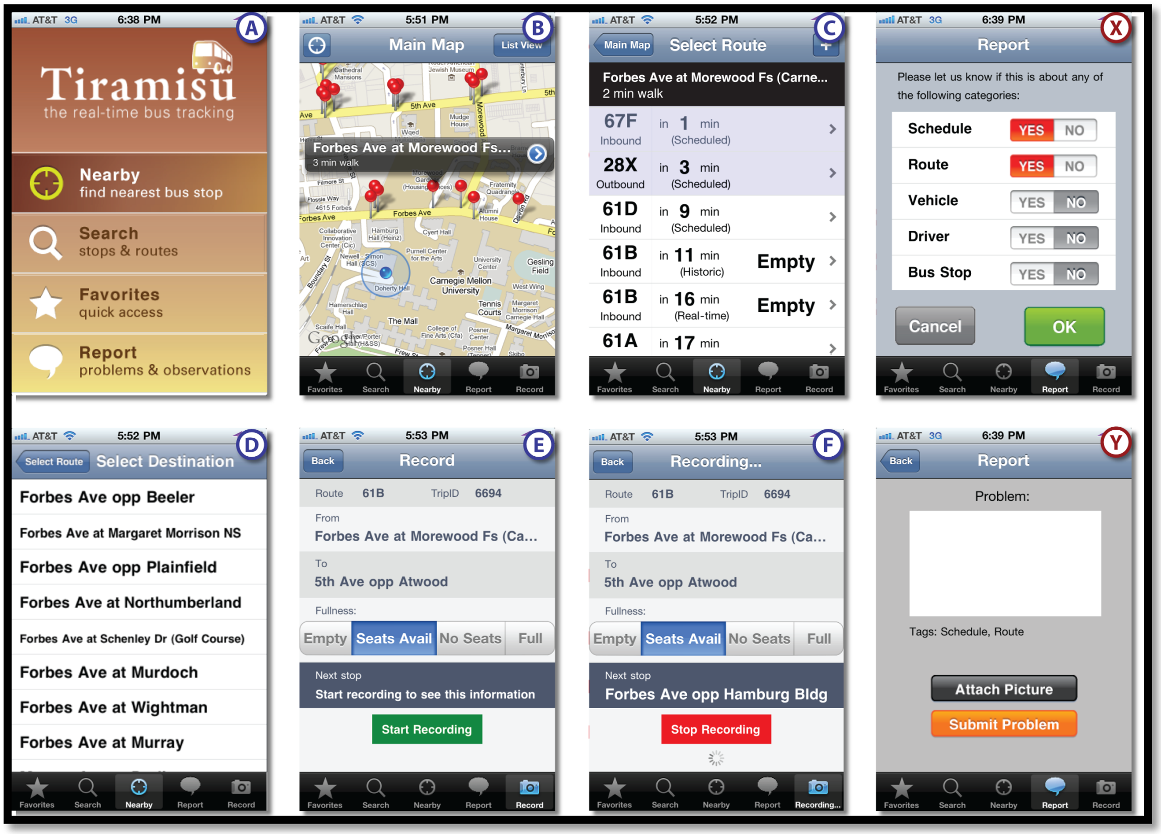

Figure 3: Screens from Tiramisu interface (Zimmerman et al. 2011)

Note: Main Menu (A): Main Map (B): Map with selectable stops based on location. Select Route (C): Arrival times for selected stop. Report (D): Select destination bus stop. Record (E): Report fullness and share GPS trace info. Recording (F): Update fullness and stop trace. Report (X) Select categories. Report (Y): Input report text and add photo.

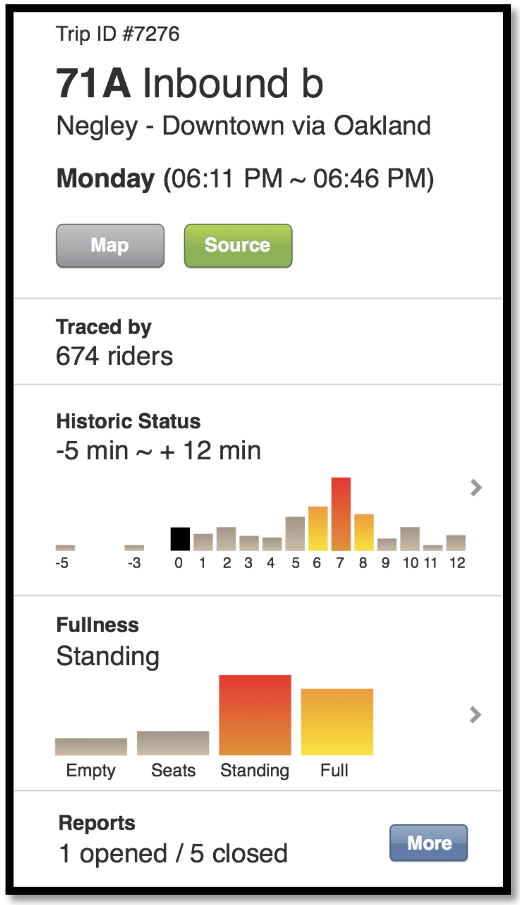

Figure 4: Tiramisu Route History View Design (Steinfeld et al. 2011)

2.3. Behaviour Modelling of Transit Experiences

Casello and Hellinga (2008) have done extensive work modelling transit demand and ridership, including for newly implemented express bus route services. The models are based on utility theory – a traditional model used in mode choice models – which suggests that people essentially weigh pros and cons for a travel mode, and decide based on which mode available has the least travel cost (wait time, reliability, in-vehicle time, financial cost, etc.). Casello et al. (2009) used a simulation model of bus arrival times and bus passenger expectations of a reasonable transit system. It was found that transit service reliability was the most significant variable when calculating travel cost. By creating three types of transit-users with different risk tolerances – very risk aversive, moderately risk aversive, and risk-neutral – the simulation model calculates for the likelihood that each subgroup will be on time or late for their scheduled trip along with how they respond under different conditions. The simulation model finds that increasing reliability of bus arrivals can decrease the total cost of using public transit.

Nour et al. (2010) extended the travel cost simulation model of Casello et al. (2009) by adding an *anxiety* component. Specifically, they proposed that anxiety is added to the travel cost when in-vehicle trips are longer than anticipated or behind schedule. The results indicate that risk-aversive transit-users are easily dissuaded from unreliable transit services, as they perceive the cost of using transit to be significantly higher, so they are likely to explore other modes of transportation.

Casello et al. (2009) discuss options for future improvements to travel behaviour empirical data in support of these simulation modelling efforts, including identifying factors that dissuade individuals from using public transportation, especially finding appropriate weights to represent anxiety. The authors expect future research to include in-situ measurement of these factors quantitatively using scales and qualitatively using voice-recording features, and preferably tracked over time and space using GPS. This would allow comparison of anxiety with early, expected or late bus arrival times via pre-determined schedules. Casello et al. further suggested that this future in-situ research would enable policymakers to make adjustments where necessary to avoid further negative perceptions of using public transportation.

3. OBJECTIVES

The overall goal of this research is to utilize a smartphone app to capture meaningful in-situ qualitative and quantitative data on transit riders' feelings and experiences, overcoming the limitations of past approaches, and supporting emerging efforts to better understand and model the transit experience. In particular, the objectives of this research include:

- Explore the usefulness of using smartphones and the Experience Sampling Method (ESM) to capture the transit experience
- Infer if ESM works, where and when, while addressing any limitations
- Explore in-depth the nature and extent of transit experiences, including situational and demographic explanatory factors

- Explore the prominence of anxiety as a theme
- Explore emerging themes from the exploratory analysis
- Make recommendations for transit planning and modelling

4. METHODS

The info-tech revolution has led handheld computer devices to become commonplace in many areas of the world. Smartphones have developed to be highly customizable and profitable in many ways – from apps that have generated hundreds of millions of dollars in revenue to apps that contribute to research. Such capabilities have proved to be promising in the collection of empirical data. The Transit Oriented Experience Survey (TOES) has been designed to measure and further understand: transit experiences, the methodology, and the utility of ESM research for the academic community.

4.1. TOES App Design

The data was collected using a custom-made touch-screen *BlackBerry* smartphone (see Figure 5) application (or "App") developed by Dunlop (2012) and code-named TOES. TOES builds off the experience sampling designs of Doherty et al. (2014) to accommodate changes recommended by pilot study participants. Such modifications enabled participants to optionally type responses instead of voice recording them (to address privacy issues on crowded buses and bus stops), and the incorporation of dynamic Likert Scale responses, rather than pull-down lists. After a pilot study (Said 2013), further improvements were made – the survey screens were reduced (from seven to five) and the text field was redesigned to be spaced comfortably away from the "Submit" button.

Figure 5: BlackBerry Storm Handheld Device Replica (Source: BlackBerry)

Once the smartphone app was launched from the main directory and the survey was manually initiated, the first screen of TOES prompted the participant to select the stage of their trip. As seen in Figure 6, the "At Bus Stop" stage of the trip is highlighted. Participants were asked to select their trip stage (i.e. "At Bus Stop", "On Bus", or "Before/After Trip") and advanced in the survey. Note that the survey remains the same no matter what is selected on Screen 1.

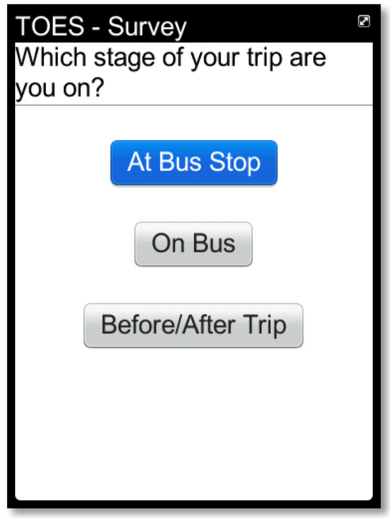

Figure 6: Screen 1 of the TOES

Once the stage of the trip was selected, the survey advanced to the next screen, asking participants to provide the details of their environment and behaviour in the form of a voice note and/or text response, as show in Figure 7. Participants in the pilot study claimed that it was awkward to say everything they wanted to on a crowded bus, so the text-input option was designed to accommodate such feelings.

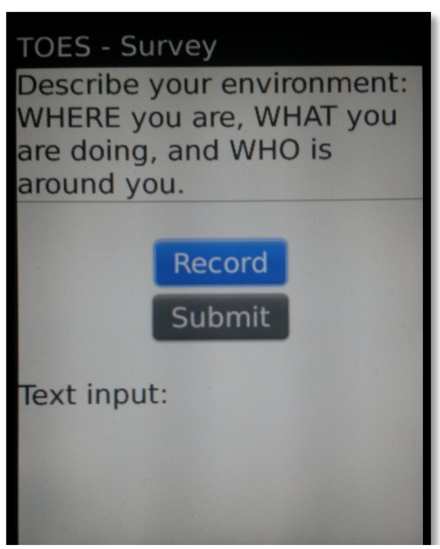

Figure 7: Open-ended Qualitative Question of the TOES

The third screen of TOES (Figure 8) provided a series of Likert scales to elicit how participants were feeling with respect to their surroundings. The variables on this screen were: clean/dirty, empty/crowded, cheerful/depressing, open/enclosed, and comfortable/uncomfortable. This screen of the survey was particularly useful to contrast how one feels about their surroundings throughout the different stages of the trip and also helped validate the survey design (i.e. if the results indicate the "On Bus" portion of the survey tends to be more crowded than the "Before/After Trip" portion).

