Voice-To-Text Usage Amongst Users of Different Age Groups

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Abstract

The present investigation represents an attempt to discover the role of using voice to text (V2T) entry in the context of age against manual text entry. Three hypotheses were formulated, one postulated that manual text entry times are slower than the entry times for voice-to-text. The second hypothesized that text entry on the phone is faster for young users than for older users, and the final hypothesis proposed that text entry employing the use of texting abbreviations (ROTFL, OMG, LOL) will speed up manual text entry, but will not show a similar benefit for voice-to-text. Three studies were conducted. The first involved a qualitative interview. The second study employed a qualitative survey to participants, and the third study involved texting times, the use of abbreviations, and error rates amongst young participants and old participants across two conditions: manual text entry and voice-to-text entry. All three hypotheses were confirmed by the results of the experimental study.

Keywords: voice-to-text, manual text entry, age effects

Voice-To-Text Usage Amongst Users of Different Age Groups

Text messaging has quickly become a primary method of communicating with each other. In 2005, there was an average of 7.2 billion text messages sent each month. More recently, in 2017, that number has grown exponentially to 781 billion text messages sent each month (Statistic Brain Research Institute, 2017). Because text messaging has exploded in popularity, the smart phone application market for text messaging apps have grown as well, making a variety of texting applications available to the public for any context imaginable, keeping us more connected than ever. For example, the application LINE allows users to video chat through their smart phone's camera, and allows users to send 'stickers', cute digital images of licensed characters which convey the user's emotion, similar to emojis. Snapchat is an application where the messages and images sent between users disappear within 24 hours of sending them. The popularity of communicating with other people through text messaging has increased the demand of reliable text entry methods. Currently, there are different manual inputs like one-finger 'swiping' type manual input, standard QWERTY virtual keyboards, and QWERTY and T9 format input using physical buttons on the phone (Smith & Chaparro, 2015).

Using your hands to input text is contraindicated in situations like driving, where your attention must be occupied elsewhere. Users who have limited hand dexterity through motor impairments also cannot use manual text entry (Corbett & Weber, 2016). Voice-to-text (V2T) is an alternate method of text entry in these situations, where limited hand availability and limited visual attention is indicated (Corbett & Weber, 2016). Voice-to-text is a method of transcribing voice input into text, allowing the user to talk into their phone's microphone and have the program transcribe the input into outputted text. Voice-to-text technology also has been used to support deaf and hard of hearing students in education, by transcribing the educator's voice into text in real time (Stinson, Elliot, Kelly & Liu, 2008). Additionally, V2T is used in the educational environment to deliver lectures to students who are otherwise unable to attend the class, and assist students who have difficulty typing on a traditional keyboard (Wald, 2016). Due to the advances in speech recognition software, major phone companies have included voice-to-text standard in their cell phones as a method of text entry (Ruan, Wobbrock, Lios, Ng, & Landay, 2016).

Voice-to-text may not only be just an alternative to manual text entry, voice-to-text input may also be faster than manual text input. Past research has demonstrated that voice-to-text entry was three times faster than manual input (Ruan et al., 2016). In addition, there were about 20% fewer errors while using voice-to-text than manual input (Ruan et al., 2016). While voice-to-text has be demonstrated to be faster than manual input in the past, there may be confounding factors explaining why people do not adopt this technology instead of manual texting. There may be factors such as privacy concerns, or not using the technology due to transcription errors, which may result from background noise (Janíček, Velíšek, Holubek, & Ružarovský, 2019). Younger people might also hold the belief that manually texting is actually faster than having a conversation on the phone, the comfort level skewing the younger people's perception of brevity (Peltier, 2019). The use of text messaging by younger cell phone users outperform the use of talking on the phone, where the average monthly number of voice minutes used by cell phone users aged 18 to 34 years old decreased from about 1200 voice minutes in the year 2008, to 900 voice minutes in 2010, while the monthly amount of text messages sent increased from 600 in the year 2008, to over 1,400 in 2020 (Howe, 2015).

Adoption of smart phones have steadily increased over time. As of 2019, over 91% of Americans own cell phones, 81% of those phones being smart phones (Pew Research Center). As more of the total population uses cell phones, interest has turned to the effect age has on cell phone usage. At the time of writing, over 91% of those aged 65+ own a cell phone, with 53% of Americans aged 65+ owing smart phones (Pew Research Center, 2019). A previous study performed by Smith and Chaparro (2015), found that older people (over the age of 60) prefer cell phones with tactile, physical keyboards, which may explain their hesitance to adopt smart phones with touch screens. Another finding showed that voice input performance between younger and older adults did not differ, and both groups reported that voice input was, "fast, easy, and accurate" for entering text (Smith & Chapparo, 2015). In addition, older adults have many cognitive and physical limitations where manual text entry is limited (Smith & Chapparo, 2015).

Our motivation for this study is to examine voice-to-text in the context of age. In this study, we began by assessing user's opinions of using voice-to-text through a qualitative interview. We were unable to have a sufficient sample size for the qualitative interview, so we then conducted a qualitative survey to assess users' voice-to-text habits. Finally, we conducted an experimental study exploring the speed of using voice-to-text against factors of manually entering text using a cell phone, age, and the use of text abbreviations. To date, there are no previously studies exploring all of the factors together.

We have hypothesized that manual text entry times are slower than the entry times for voice-to-text. Additionally, we predict that text entry on the phone is faster for young users than for older users. Finally, we hypothesize that text entry employing the use of texting abbreviations (ROTFL, OMG, LOL) will speed up manual text entry, but will not show a similar benefit for voice-to-text.

Experiment One: Qualitative Interview

The goal of this study is to gain knowledge about the habits of using voice-to-text across different age groups. We also set out to understand why the participants use voice-to-text, why the participants do not wish to use voice-to-text, and which devices the participants typically use to deploy voice-to-text input. This information will allow us to understand if there are different attitudes between young people and older adults.

Experiment One: Methods

Participants

For the qualitative inquiry, we interviewed 29 participants in total, ranging in age from 19 to 57 years of age. All of the participants are volunteers and were sampled through convenience sampling. These participants were recruited directly by the students in our class (PSYC 512, Research Methods, University of Idaho), and are mostly comprised of family and friends. Because this was a class project, IRB approval was unnecessary.

Materials and Procedure

The qualitative interview was completed using a writing instrument, paper, and the use of a computer with word-processing capability.

The qualitative interview was comprised of a nine-item questionnaire presented in a structured manner. The structure for the qualitative interview was developed from studying the existing literature of voice-to-text studies, and through developing and combining researchers' assumptions of voice-to-text related to age, context of use, and usage habits.

Each participant was either directly talking with the researcher in person in a