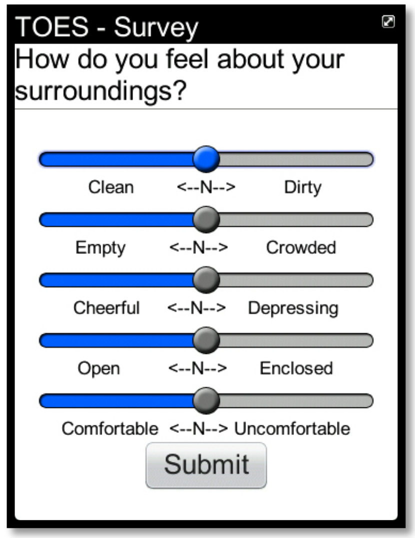

Figure 8: Environmental Likert Scale Quantitative Question of the TOES

Similar to Figure 8, the fourth screen of the survey (Figure 9) had a series of Likert scales to elicit how participants were feeling with respect to their wellbeing. Figure 9 displays the following variables: relaxed/anxious, happy/frustrated, excited/bored, sociable/irritable, and safe/unsafe. Again, this screen was especially useful when contrasting how one feels throughout the different stages of the trip.

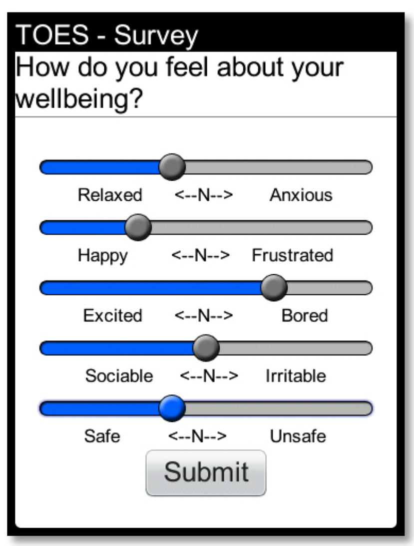

Figure 9: Wellbeing Likert Scale Quantitative Question of the TOES

The fifth and final screen of TOES (Figure 10) asked participants to provide a voice and/or text note for the following question: "*Describe anything that has happened that changed how you feel since the last survey or the start of your trip?*" followed by "*What are the most enjoyable and least enjoyable things you have experienced?*". Again, participants were advised that it is not mandatory to answer both questions; rather, to answer whatever comes to mind.

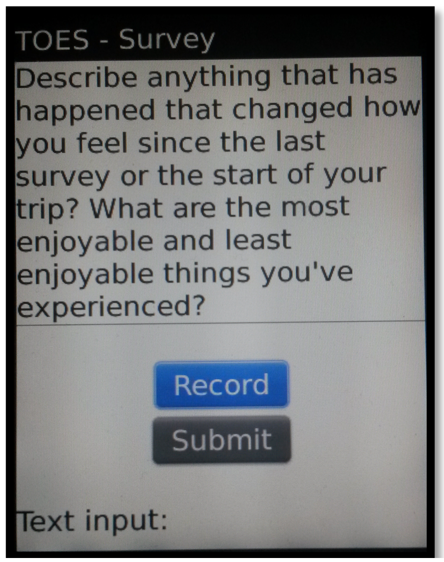

Figure 10: Open-ended Qualitative Question of the TOES

The TOES app saved all responses in both text and audio files to be later downloaded from the Blackberry once connected to a computer using the *BlackBerry Desktop Manager*. The survey responses were time-stamped and each device provided a user identification (User ID) to organize the files. The qualitative questions (Screen 2 and 5) produced both audio and text files. The quantitative questions (Screen 3 and 4) produced text files with numerical values that pertain to the scale bar variables. The scale bars were coded to have values 0 to 8 for each variable, 0 being the most positive and 8 being the most negative. For example, the first variable on Screen 3 of TOES asked participants to rate the degree of cleanliness of their surrounding with 0 being the cleanest, 4 being neutral and 8 being the dirtiest. These numerical values were copied into a Microsoft Excel spreadsheet for every stage of the trip and for every participant. The data from the qualitative questions (Screen 2 and 5) were transcribed into *Microsoft*

Excel for every stage of the trip and participant as well. Figure 11 displays an example of the data table stored:

H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
MO	DAY	YEAR	Start Time	End Time	HR	MIN	TEMP	WEATHER	ROUTE	Q0	Q0-1	Q1-V	Q1-T	Q2-1	Q2-2	Q2-3	Q2-4	Q2-5	Q3-1	Q3-2	Q3-3	Q3-4	Q3-5
3	5	2013	12:30:00	13:30:00	12	30		Warm Day		Before/After trip	Before		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	5	2013						Warm Day		Bus Stop			at 7 bus stop	2	4	2	6	5	6	3	6	2	4
3	5	2013						Warm Day	7	On Bus			lots of studer	5	3	5	6	5	5	6	6	6	5
3	5	2013						Warm Day		Bus Stop			bus took a ur	6	3	5	7	5	6	5	7	2	7
3	5	2013						Warm Day		Before/After trip	After		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	5	2013	18:30:00	20:15:00	18	30		Cold Night		Before/After trip	Before		Walking to b	2	4	1	1	0	0	0	0	0	0
3	5	2013						Cold Night		Bus Stop			At 7 bus stop	4	2	3	4	2	4	4	4	4	4
3	5	2013						Cold Night		On Bus			On bus, bus a	7	8	5	8	6	4	7	4	6	3
3	5	2013						Cold Night		Before/After trip	After		Finished bus	2	3	4	4	4	5	4	4	4	1
3	5	2013						Cold Night		Bus Stop			At the iXpres	4	4	4	4	4	1	1	3	3	2
3	5	2013						Cold Night		On Bus			?	6	3	4	4	3	5	4	6	4	4
3	5	2013						Cold Night		Before/After trip	After		Just got off tl	2	2	2	2	1	2	1	1	1	0
3	7	2013	10:00:00	11:45:00	10	00		Very Warm Day		Before/After trip	Before		Bus just arriv	6	5	4	3	3	3	3	7	3	3
3	7	2013						Very Warm Day	7	On Bus			A lot of peop	7	3	3	3	3	1	3	6	3	3
3	7	2013						Very Warm Day		Before/After trip	After		At the mall b	3	0	3	2	2	2	2	5	3	2
3	7	2013						Very Warm Day	9	On Bus	9		on the secon	6	3	5	3	3	1	4	6	3	3
3	7	2013						Very Warm Day		Bus Stop			at another bu	5	5	5	6	3	2	3	7	5	3
3	7	2013						Very Warm Day		On Bus			still on the 9	6	7	3	3	3	3	3	5	3	3
3	7	2013						Very Warm Day		Before/After trip	After		just finished	5	8	3	3	6	2	3	6	3	2
3	7	2013	11:15:00	12:15:00	11	15		Very Warm Day		Before/After trip	Before		heading to th	6	2	5	1	2	0	2	3	1	0
3	7	2013						Very Warm Day		Bus Stop			just waiting f	7	5	3	3	1	1	3	2	1	1

Figure 11: Sample of Excel Spreadsheet with Encoded Survey Data

In conjunction with TOES, GATE – a GPS-enabling application – was used to track the travel paths of each participant. Similar to how TOES files were saved, the GPS coordinates were also saved to each smartphone device and because each file was time-stamped it was easy to identify which GPS coordinates belonged to whom.

4.2. Instructions to Users

Participants of the research were asked to make a simple trip from using public transportation from Wilfrid Laurier University (WLU) to Conestoga Mall, and then back to WLU using an alternate bus route. During their participation, participants were asked to carry one of the several *BlackBerry* devices to collect data using TOES periodically throughout their trip. Each participant was instructed on how to initiate and complete TOES by observing a "demo" survey prior to participation. After observation, participants were given a survey "trial" to ensure they were capable of navigating to and through the application. Participants would essentially locate the application from the main menu and simply select the application for initiation/launch. After participants proved to be comfortable and capable of using TOES, a return-trip time commitment was made to more closely simulate real-life transit experiences.

Participants were to complete the survey before they started their trip, at the bus stop, on the bus, and after they have reached their destination. As such, the survey was completed multiple times throughout the duration of the study. More specifically, if a participant decided to go into Conestoga Mall, the participant completed the survey eight times; otherwise the participant completed the survey six times. For those who decided to go into the mall, participants completed the survey in the following order: "Before Trip", "At Bus Stop", "On Bus", "After Trip", "Before Trip", "At Bus Stop", "On Bus", "After Trip". For those who decided to just use public transit to get to the mall and leave promptly after arriving, they completed the survey in the following order: "Before Trip", "At Bus Stop", "On Bus", "At Bus Stop", "On Bus", "After Trip". Again, the survey questions are the exact same for each stage of the trip.

4.3. Study Site

Kitchener-Waterloo (K-W) is a smart city home to a vast, young student population that produces some of the most innovative people in the world (Smyth 2014; Bellemare 2014; Smyth 2016). K-W is home to the University of Waterloo (UW), WLU and Conestoga College, and within recent years, Waterloo has added: Centre of International Governance and Innovation (CIGI), Balsillie School of International Affairs (BSIA) and the Perimeter Institute for Theoretical Physics (PI) – all institutions with relevant graduate-level research. Moreover, K-W is home to Google's largest engineering office in Canada (El-Akkad 2011; Bellemare 2014; Google). K-W is also home to an array of financial firms, including: Sun Life Financial, Manulife Financial, Citi Financial, KPMG, and more. Such a combination of academic and business intellect has allowed K-W to grow a stronger image within academia and has been compared to Silicon Valley and Route 128 (Colapinto 2007; Barrenechea 2014).

K-W data obtained from Statistics Canada data revealed that public transit usage for work purposes had increased nearly 15% between 1996 and 2001, 31% between 2001 and 2006, and 12% between 2006 and 2011, as shown in Table 1. Over the course of the 15-year time period, transit-use for work purposes had risen by 68.5% relative to a population growth of only 24%.

Table 1: Historical Transit Usage and Cycling Trends in Kitchener-Waterloo

Transportation Mode to Work	Year			
	1996	2001	2006	2011
Public Transportation	5,790	6,650	8,710	9,755
Employment (%)	4.8%	4.8%	5.6%	6.2%
Relative Growth (%)	NA	**14.9%**	**31.0%**	**12.0%**
Walk or Cycle	9,140	9,420	11,500	9,370
Employment (%)	7.5%	6.8%	7.5%	6.0%
Relative Growth (%)	NA	3.1%	22.1%	-18.5%
Total Population	256,369	276,942	302,143	317,933
Employment (%)	47.5%	50.3%	51.1%	49.3%
Relative Growth (%)	NA	8.0%	9.1%	5.2%
Source: Statistics Canada 1996, 2002, 2007, 2012, 2013a, 2013b, 2013c				

After considering these figures, it was clear that the transit-user population could benefit from an improved transit system. Table 1 displays the growth in the employed population that use public transit to get to work year-by-year, along with the relative growth to the year-by-year population growth total. However, it is imperative to note that the data in Table 1 is specific to those who used transit to get to work, so there is a large gap in the data, leaving out a vast student population who frequently depend on transit. Therefore, we can presume that transit-user population could benefit from an improved transit system within K-W even greater than the data suggests.

4.4. <u>Sampling</u>

The research was conducted in Waterloo along Grand River Transit (GRT) bus routes whereby undergraduate students from WLU human geography and urban and economic geography courses made a single trip to Conestoga Mall using the mainline bus route (the 7) and back from the mall using an alternate bus route (9, 12, or 200 iXpress). The travel path options are identical to those from the initial data collection undertaken for an undergraduate thesis in March of 2013 (Said 2013). Participants of the first group were required to have little-or-no transit experience, could not travel with peers and were not applied any time-pressure. Participants from the second group included anyone – they could travel with peers, but there was time-pressure applied, unlike the initial sample collected in March of 2013. The parameters for participants of the third group were similar to those of the second group, though the distinction is that the participants were from a second-year urban and economic geography class, whereas the first two groups included first-year human geography students.

The participants of the study were recruited from three different undergraduate cohorts. Students who were compelled by the opportunity to partake in the research and gain a 2% participation grade contacted me to schedule a time and date of their desired participation. Upon the scheduled time and date, each participant provided a signed informed consent statement that contained all the information about the study. However, for obligatory reasons, the terms of the consent statement were discussed to ensure participants fully knew what was expected from their participation, also ensuring participants provided useful data.

4.5. Data Preparation

Preparing the data was a rather lengthy process. As previously mentioned, each survey iteration saved voice notes and text notes that were provided by participants. Each voice and text file was (temporarily) saved under the name of the participant for ease of organization. After the survey and GPS data was organized into individual file folders for each participant, the data from each folder was cleaned to remove any survey errors (i.e. empty voice or text files). The organized participant data was then ready to be compiled into a spreadsheet. The data for each participant (voice and text files) were entered into the spreadsheet chronologically. The above process was repeated for each of the 962 survey iterations. Furthermore, Table 2 contains an array of other variables entered into the spreadsheet. Altogether, all survey iterations contain 50 variables organized, coded and prepared for analysis.

Table 2: List of Variables Coded

Variable Name	Description	Measurement Units
User ID	Unique participant code	e.g.: 1, 2, 3
Trip ID	Unique participant date and code	e.g.: 201301, 201302, 201303
Quality Indicator	Describes data quality	e.g.: 1, 2, 3
Survey Iteration	Survey trial number	e.g.: 1, 2, 3, 4, 5, 6, 7, 8
Participant Name	Name of participant	e.g.: John Smith
Gender	Gender of participant	e.g.: Male, Female
Month	Month of participation	e.g.: 3, 4, 11, 12
Day	Day of participation	e.g.: 11, 13, 22, 24
Year	Year of participation	e.g.: 2013, 2014, 2015
Start Time	Start time of participation	e.g.: 13:25:00
End Time	End time of participation	e.g.: 15:00:00
Weather Conditions	Weather conditions during participation	e.g.: Fair Weather, Poor Weather
Bus Route	Bus route survey iteration was completed	e.g.: 7, 9, 12, 200, 202
Solo vs. Group Travel	Did the participant travel individually or with a peer	e.g.: S, G
Length of Voice Notes (seconds)	The length of all voice notes provided for the particular survey iteration	e.g.: 64, 45, 92
Voice Note Word Count	The number of words used for all voice note responses for the particular survey iteration	e.g.: 88, 74, 101
Text Note Word Count	The number of words used for all text note responses for the particular survey iteration	e.g.: 39, 62, 51
Combined Word Count	The number of words used for all voice and text note responses for the particular survey iteration	e.g.: 127, 136, 152
# of Voice Responses	The number of voice responses provided for the particular survey iteration	e.g.: 0, 1, 2
# of Text Responses	The number of text responses provided for the particular survey iteration	e.g.: 0, 1, 2
# of Non-responses	The number of non-responses provided for the particular survey iteration	e.g.: 0, 1, 2
Hometown	Participant's hometown	e.g.: Hockley Valley, Newmarket, Cambridge
Experience Before K-W	Experience using public transportation before moving to K-W	e.g.: Once every two weeks, once a month, never

Experience During K-W	Experience using public transportation in K-W	e.g.: Once a week, twice a week, five times a week
Stopping in Mall?	Does the participant plan to visit Conestoga Mall	e.g.: Yes, No
Time Left	The time the participant left the office	e.g.: 10:55am, 11:35am, 1:40pm
Time Pressure	The time pressure applied (to some participants)	e.g.: 1h, 1h15m, 1h30m
Time Arrived	The time the participant returned to the office	e.g.: 11:50am, 12:35pm, 2:50pm
On Time?	If the participant was or was not on time	e.g.: Yes, No
Notes	Miscellaneous notes to help code the data	e.g.: The final screen of the survey was accidentally skipped for the first "Before Trip" survey

Regarding the preparation of the qualitative data, the voice note data was coded in such a way to accurately attain the word counts for each voice note. More specifically, when transcribing each voice note, only commas and periods were used – no hyphens or other grammatical characters were necessary when accurately determining the word count. The way the word count formula works in Microsoft Excel is to count the number of spaces between each word, plus one. As such, if the voice data were to be transcribed using proper grammar then the word count numbers would be slightly skewed. Additionally, the text notes that participants provided were understandable, though often times had spelling errors and needed to be edited to more accurately represent the word count provided. For example, some participants might accidentally provide a text response that had two or more words "stuck" together with no space in-between them. Thus, it was necessary to edit the text notes in the spreadsheet code for fair representation of the data.

A list of the 11 nominal variables analyzed can be viewed in Table 3. As seen in the table, the population sample was the same for each variable. This is because the population was broken up into each of the themes, whether each theme had two, three or four variables.

Table 3: List of Nominal Variables Analyzed

Variable Name	Label	Measurement Units	Sample Size (N)
Gender	Gender	1 (Female); 2 (Male)	145
Trip Stage	Trip Stage	1 (Before Trip); 2 (At Bus Stop); 3 (On Bus); 4 (After Trip)	145
Bus Route	Route	7; 9; 12; 200	145
Stopping in Mall?	Mall Trip?	1 (Yes); 2 (No)	145
Weather	Weather	1 (Fair Weather); 2 (Poor Weather)	145
Travel Type	Travel Type	1 (Individual Trip); 2 (Group Trip)	145
Student Year	Student Year	1 (First-year Student); 2 (Second-year Student)	145
Transit Experience	Transit Experience	1 (Great); 2 (Moderate); 3 (Very Little/None)	145
Survey Version	Survey Version	1 (TOES Version 1); 2 (TOES Version 2)	145
Quality Indicator	Quality Indicator	1 (Great); 2 (Good); 3 (Bad)	145
Anxious Experiences	Anxious Experiences	1 (Anxious); 2 (Non-anxious)	145

Table 4 lists the Likert scale bar slider questions presented in the survey design section above. Both scale bar slider questions capture quantitative data, though Question 2 pertains to the environment while Question 3 pertains to wellbeing.

Table 4: List of Ordinal Variables Analyzed

Variable Name	Label	Measurement Units	Sample Size (N)	Mean	Range
Question 2-1	Q2-1 Cleanliness	0-Very Clean to 8-Very Dirty	959	3.6	0 - 8
Question 2-2	Q2-2 Crowdedness	0-Very Empty to 8-Very Crowded	959	3.3	0 - 8
Question 2-3	Q2-3 Cheerfulness	0-Very Cheerful to 8-Very Depressing	959	3.5	0 - 8
Question 2-4	Q2-4 Openness	0-Very Open to 8-Very Closed	959	3.2	0 - 8
Question 2-5	Q2-5 Comfort	0-Very Comfortable to 8-Very Uncomfortable	959	2.9	0 - 8
Question 3-1	Q3-1 Anxiety	0-Very Relaxed to 8-Very Anxious	958	2.7	0 - 8
Question 3-2	Q3-2 Happiness	0-Very Happy to 8-Very Frustrated	958	2.9	0 - 8
Question 3-3	Q3-3 Excitement	0-Very Excited to 8-Very Bored	958	3.8	0 - 8
Question 3-4	Q3-4 Sociability	0-Very Social to 8-Very Irritable	958	3.1	0 - 8
Question 3-5	Q3-5 Safety	0-Very Safe to 8-Very Unsafe	958	2.1	0 - 8

There was one less survey completed for Question 3 due to a software error, which explains the (minor) sample size difference. As seen in Table 4, positive feelings have lower values while negative feelings have higher values. The average value rests at 3.8, which is on the cusp of the neutral value of 4.

Table 5 lists the scale variables analyzed, which also happened to be the methodological variables for the qualitative questions. The sample sizes largely vary in Table 4 because participants had the option to provide voice and/or text notes in elaborating about their environment and wellbeing. It is clear that there was a lot more voice data provided on average than text data based off the sample size, averages and the range of data.

Table 5: List of Scale Variables Analyzed

Variable Name	Label	Sample Size (n)	Mean	Range
TIME (s)	Time (s)	602	49.4	3 - 238
LENGTH (V)	Length of Voice Note	604	88.1	3 - 319
LENGTH (T)	Length of Text Note	445	32.1	1 - 147
LENGTH (V+T)	Length of Voice and Text Note	936	72.1	1 - 319
VR	# of Voice Responses	1,615	1.68	0 - 4
TR	# of Text Responses	871	0.91	0 - 4
NR	# of Non-responses	133	0.14	0 - 4

4.6. Data Analysis Procedures

The research includes both a quantitative and qualitative analysis, along with a methodological measure to further understand the potential of ESM research. The data analysis was conducted using both SPSS (Version 23) and Microsoft Excel. Microsoft Excel was used to organize and prepare the data for SPSS analysis. SPSS was used for the bulk of the analysis while Microsoft Excel was subsequently used to create clean tables, charts and graphs.

Once the data was collected, various measurements were made for the qualitative and quantitative data similar to the analysis undertaken by Quinlan Cutler et al. (2014) and Doherty et al. (2014), which included the total number of: negative feelings versus positive feelings, and surveys completed. These figures were then compared amongst other variables and sample characteristics to explore potential relationships using chi-squared Test’s.

In addition to assessing the methodology, the intention for the analysis was to compare and contrast emotional and experiential responses by key participant and situational variables, including:

- Gender
- Stage of Trip
- Bus Route
- Mall Trip vs. Mall Bypass
- Weather Conditions
- Solo vs. Group Travel
- 1^{st}-year vs. 2^{nd}-year
- Level of transit experience
- TOES Version 1 vs. Version 2
- Anxious Experiences

5. RESULTS

This chapter presents methodological and empirical data analysis that is subcategorized by the aforementioned key variables, followed by the qualitative analysis of the voice data. To start, an overview of the sample characteristics is presented below.

5.1. Sample Characteristics

A total of 145 people participated in the survey, providing a total of 962 situational survey responses – an average of 6.6 surveys per participant. Three distinct groups were recruited:

- 50 first-year human geography students with little-to-no transit experience, travelling individually under no time-pressure
- 53 first-year human geography students with any level of transit experience, permitted to travel in pairs or groups and subjected to time-pressure
- 42 second-year urban and economic geography students with any level of transit experience, permitted to travel in pairs or groups and subjected to time-pressure

Of the 145 people who participated in the survey, 57% (83) were male and 43% (62) were female. Of these figures, 71% (103) were first-year students and 29% (42) were second-year students. Regarding the level of transit experience, those with a high-level of transit experience accounted for 47.6% (69) of the participants, while those with a moderate- and low-level of transit experience accounted for 8.3% (12) and 44.1% (64) of the participants, respectively. Further, 72% (105) of the participants represented individual travels while 28% (40) of the participants represented travelling in pairs or groups, and, 34.5% (50) of the participants represent TOES 1 data collection while 65.5% (95) of the participants represent TOES 2 data collection.

5.2. Situational Characteristics

Of the 962 situational surveys, approximately 60% of the data was captured on the bus and at the bus stop, with approximately 40% shared between the before trip, after trip and at mall surveys iterations. The breakdown of the 287 survey iterations captured by bus route is shown in Table 6. Most of the bus route data was captured on route 7 (45.3%) and route 200 iXpress (25.8%). Due to GPS failures, 14.3% of the bus routes were unknown, which will be discussed in detail within later chapters. Further, 39.3% (57) of the participants decided to stop into Conestoga Mall while 60.7% (88) of the participants decided to bypass the mall and return to WLU, and lastly, 47% of the data was captured in fair weather and 53% of the data was collected in poor weather.

Table 6: Bus Route Percentages

Bus Route	Report (%)
7	45.3
9	8.4
12	4.5
200	25.8
202	1.7
Unknown	14.3

5.3. Data Quantity and Quality Characteristics

Identifying the best quality data for analysis was an important first step in this research. To do so, the data was categorized into great data, good data and bad data. Great data refers to data provided when participants did exactly what they were supposed to throughout their participation. Good data refers to data that is entirely usable, though the participant may have forgot to do a survey at some point throughout their participation. Bad quality data refers to participants who provided very little data due to software glitches preventing data capture or did not follow key instructions (e.g. incomplete surveys for multiple trip stages). Based on this, 83.4% (121) of the participants provided great data, 11% (16) good data, and 5.5% (8) bad data. Thus, nearly 95% of the data collected was deemed useable for subsequent analysis. The 8 participants that provided bad data came from the original data collection of TOES, with the qualitative data being unusable and the quantitative data being usable. As such, the 8 pieces of data were only removed from the qualitative analysis, whilst still using the quantitative data.

5.4. Methodological Results

As noted in the methods, participants had the option to provide voice and/or text data in responding to the multiple qualitative questions of TOES, such as how participants felt about their environment or wellbeing. A total of 1,615 voice and 871 text note files were reported, the length of which are summarized in Table 7. Participants clearly favoured providing voice notes over text notes at approximately 2:1 ratio. A total of 29,724 seconds (495 minutes; 8.3 hours) of voice notes was captured, the mean length of which was 49.4 seconds, with the longest voice note being 238 seconds. The mean word count for all voice notes is 88.1, though this varied widely with a standard deviation of 50.1 words. This was more than double the mean word count for text notes at 32.1 words, with a standard deviation of 22.

Figures 12 and 13 illustrate the distribution of word count for all voice and text notes with detail. It is clear that there is a slight tail in the distribution in both cases. The distributions are very similar in nature, though the distribution for text responses includes a few outlier responses, though nothing dramatic enough to be of concern. Generally speaking, the distributions further illustrate that the participants were much more elaborate in their voice responses than in their text responses.

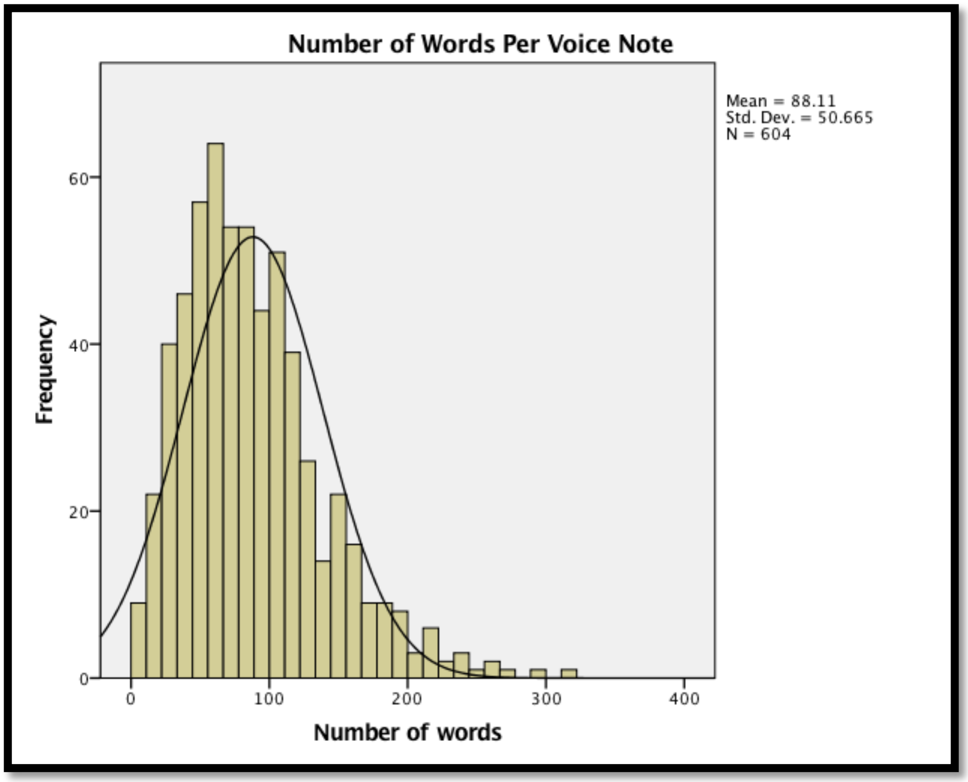

Figure 12: Frequency Distribution of Words Per Voice Note

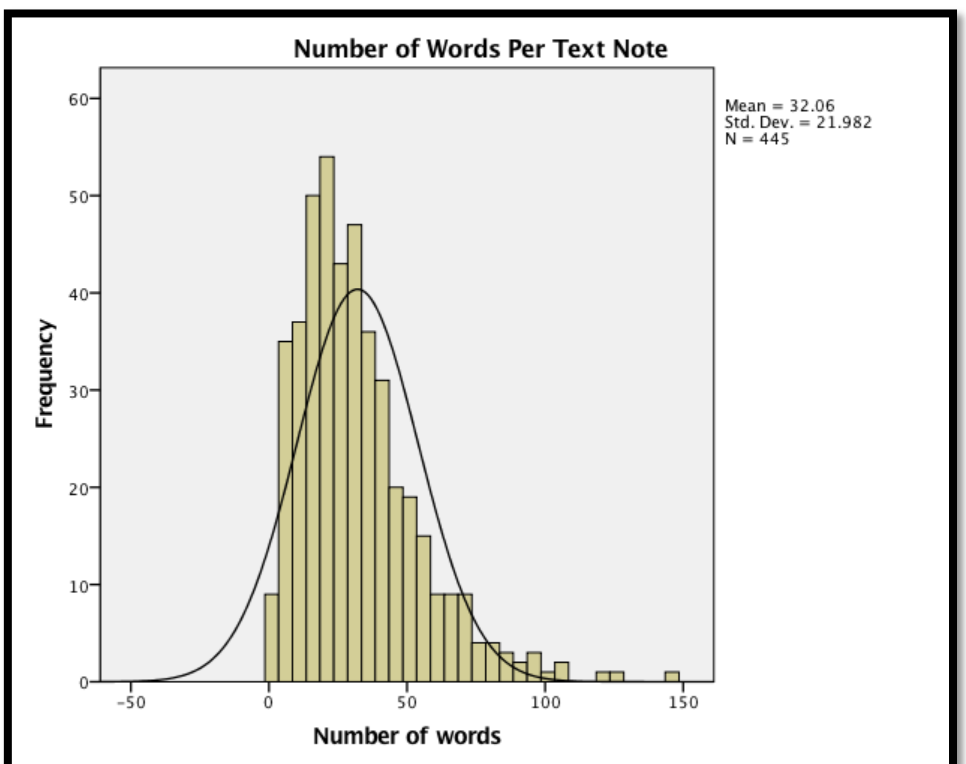

Figure 13: Frequency Distribution of Words Per Text Note

Table 7: Voice and Text Data Features

	Min	Max	Range	Mean	Standard Deviation	Sum
Time (seconds)	3	238	235	49.4	32	29,724
Length of Voice Note (words)	3	319	316	88.1	50.7	53,220
Length of Text Note (words)	1	147	146	32.1	22	14,266
Length of Voice and Text Note (words)	1	319	318	72.1	50.1	67,484
Number of Voice Responses	0	4	4	1.68	1.5	1,615
Number of Text Responses	0	6	6	0.91	1.1	871
Number of Non-responses	0	4	4	0.14	0.49	133

A more detailed voice, text and non-response frequency analysis is presented in Tables 8, 9 and 10. Of the 962 survey iterations, 66% (636) provided a voice note at some point during their participation, and when a voice-response was provided, most participants provided 2 voice responses. Moreover, 46.5% (447) of survey iterations provided a text note at some point during their participation, and when a text-response was provided, most participants provided 2 text responses, which were relatively more rare – 9.6% (66) of survey iterations had no voice or text responses at all.

Table 8: Voice Response Frequency

# of Voice Responses	Frequency	Report (%)
0	326	33.9
1	65	6.8
2	**348**	**36.2**
3	38	4
4	185	19.2

Table 9: Text Response Frequency

# of Text Responses	Frequency	Report (%)
0	515	53.5
1	119	12.4
2	**274**	**28.5**
3	14	1.5
4	39	4.1
6	1	0.1

Table 10: Non-response Frequency

# of Non-responses	Frequency	Report (%)
0	870	90.4
1	**64**	**6.7**
2	17	1.8
3	9	0.9
4	2	0.2

Table 11: Frequency Analysis of Response Preference by TOES design

TOES Version 1+2 (N=137), TOES Version 2 (N=95)			
	Survey Version	Frequency	Report (%)
Pure Voice Response	TOES V1+2	48	33.1%
	TOES V2	24	25.3%
Pure Text Response	TOES V1+2	35	24.1%
	TOES V2	32	33.7%
*< Voice Response	TOES V1+2	49	33.8%
	TOES V2	30	31.6%
*< Text Response	TOES V1+2	13	9.0%
	TOES V2	8	8.4%
Equal Preference	TOES V1+2	0	0.0%
	TOES V2	1	1.1%
**Voice & Text Response	TOES V1	64	44.1%
	TOES V2	25	26.3%

*Refers to participants who provided both voice and text responses, but mostly one over the other

**Refers to participants who provided a voice and text response for the same question

As seen in Table 11, of the 137 participants, 48 provided voice notes throughout the entire duration of their participation (i.e. voice notes provided for every question of every survey iteration), and 34 participants provided text notes throughout the entire duration of their participation. Additionally, there were 64 cases where participants provided both a voice note and a text note for the same question. By focusing on the most recent version of TOES (N=95), it is apparent that participants who did have a preference in how they provided data, it was to provide purely text responses over the course of their participation. In addition, there were 25 cases where participants provided both a text and voice note for the same question.

An analysis of the voice, text and non-response frequency by question type is shown in Table 12. The findings in Table 12 indicate that participants did not have a preference in providing voice or text responses by question when compared using a chi-squared test (χ^2=0.77), though; it was interesting to find that participants provided significantly more non-responses for Question 4 (χ^2=0.027).

Table 12: Frequencies of voice, text and non-responses by open-ended question type

Qualitative Survey Questions				
	Describe your environment: WHERE are you, WHAT are you doing, and WHO is around you.		Describe anything that has happened that changed how you feel since the last survey or the start of your trip? What are the most enjoyable and least enjoyable things you've experienced?	
	Frequency	Report (%)	Frequency	Report (%)
Voice Responses	354	53.6	346	53.2
Text Responses	298	45.2	282	43.4
Non-responses	11	1.7	27	4.2
Total	660	100.0	650	100.0
*Note this table only includes data from most recent version of TOES (N=95)				

Similar to the investigation in the tables above, it was also of interest to investigate the response preferences by each of the open-ended questions, shown in Table 13. Overall, and when compared using a chi-squared test, the differences by preferred response method are insignificant (χ^2=0.67). Regardless, it should be noted that participants who provided both voice and text responses to answer questions favoured voice notes.

Table 13: Frequencies of methodology preferences by each open-ended question type

Qualitative Survey Questions				
	Describe your environment: WHERE are you, WHAT are you doing, and WHO is around you.		Describe anything that has happened that changed how you feel since the last survey or the start of your trip? What are the most enjoyable and least enjoyable things you've experienced?	
	Frequency	Report (%)	Frequency	Report (%)
Pure Voice Responses	29	30.5	33	34.7
Pure Text Responses	32	33.7	30	31.6
* < Voice Responses	25	26.3	21	22.1
* < Text Responses	6	6.3	5	5.1
Shared Responses	4	4.2	1	1.1
Total	95	100.0	95	100.0
Voice & Text Responses	16	2.4	9	1.4
* "<" Refers to participants who provided both voice and text responses, but mostly one over the other				
Note this table only includes data from most recent version of TOES (N=95)				

Table 14: Methodological Response Variables (Length of Voice Notes, Word Counts and mean Response Types) by key Participant and Situational Variables

	Mean Time	Mean Word Count per Response			Mean Response Type		
Variable	Voice Note Length (Seconds)	Voice Note	Text Note	Voice + Text Note	Voice Response	Text Response	Non-response
Gender							
Male (N=78)	**52.2**	**93.9**	32.8	76.3	1.74	0.81	0.16
Female (N=59)	45.1	79.6	31.2	66.3	1.6	**1.04**	0.11
Stage of Trip							
Before Trip (N=125)	38	62.8	22.4	52.8	1.68	0.69	**0.29**
At Bus Stop (N=264)	48.1	89.3	29	72.5	1.76	0.88	0.1
On Bus (N=274)	53.9	90.2	**37.1**	72.8	1.44	**1.19**	0.15
After Trip (N=133)	**57.7**	**102.1**	32.5	85	1.93	0.71	0.1
Bus Route							
7 (N=124)	**43.1**	77.5	31.2	64	1.37	1.27	0.18
9 (N= 23)	75.1	113	46.1	98.4	2	1.21	0.08
12 (N=13)	60.4	99.2	41.4	92.2	2	0.69	0
200 (N=70)	63.2	99.8	45.2	85.7	1.71	0.93	0.11
Mall Trip vs. Mall Bypass							
Mall Trip (N=53)	44.9	85.2	31.3	68.5	1.63	0.86	0.14
Mall Bypass (N=84)	**52.9**	90.3	32.7	**75.1**	1.72	0.94	0.14
Weather Conditions							
Fair Weather (N=63)	48.8	87.2	**34.2**	71.4	1.62	0.98	0.14
Poor Weather (N=74)	49.8	88.9	30	72.7	1.73	0.84	0.14
Individual vs. Group Travels							
Individual Travel (N=97)	**54.2**	**91.2**	31.9	73.9	**1.81**	**0.99**	0.16
Group Travel (N=40)	37.8	80.1	32.1	67.1	1.35	0.71	0.08
1st-Year vs. 2nd-Year Students							
1st-Year (N=95)	49.5	86.5	28.9	72.8	2	0.9	0.2
2nd-Year (N=43)	48.9	**92.9**	**38.4**	70.4	1.02	0.98	0.04
Transit Experience							
High (N=69)	43.7	86.4	32.6	67.1	1.09	0.89	0.05
Moderate (N=12)	46.3	92.5	36.3	63.3	0.86	1.04	0.11
Low (N=56)	37.5	83	29.8	67.1	1.22	0.74	0.04
TOES Version 1 vs. TOES Version 2							
TOES Version 1 (N=42)	59.9	90.8	29.9	84.5	2.94	0.94	0.31
TOES Version 2 (N=95)	42.9	86.5	32.8	66.6	1.08	0.89	0.06

Data Quality							
Great Quality N=121)	49.3	89.3	31.2	73.3	1.63	0.83	0.08
Good Quality (N=16)	50.9	82.8	34.7	72.5	1.88	1.28	0.29
Bad Quality (N=8)	46.1	**54.9**	38.6	**43.9**	2	1.38	**0.76**
Anxious Iterations (N=179)	52.6	89.2	31.1	75.2	1.88	0.74	0.13
Non-anxious Iterations (N=410)	49.1	85.1	29.9	68.1	1.65	**0.94**	0.13

Table 14 explores the length of time participants provided voice data; the word counts for the voice notes and text notes; along with the survey response preference type provided in the qualitative component of the survey. Table 14 displays the differences of the 11 key participant and situational variables. As noted in the methods chapter, the word counts were measured using a formula in Microsoft Excel. The results reveal that the stage of the trip had the most impact on the frequency and length of all responses. While most of the voice data came from the bus stop and on the bus, participants provided longer voice notes after their trip averaging of 58 seconds, compared to the on the bus average of 54 seconds, the bus stop average of 48 seconds and beginning of trip average of 38 seconds. The overall difference in the amount of voice data provided at the end of the trip and at the beginning of the trip is a substantial 35%. Further, participants provided more words per voice note after their trip than at the start of their trip (102 words per voice note compared to 63, nearly 40%), while providing 90 words per voice note on the bus and 89 words per voice note at the bus stop. Regarding participants that provided text data, the hierarchy remains the same though with different values; that is, that participants provided more words after their trip than at the start of their trip. In addition, participants provided less voice responses on the bus than any other stage of the trip, which corresponds with participants providing more text responses than on any other stage of the trip. Lastly, participants were more likely to provide non-responses more at the beginning of their trip than at the bus stop and after their trip.

By bus routes, the only finding was that participants provided less voice data on bus route 7 than on any other bus. Participants felt more inclined to provide voice data on the 9 with an average of 75 words per voice note, followed by the 200 iXpress, with an average of 63 words per voice note.

Understanding how the survey was utilized in different weather conditions is of great interest because the results can be applied to future research. For example, understanding how participants interact with the survey methodology under differing weather conditions can be insightful for any future research that requires similar data collection methods (i.e. collecting data about: cognitive processing capabilities indoors vs. outdoor conditions; food choices in urban areas; transit experiences; etc.). Weather conditions were classified as either fair or poor. Participants provided fewer words per text response and much less text responses in poor weather conditions, which corresponds with the finding that participants in poor weather conditions provided more voice data than participants in fair weather conditions. However, participants in all weather conditions provided the same length of voice data per voice note with about 50 seconds per voice note on average. In addition, participants provided the same amount of words per voice note in all weather conditions – approximately 88 words per voice note.

Investigating how participants utilized the survey differently between those who travelled individually versus those who travelled with a peer or in a group yielded rather interesting findings. In particular, participants who travelled individually provided more voice data with an average of 54 seconds per voice note compared to the 38 seconds per voice note participants from participants who travelled in pairs or in a group – a 30% difference. Further, participants who travelled individually provided more words per voice note compared to those who travelled with others. Overall, participants provided more voice data travelling individually compared to travelling with others.

Investigating the difference between how first-year and second-year students utilized the survey was somewhat limited. While first- and second-year students provided voice notes similar in length – with approximately 49 seconds per voice note on average – second-year students provided more words per text note with 38 words per text note, while first-year students provided 29 words per text note. The variance in words per text note represents almost a 25% difference.

Participants were screened before participation to determine their degree of familiarity using public transportation. Regarding the level of transit experience, there were few findings in comparing how the survey was used differently between participants with low transit experience and participants with high transit experience. In particular, participants with high- and moderate-level transit experience provided lengthier voice notes compared to participants with low-level transit experience. However, there is only a difference of approximately 15%.

Regarding the data captured before and after the revisions were made to TOES, there were four key findings in comparing how the survey was used differently between the first and second version of the survey design. In particular, the first version of the survey yielded more voice data in length, with the average voice note of 60 seconds, while the most recent version of the survey yielded an average of 43 seconds per voice note – almost a 30% difference. In addition, TOES Version 1 participants provided more data (when combining voice and text note word counts) with an average of 85 words compared to the 67 words provided by TOES Version 2 participants – over a 20% difference.

By gender, it was found that males provided longer voice notes on average (52 seconds per voice note) than females (45 seconds per voice note), though a difference of only 16%. It was also found that males provided longer voice notes on average (94 words per voice note) than females (80 words per voice note), though again only a difference of 15%. Collectively between total data provided between voice notes and text notes, males provided more data on average (76 words per voice and text notes) than females (66 words per voice and text notes), though a difference of only 15%. Lastly, females provided more text responses on average (providing at least one text response) than males (providing 0.8 text responses), a proportional difference of 25%.

Comparing data quality, and in looking at the comparison between how each population sample differs, participants flagged for bad data quality spent less time providing voice data and words per voice note. Participants flagged for bad data provided an average of 55 words per voice note to match the 83 and 90 words per voice note for good and great data quality – a 34% and 39% difference, respectively. Overall, participants flagged for bad data provided much less data. The bad data was omitted from all other analyses.

A total of 30% (179) of all survey iterations recorded levels of anxiety; with 61.4% (89) of participants recording at least one anxious experience and 38.6% (56) of participants experienced no anxiety. Anxious iterations are those that reflected a value of 5 or greater on the "Relaxed/Anxious" scale question. The only discovery for the comparison was that there were less text responses in anxious iterations than non-anxious iterations. The results indicate that there is no major methodological difference between those who felt anxious and those who did not, which is a positive sign with respect to the methodology.

5.5. Quantitative Results of Wellbeing and Environmental Variables

5.5.1. Environmental Likert Scale Questions

The findings in this section pertain to the Likert scale survey questions regarding the environment and wellbeing of the participants. Over the 959 survey iterations there were a total of 2,600 positive feelings (54**%**), 1,450 negative feelings (30**%**) and 745 neutral feelings (16**%**) recorded by the 145 participants. Table 15 displays the results for each specific environmental feeling question in greater detail. Positive feelings are Likert scale values 0 and 3, with 4 being neutral, and negative feelings being values 5 to 8. As such, the positive and negative feelings were grouped from the corresponding values. Generally speaking, participants felt positive nearly twice as much compared to feeling negative when responding to how they felt about their environment. In looking at the percent values of the highest feelings of positivity, participants felt more positive when referring to their comfortability rating, more negative when referring to their environment being dirty, and most neutral when responding to their environment being cheerful or depressing. The comparisons were significant, when compared using a chi-squared test (χ^2=<0.00).

Table 15: Environmental Feelings Frequencies

How do you feel about your surroundings?						
	Clean/ Dirty	Empty/ Crowded	Cheerful/ Depressing	Open/ Enclosed	Comfortable/ Uncomfortable	Overall Average
Positive (N=2600)	48.5%	56.4%	49.0%	57.6%	59.6%	54.2%
Neutral (N=745)	14.4%	10.9%	21.5%	12.4%	18.5%	15.5%
Negative (N=1450)	37.1%	32.6%	29.5%	30.0%	21.9%	30.2%

Table 16: Mean Quantitative Environmental Variable Values for Question 2 of TOES

Variable	Clean/ Dirty	Empty/ Crowded	Cheerful/ Depressing	Open/ Enclosed	Comfortable/ Uncomfortable
	How do you feel about your surroundings?				
Gender					
Male (N=83)	3.6	3.3	3.5	3.3	3
Female (N=62)	3.6	3.3	3.5	3.2	2.8
Stage of Trip					
Before Trip (N=133)	3.6	2.8	3.3	2.3	2.3
At Bus Stop (N=278)	**4.1**	2.9	**3.9**	3	**3.4**
On Bus (N=294)	3.8	**3.9**	**3.8**	**4.6**	**3.3**
After Trip (N=141)	3.1	3	3	2.3	2.5
Bus Route					
7 (N=130)	**4.2**	**5.5**	**4.1**	**5.4**	**4**
9 (N= 24)	3.3	1.7	3.3	2.9	2.4
12 (N=13)	1.9	2.2	3.2	2.5	2.5
200 (N=74)	3.6	2.4	3.8	4	2.7
Mall Trip vs. Mall Bypass					
Mall Trip (N=57)	3.4	3.6	3.2	3.1	2.8
Mall Bypass (N=88)	**3.8**	3.1	**3.7**	3.3	3.1
Weather Conditions					
Fair Weather (N=68)	3.4	3.2	3.2	3.1	2.6
Poor Weather (N=77)	3.7	**3.5**	**3.7**	3.3	**3.2**
Individual vs. Group Travels					
Individual Travel (N=105)	**3.7**	3.4	**3.6**	3.3	3
Group Travel (N=40)	3.3	3.2	3.1	3.1	2.8
1st-Year vs. 2nd-Year Students					
1st-Year (N=103)	3.6	**3.5**	**3.6**	3.3	**3.1**
2nd-Year (N=43)	3.4	3	3.2	3.1	2.5
Transit Experience					
High (N=69)	3.4	3.2	3.4	3.2	2.9
Moderate (N=12)	3.3	3	3.5	3.2	3
Low (N=64)	3.9	3.5	3.5	3.2	3
TOES Version 1 vs. TOES Version 2					
TOES Version 1 (N=50)	3.9	3.5	3.6	3.4	3.2
TOES Version 2 (N=95)	3.4	3.2	3.4	3.2	2.8
Data Quality					
Great Quality (N=121)	3.5	3.3	3.4	3.1	2.9
Good Quality (N=16)	3.8	3.6	3.7	3.7	3.4
Bad Quality (N=8)	3.9	3.8	4	3.8	3.6

Anxious Iterations (N=179)	**4.3**	**4**	**4.5**	**3.9**	**4.8**
Non-anxious Iterations (N=410)	3.5	3.1	3.5	3.2	2.7

Table 16 explores the environmental Likert Scale questions of the survey by each of the key participant and situational variables. As seen in Table 16, there were numerous findings during the different stages of the trip. Notable participants felt their environment to be:

- cleaner during the end of their trip opposed to at the bus stop or on the bus
- more crowded on the bus than anywhere else
- more cheerful at the end of their trip than at the bus stop or on the bus
- more enclosed on the bus than anywhere else
- more comfortable at the beginning and end of their trip than on the bus or at the bus stop

Investigating how participants felt about their environment for each bus route is of great interest because the data can share insightful information for the local transit authorities (i.e. Grand River Transit). For example, participants reported that route 7 was dirtier more frequently than the 200, 9 and 12 routes, by 13%, 21% and 55%, respectively. Further, participants felt that route 7 was more crowded than the 200, 12 and 9 by 56%, 60% and 69%, respectively. Lastly, and unsurprisingly, participants claimed the 7 to be more enclosed than the 200, 9 and 12 by 26%, 46% and 54%, respectively.

The data suggests that participants who stopped in the mall seemed to have a better trip overall compared to participants who bypassed the mall. Participants who stopped in the mall reported a cleaner environment by 11% than those who bypassed the mall. In addition, participants who went into the mall more frequently reported their environment to be crowded compared to participants who bypassed the mall, by 14%. Lastly, participants who stopped in the mall felt their environment to be more cheerful than participants who bypassed the mall by 14%.

In comparing how participants felt about their environment in varying weather conditions, the data suggests that participants felt better for all environmental variables in fair weather conditions. However, the only findings were that participants felt their environment to be more crowded, depressing and uncomfortable in poor weather conditions, though the magnitude differential is a mere 9%, 14% and 19%, respectively.

Participants who travelled with a peer or in a group had more positive experiences on average than participants who travelled individually. However, the only findings were that participants who travelled with a peer or in a group felt their environment to be cleaner and more cheerful by a slim 11% and 14%, respectively.

Second-year students happened to have more positive experiences on average than first-year students for all environmental variables. First-year students felt their environment to be more depressing, crowded and uncomfortable than second-year students by 11%, 14% and 19%, respectively.

Regarding the comparison between anxious iterations and non-anxious iterations, every slider question yielded different averages. Participants who provided anxious iterations felt their environment to be more enclosed, dirtier, depressing, crowded, and uncomfortable than non-anxious iterations by 18%, 19%, 22%, 23%, and 44%, respectively.

5.5.2. Wellbeing Likert Scale Questions

Over the 958 survey iterations there were a total of 2,838 positive feelings (59%), 2,391 negative feelings (30%) and 1,756 neutral feelings (15%) recorded by the 145 participants. Table 17 displays the results for each specific wellbeing feeling question in greater detail. Generally speaking, participants felt positive nearly three times as much compared to feeling negative when responding to how they felt about their wellbeing. In looking at the percent values of the highest feelings of positivity, participants felt significantly more positive when referring to their safety, significantly more negative when referring to their excitement, and most neutral when responding to excitement and sociability (χ^2=<0.00).

Table 17: Wellbeing Feelings Frequencies

How do you feel about your wellbeing?						
	Relaxed/ Anxious	Happy/ Frustrated	Excited/ Bored	Social/ Irritable	Safe/ Unsafe	Overall Average
Positive (N=2838)	66.1%	61.4%	41.9%	54.1%	72.9%	59.2%
Neutral (N=1011)	13.2%	22.8%	25.7%	25.4%	18.6%	21.1%
Negative (N=941)	20.8%	15.9%	32.5%	20.6%	8.6%	19.6%

Table 18: Mean Qualitative Values for Question 3 of TOES

	How do you feel about your wellbeing?				
Variable	Relaxed/ Anxious	Happy/ Frustrated	Excited/ Bored	Social/ Irritable	Safe/ Unsafe
Gender					
Male (N=83)	2.5	2.8	3.7	3.1	2.1
Female (N=62)	**3**	2.9	3.8	3.2	2.1
Stage of Trip					
Before Trip (N=133)	2.3	2.3	3.3	2.6	1.6
At Bus Stop (N=278)	**3**	**3.2**	**3.9**	**3.3**	**2.4**
On Bus (N=294)	**2.9**	**3.2**	**4.3**	**3.5**	**2.4**
After Trip (N=141)	2.4	2.5	3.3	3	1.8
Bus Route					
7 (N=130)	3.2	**3.5**	4.3	3.7	**2.6**
9 (N= 24)	2	2.7	4.1	2.9	1.9
12 (N=13)	2.9	2.6	4.2	3.2	1.5
200 (N=74)	3	3.1	4.3	3.6	2.1
Mall Trip vs. Mall Bypass					
Mall Trip (N=57)	2.5	2.6	3.5	2.9	1.9
Mall Bypass (N=88)	**2.8**	**3.1**	**4**	**3.3**	**2.2**
Weather Conditions					
Fair Weather (N=68)	2.6	2.7	3.7	3	2
Poor Weather (N=77)	2.8	**3**	3.8	3.2	**2.2**
Individual vs. Group Travels					
Individual Travel (N=105)	2.8	**3**	3.8	**3.3**	2.1
Group Travel (N=40)	2.6	2.6	3.6	2.8	2

1st-Year vs. 2nd-Year Students					
1st-Year (N=103)	2.7	2.9	**3.8**	3.2	2.2
2nd-Year (N=43)	3.4	3	3.2	3.1	**2.5**
Transit Experience					
High (N=69)	2.8	2.9	3.7	3.1	2
Moderate (N=12)	2.3	2.8	3.7	3	1.6
Low (N=64)	2.6	2.9	3.9	3.2	2.3
TOES Version 1 vs. TOES Version 2					
TOES Version 1 (N=50)	2.7	2.9	3.9	3.3	2.3
TOES Version 2 (N=95)	2.7	2.8	3.7	3.1	2
Data Quality					
Great Quality (N=121)	2.7	2.8	3.7	3	2
Good Quality (N=16)	2.9	3.4	4.4	3.6	2.5
Bad Quality (N=8)	3.1	3.3	4.2	3.7	2.6
p-value	0.57	0.96	0.08	0.66	0.20
Anxious Iterations (N=179)	**6**	**4.6**	**4.6**	**4.5**	**3.5**
Non-anxious Iterations (N=410)	2.1	2.8	3.7	3.2	2.1

Table 18 explores the wellbeing Likert Scale questions of the survey by each of the key participant and situational variables. Similar to the environmental slider questions, there were numerous findings from the participant and situational variables for the different stages of the trip. Notable, participants felt their wellbeing to be:

- more anxious on the bus and at the bus stop than at the start of their trip and end of their trip by 26% and 21%, respectively
- more frustrated on the bus and at the bus stop than at the start of their trip and end of their trip by 39% and 28%, respectively
- more excited at the start of their trip and at the end of their trip than on the bus and at the bus stop by 31% and 18%, respectively
- more social at the start of their trip than at the bus stop or on the bus by 27% and 35%, respectively.
- more unsafe at the bus stop and on the bus than at the start of their trip and at the end of their trip by 50% and 38%, respectively

Investigating how participants felt about their wellbeing for each bus route is of paramount interest because the data can share insightful information for local transit authorities. However, there were only two findings regarding frustration and safety. The data suggests that participants felt more frustrated using the 7 than any other bus route, with the 9 and 12 being the least frustrating by a 34% difference. Participants also happened to feel less safe on the 7 compared to the 9 and 12, with the 12 yielding the highest levels of safety. In other words, participants felt the 7 to be less safe than the 9 and 12 by 37% and 73%, respectively.

The data suggests that participants who stopped in the mall – similar to the environmental comparisons – seemed to have a better trip overall. Participants who stopped into Conestoga Mall felt more relaxed, happy, excited, social and safe compared to participants who opted to transfer straight back towards WLU.

By looking at how participants handled anxiety, and if there were any interactive variables to accompany such feelings, the results indicate that participants who experienced anxiety felt more frustrated, bored, irritable and unsafe compared to non-anxious experiences by 64%, 24%, 41% and 67%, respectively. The data suggests that feelings of anxiety can greatly affect wellbeing, and ultimately add to the cost (or burden) of using public transportation.

Other differences in feelings of wellbeing included:

- females reported feeling anxious using public transit about 20% more often than males
- participants travelling in poor weather conditions felt more frustrated and unsafe than participants travelling in fair weather conditions
- participants who travelled individually felt less happy and less social than participants who travelled in pairs or in a group
- second-year students felt less safe than first-year students
- participants with low transit experience felt more anxious, frustrated and unsafe

5.6. Qualitative Results for Environmental and Wellbeing Open-ended Questions

This section presents a content analysis of what was actually reported in the voice and text responses, and how frequently. A total of 67,486 words from the Environmental & Wellbeing open-ended questions were analyzed (more than thrice the length of this thesis!). The total number of different words provided was 2,567 – a substantive variation in words, especially compared to closed-ended response sets. As seen in Table 19, the most frequent words used still only account for a fraction of the grand total of words. For instance, the word "bus" was the most frequently used word, but only accounts for 3.6% of the total words provided.

Table 19: Environmental and Wellbeing Open-ended Question Response Word Frequency

Word	Frequency	Report (%)
Bus	2,421	3.6
People	853	1.3
Just	750	1.1
Now	698	1.0
Stop	554	0.8
Mall	492	0.7
Waiting	478	0.7
Around	450	0.7
Enjoyable	414	0.6
Back	404	0.6
Really	397	0.6
Lot	377	0.6
Walking	376	0.6
More	362	0.5
Trip	350	0.5

As an alternative to frequency counts, and as a visual aid, word clouds were generated using *WordItOut.com*. The word clouds were designed to have size and colour hierarchy, where the larger and darker words reflect higher frequencies of that word being used during the qualitative component of the survey. Figure 14 depicts a word cloud where the parameters are set such that there is a maximum of 200 different words that have a minimum frequency of 40. As expected, the word with the highest frequency is the word “bus”; otherwise a wide variety of words appear. Figure 15 depicts an alternative word cloud where the parameters were set to have a maximum of 50 words where the minimum frequency was 200. In this case, only 33 words that have a minimum frequency of 200, and some other commonly used words are highlighted such as “people” and “stop”.

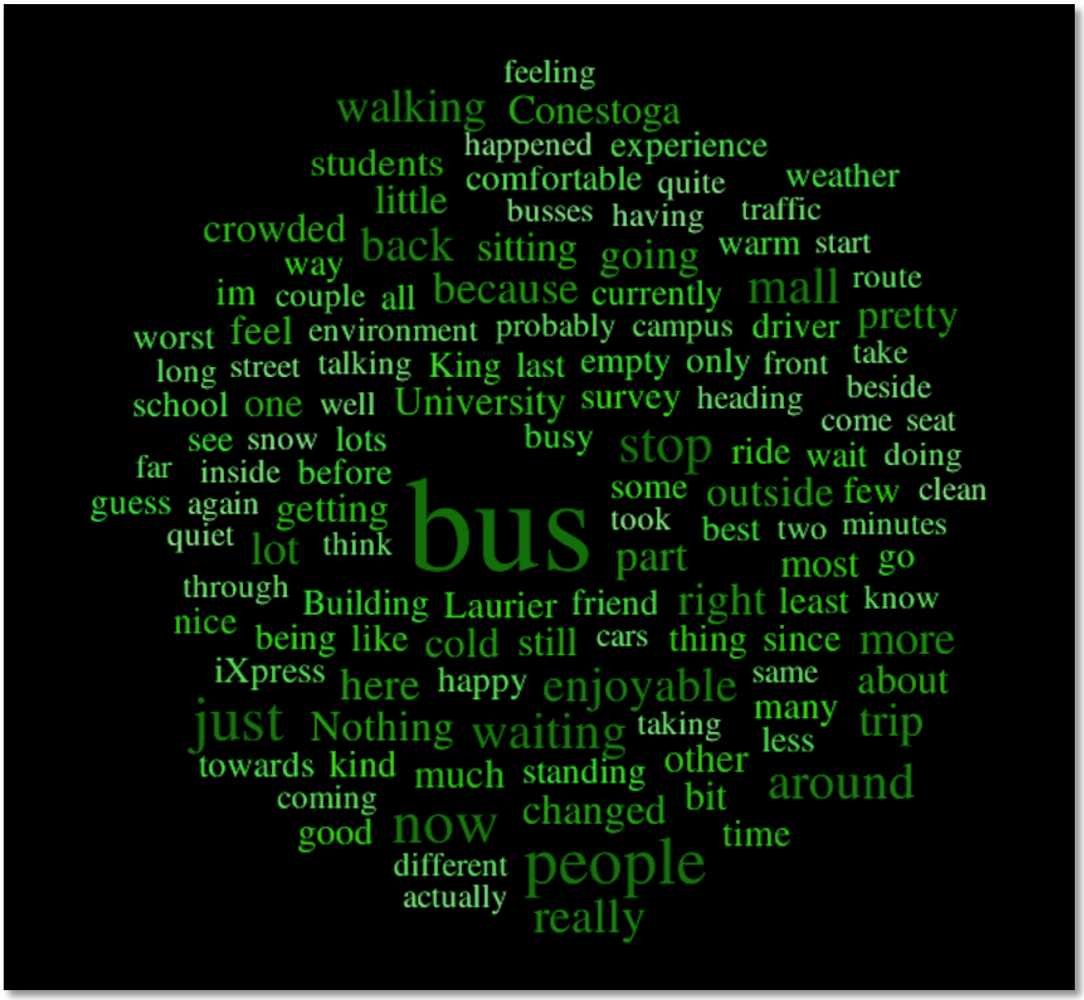

Figure 14: *WordItOut* word cloud by 200 different words with a minimum frequency of 40

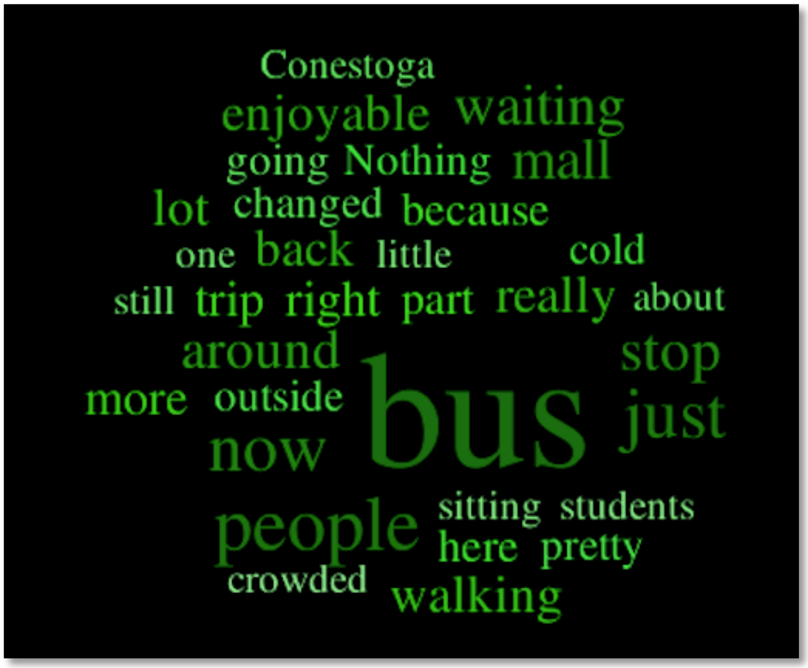

Figure 15: *WordItOut* word cloud by 50 different words with a minimum frequency of 200

Whilst word clouds provide a quick and simple visual analysis of word frequency, a more in-depth review through sifting, and sorting of actual responses (not just individual words) was used to identify 8 key themes, as shown in Table 20. Their overall frequency of mention, frequency by gender, and example quotes are shown. As seen, participants most often commented about poor weather conditions (38%) and crowdedness (23%). It is interesting to note that participants commented about poor weather conditions nearly four-times more than good weather conditions, despite poor weather conditions and fair weather conditions accounting for 53% and 47% of the surveys, respectively.

Table 20: Themes and Frequencies of Qualitative Data Verbalized for both Open-ended Questions

Theme	Example Quote	Overall Frequency	Overall % of N
Poor weather conditions	"It's raining and it's cold. Not much protection at this bus stop, broken glass for the bus shelter, so a lot of cold is coming in."	259	38.1
Crowdedness	"Some more people came on, so it's even more crowded now. Still have to stand pressed up against people, but it's okay, and should get to the mall in about 5 minutes."	158	23.3
Weather conditions/fresh air	"The most enjoyable part of the trip is being able to stand outside, good weather and a lot less people, so I'm less anxious and it feels a lot more clean."	75	11.0
Feeling unsafe or uncomfortable	"There's an old man who kind of started to have a conversation with me and it's a little bit uncomfortable. I'm smiling and trying to have a conversation with him, and we'll wait for the bus here."	61	9.0
Feeling anxious	"I'm really worried and have anxiety right now knowing that the trip is going to take much longer than anticipated. It's also cold outside, so it's making me very irritable and frustrated with everything around me."	46	6.8
Dirty bus/bus stop	"This bus is much dirtier than the last one, the puddles are even bigger, and the corners are filled with what looks like years of piled up mud. Not too much garbage around. I feel kind of dirty."	43	6.3
Seeing a new part of Waterloo	"I'm getting to see a part of Waterloo that I haven't seen before. This bus is going through neighbourhoods that I haven't seen."	24	3.5
Bus lateness	"I'm just at the bus stop, the only thing that has changed is that I'm getting a little annoyed because the bus is late."	13	1.9
Total		679	100.0

6. DISCUSSION

This thesis utilized an app designed to capture qualitative and quantitative in-situ data for students using public transportation in Waterloo, Ontario. The feasibility of the app was also explored to determine if the survey design is practical and can validate the results of the study. There were numerous qualitative, quantitative and methodological findings to be further discussed in this chapter, including their relationship to past literature, and contribution to bridging some gaps in our knowledge. In particular, there were several variables that impacted the methodological and empirical analyses. The most notable variables related to the methodology included: gender, stage of trip and travelling individually versus travelling with peers. The most notable qualitative results include: anxiety, stage of trip and participants who stopped into the mall versus participants who bypassed the mall. These are discussed in more detail in the following sections.

6.1. Methodological Interpretations

Investigating the effectiveness of the methodology was a key consideration for future research, given its relative novelty. The methodology was successful in a few key ways. First and foremost, the survey worked for 95% (137) of the participants, and the data gathered was rich in qualitative and quantitative data. 53,220 words of voice data and 14,266 words of text data were captured from a total of 8.3 hours of qualitative data. Such data was gathered over 1,615 voice notes and 871 text notes. The overall average number of survey iterations completed was 6.6 per participant, and included an average of 88 and 32 words per voice and text response, respectively. In addition, the maximum amount of words provided for a single voice and text response was 319 and 147, respectively.

Given that TOES offers the flexibility of providing voice and/or text responses for the qualitative questions, it was interesting to investigate participant preferences reporting their experiences. Participants provided their data purely in text or voice responses, or some combination of the two. Interestingly, just one participant provided an equal number of voice notes and text notes throughout the entire duration of their participation. Furthermore, participants generally opted to provide more voice data than text by a ratio of about 4:1, with only a few participants providing more text data than voice. While the preferences to which participants provided their data is not of paramount importance, it does indicate that participants might have a preference. This suggests that providing the flexibility for participants to use voice and/or text responses to report their experiences is imperative, and it is strongly recommended in future research.

The existence of item non-responses can provide insight into problematic sections of the methodology. It was found that most non-responses came from the second qualitative question of the survey, which asked "*Describe anything that has happened that changed how you feel since the last survey or the start of your trip? What are the most enjoyable and least enjoyable things you've experienced?"*. Furthermore, most of these non-responses tended to come from the beginning of the trip. The reason is likely because it may have been difficult to comment about anything that has changed at the start of the trip. In other words, several students opted to disregard the question because they felt that there was no appropriate answer. Such belief is rooted from several participants commenting about how it was difficult to answer this question at the beginning of the trip post-participation, and numerous students echoed this belief as a text or voice note. For example, students provided "nothing" or "the trip just started" as a response to the question. It makes sense that more non-responses come from the start of the trip because it might be difficult to comment about anything that has changed how one feels "since the last survey" or start of their trip, given that the trip had just started.

Delving into how the methodology was used by gender potentially shed some light for future research. The results suggest that males provided more voice data than females and that females correspondingly provided more text notes than males. Although there was no results to explain this, it may suggests that males are more comfortable speaking into the smartphone device, or that they prefer to use the easiest method possible to participate.

Regarding the methodological results for the different stages of the trip, participants provided more data at the end of their trip than at the beginning of their trip, at the bus stop or on the bus. Participants typically had little to report on at the beginning of their trip. Conversely, participants tended to summarize their entire trip from start-tofinish and comment about the overall experience participating in the study. Such commentary led to more data for the latter part of all trips on average.

Participants who travelled with peers provided less data overall, likely because they have more time on their hands, and more willing to elaborate further on their experiences without any peer pressure. This suggests that if the research can be carried out with individual participation, it is in the best interest to do so.

It is unsurprising that the length of voice notes were less for bus route 7 than any other bus route, combined with the provision of more text responses. This is believed to be principally due to the combination of a very crowded environment and feelings of awkwardness speaking into a phone in front of strangers. It is typical for mainline bus routes to be overused by transit-users given their routes provide access to key areas, which was why it was somewhat expected.

Weather conditions played a surprising role in the amount and types of data provided. Participants tended to provide fewer text responses and words overall in poor weather conditions, opting instead for more voice data. Several participants commented about the smartphone device being difficult to use when it was cold out. As such, participants may have been annoyed and felt less inclined to provide more full, rich qualitative data. Regarding participants providing more voice data in poor weather conditions, the BlackBerry Storm is a heat-sensitive touch-screen, and as such, participants likely opted to provided voice data in poor weather conditions because it was easier to provide data. That said, it was interesting to find that participants provided strikingly similar averages in data for poor and fair weather conditions, which can suggest that participants will provide the same amount of voice or text data regardless of weather conditions. This is useful for future research as it suggests that multiple entry methods are imperative if the instrument is used under real-world conditions involving changes in weather.

Anxiety was a common theme throughout the research, especially in the quantitative analysis; however, it was exciting to find that there is no difference in how the survey was used by people who were anxious. This finding might suggest that the survey design can be an effective and reliable method for a variety of research topics.

6.2. In-situ Transit Experiences

The actual reported experiences and feelings of transit riders captured by the in-situ methodology were of key focus of this research, and were found to vary by several factors. Most notably, anxiety, bus routes, stage of trip and participants who stopped into the mall versus participants who bypassed the mall yielded rather interesting findings to consider.

The experience of anxiety was a key focus of this research. It was interesting to find that females felt more anxious using public transportation. As highlighted in the results chapter, participants whom felt anxious throughout their participation felt their environment to be more: dirty, depressing, crowded, uncomfortable and enclosed; and felt more: frustrated, bored, irritable and unsafe about their wellbeing. This finding is similar to past research on how anxiety has adverse effects on the transportation experience. For example, Nour et al. (2010) suggests that anxiety may account for only 10% of the total cost of using public transportation in K-W; though, 5 to 10% of cases were anxiety-prone individuals where anxiety accounted for more than 50% of the total cost. It is acknowledged that some individuals deal with stress better than others and vice versa, so it is important to understand the 5 to 10% of cases where anxiety has a greater weight on the cost of using transit, and to accommodate such individuals with introspective research into what variables can be modified to improve the transit experience as a whole.

Participants felt most negative and less happy using bus route 7. One of the largest differences was likely that the 7 was dirtier than all other busses, likely resulting from it being a mainline bus route. Almost every participant took the mainline bus route 7 to Conestoga Mall, which also happened to be more crowded than any other bus used. As such, it is no surprise that crowdedness was higher on the bus than any other stage of the trip. In addition, it was also interesting that participants felt more depressed and uncomfortable at the bus stop or on the bus, compared to the beginning or end of their trip, which might suggest that using public transportation can be both uncomfortable and depressing. Further, participants felt more anxious, frustrated, bored, irritable, and unsafe at the bus stop and on the bus, compared to before and after their trip. As such, there are clearly areas of public transportation that could be modified to ensure the total perceived cost of using public transportation is not too high for students (and likely non-student cohorts as well).

Weather conditions played an interesting role on reported experiences and feelings throughout transit trips. Notably, participants felt more crowded and uncomfortable in poor weather conditions. Presumably, people are more inclined to stand under a bus shelter and use public transportation in poor weather conditions, which was echoed in numerous responses by participants themselves in the qualitative component of the research. Further, and unsurprisingly, it was found that participants felt more depressed in poor weather conditions. Most likely, people simply do not want to be outside, let alone travel, in poor weather conditions, which happens to have corresponding findings of participants feeling less happy and less safe travelling in poor weather conditions.

On the bright side, it was found that participants who travelled with a friend or a group of friends had a better trip overall. Participants who travelled with peers felt more cheerful, happy and social. In addition, and interestingly, participants who travelled with peers also happened to feel that their environment was cleaner. It is possible that feeling happy and being with friends in a social environment deters one's attention from the cleanliness of their environment. It is also possible that commuting with peers and feeling more happy and social creates a better environment.

It was interesting to find that participants who stopped into Conestoga Mall felt more happy, excited, cheerful, social and safe, compared to participants who opted to transfer back to WLU and bypass Conestoga Mall. It is likely that participants whom stopped into the mall felt more positive because of the utility of the activities at the destination such as buying new items and visiting marketplaces (consumer satisfaction). Furthermore, participants who stopped in the mall felt less anxious – perhaps spending money at malls really are a form of "retail therapy".

Additionally, it was interesting to see how 1st-year students experienced the GRT differently than the 2nd-year students. In particular, it was found that 1st-year students felt their environment to be more crowded, depressing, uncomfortable and unsafe. These findings might suggest that the 2nd-year students have adjusted more, accepted more, or generally become less aware/concerned of negative aspects of the bus environment.

These findings may support the notion that people may easily acclimatize to new transit systems or using public transportation, given that just a one-year difference yielded more positive experiences overall.

6.3. Practical Implications and Future Research

Measuring actual in-situ transit-user experiences was shown in this thesis to be valuable in understanding specific details about transit experiences such as sources of anxiety. By gathering specific information about transit experiences, we can infer in greater detail what issues need to be addressed, in what situations, by whom, and to what extent. However, this research was limited to a single trip from a university to a regional mall by students, and thus could use expansion in the future. In the least, it demonstrates how smartphone technologies could potentially reduce the burden and expense of mass-scale data collection efforts.

The desire to shift from an auto-dependant to a transit-dependant community in high-density urban environments would likely be well served by an enhancement of transit experiences. Enhancing transit experiences may require similar research taken further to investigate areas that can be adjusted to potentially help modify general negative experiences. The success of the method and relative ease of implementation via smartphones, combined with the existence of significant negative experiences in certain situations and market segments, suggests that the very same methodology could be modified to potentially address such issues. The TOES has shown promise in its feasibility and effectiveness in capturing meaningful data, and extensions of the research can potentially be uplifted with the help of crowdsourcing efforts. For instance, an app similar to Tiramisu (Steinfield 2010; Steinfield et al. 2011; Zimmerman et al. 2011) could be developed for transit-users to report transportation infrastructure issues to local transit authorities to queue, and users can potentially adjust their schedule based off the "real time" data provided by the transit-user community.

A major consideration for future research is to place more emphasis on the influence anxiety has on using public transportation. While bus schedule reliability is unanimously the more significant source of travel-related anxiety, this research finds that anxiety can derive from many other environmental and wellbeing variables when using public transportation. For example, females tended to feel more anxious than males, and participants travelling individually yielded higher levels of anxiety. Given that the study sample is limited, such insights are examples of how travel behaviour-based models developed by Casello et al. (2009) and Nour et al. (2010) can recalibrate metrics used to exemplify variables representing different transit-user groups when modelling the total cost of using transit when in-vehicle trips are longer than anticipated. In addition, Nour et al. (2010) admit that the weights asserted on the anxiety component of the modelling efforts have little basis, other than that they are within an acceptable range presented in literature. As such, there is a pressing need to find appropriate weights to represent anxiety for each of the risk aversive groups outlined in the work of Casello et al. (2009) and Nour et al. (2010) to increase accuracies of their behaviour-based models.

Gathering in-situ transit experience data can greatly benefit from the addition of a reliable and battery conservative GPS-tracking component. In addition to providing qualitative and/or quantitative data, the GPS component may enable researchers to make spatial inferences regarding negative transit experiences, such as linking certain environmental and wellbeing variables to specific locations. Further, GPS tracking could be used to automatically know which bus route participants are using. Doherty and Ettema (2006), Casello et al. (2009) and Nour et al. (2010) discuss a similar survey design to the TOES where smartphone devices are synced with GRT route schedules to recognize bus stop locations and calculate variances in arrival times. Nour et al. (2010) further adds how such methodologies can develop appropriate weights for the anxiety component of the generalized cost model to more accurately understand the total cost of using public transportation. It is hoped that future research will include the addition of GPS bus arrival measurement tools; as such efforts are important to validate and/or contribute to the accuracy of travel cost modelling. Furthermore, and in considering crowdsourced data and how commonplace smartphones have become, future survey designs have considerable potential to: be calibrated for various bus networks; capture rich data and further delve into understanding the transit experience; and ultimately, understand what factors can be fine-tuned to create better transit experiences.

In future applications of this (or similar) methodology, it is recommended that data be collected over longer periods of time. Initially, one may believe that participants will eventually develop some type of fatigue, though this can be avoided with appropriate controls. Exploring how participants feel using public transportation over several trips can cater to an array of different analyses. For example, exploring how (experienced and non-experienced) participants vary in their experiences trip-to-trip, time of day, in differing weather conditions, and beyond. Further, it would be interesting to see if non-experienced participants gradually felt better about using public transportation, and how short (or long) it took for such participants to adapt to a transit lifestyle. The ultimate objective is to more intimately understand and measure the many variables that influence the transit experience as proof to aid policy makers in making decisions with respect to budget-straining transportation infrastructure projects.

6.4. Challenges and Limitations

First and foremost, the data that was collected was not the most reflective of the transit-user population. The data sample is chiefly a student population sample, and even then, may not necessarily represent students of different demographics or from different departments. Students were gathered from geography classes, and all students were called upon for their participation, if captivated, for bonus marks. Despite all students from the geography classes being provided with and equal opportunity to participate in the study, this introduces a self-selection bias into the study.

The data is also derived from a self-report study, which can be prone to validity problems. For example, self-reported answers can be exaggerated or skewed from the truth. However, unlike most self-report studies, this thesis avoids the social desirability bias by having participants provide data in the absence of the researcher. However, this too can be a limitation as the researcher may have little knowledge about the context or the setting in which the data is provided, and participants may not follow instructions in the absence of the researcher. While the context may not have been entirely understood, instructions were followed 95% of the time, which is great.

It is also acknowledged that the dataset is prone to a repeated observation bias resulting from using averages of repeated observations, which inevitably compress the tails of the data distribution and generating lead to artificially smaller standard deviations. While this is acknowledged, the research presented is very much exploratory, so I went ahead with breaking the rule. However, when comparing the compiled averages of the quantitative data with the individual participant averages form their respective iterations, the differences were insignificant.

The data sample included an uneven number of males and females, which can be perceived as a limitation. Males represented 57% of the data sample while females represented 43%. However, the results indicate that there are no differences between the two genders with respect to the environmental and wellbeing variables, with the exception that females tend to be more susceptible to feeling anxious while using public transportation. Methodologically speaking, males provided more voice data, while females provided more text responses.

Investigating how, and to what extent, weather played a role on transit experiences; weather was clumped into fair weather and poor weather. Future research can delve into greater detail and benefit by gathering local weather data for each hour (or half-hour) and each day of participation, and apply exact temperatures to the corresponding participants. Such an effort can provide insight into any thresholds in how participants utilize the survey, or feel about their environmental and wellbeing variables, and ultimately, provide a more precise analysis.

The touch-screen on the smartphone devices are heat-sensitive. As such, and on several occasions during cold weather, participants were unable to text to provide their responses when waiting at the bus shelter or on the walk outside to the first bus stop. This shortcoming required provision of an “NA” in the corresponding grid cells to more accurately calculate for the non-responses. Further, and while rarely, participants communicated that it might be found to have a partially completed survey due to a survey glitch (independent from poor weather conditions), and a note was made of where the glitch occurred (i.e. at the first bus stop, on the second bus, etc.). In organizing and cleaning the data, such notes would make it evident that a glitch did occur, and an “NA” was entered into the corresponding grid cells for that survey iteration that might appear to be a non-response (or an “NR”). Such glitches are a shortcoming because it is unknown why the survey may opt to close itself, which can also influence the data results to some extent.

7. CONCLUSIONS

With population increases and more drivers on the road, traffic congestion within the Greater Toronto and Hamilton Area continues to rank as the worst in Eastern Canada and greenhouse gas emission contributions continue to increase. It is promising that the provincial government has invested billions of dollars into public transportation projects Southern Ontario, enabling several communities to adopt LRT systems and enhance public transit. As supported within the literature (O'Sullivan & Morrall 1996; Cervero & Kockelman 1997; Handy et al. 2005; Caulfield & O'Mahony 2009), the built environment is fundamental in marketing transit-usage, though it can be argued that measuring transit experiences are equally (if not more) important in understanding the total cost of using transit (Casello et al. 2009; Nour et al. 2010; Casello et al. 2012).

As in this thesis, measuring in-situ transit experiences can enable researchers to understand how transit users are feeling, why they are feeling and to what extent they are feeling positive or negative, and if certain conditions induce or reduce such feelings. With the use of open-ended questions and Likert scale bars to collect data, it was found that anxiety played a key role in the use of public transportation. In other words, participants who experienced anxiousness felt more negative for all ordinal variables measured on average than participants who did not feel anxious, which can speak to how important it is to consider anxiety when generating travel cost models. Such findings can contribute towards enhancing current travel cost models that lean on anxiety to more accurately measure the total cost of using public transportation.

The Experience Sampling Method has provided a great insight into how participants feel using public transportation. While 95% of the data collected was usable, the population sample is limited to a student sample of the transit-user population, which was also introduced to a self-selection bias. Regardless, this thesis has demonstrated that apps such as TOES can capture a range of empirical observations of the transit experience in novel ways using smartphone technologies. Ideally, future research of this nature ought to modify the survey design, reflect a diverse transit-user population and add a GPS component to enable various types of spatial analyses. In addition, it would be most appropriate if such research is carried out by and marketed as a Metrolinx initiative to gain rapid traction. Metrolinx has tremendous influence on numerous transit-related matters within the GTHA, and it can be effective for Metrolinx to induce transit-users to partake in such crowdsourcing efforts with minor incentives, such as awarding Presto credits to useful data providers. Such efforts can address the pressing need to mitigate traffic congestion (to some extent) in the short-term, while having a lasting impression and serving as an analytical tool to be utilized by policy makers and project managers for ongoing policy interventions.

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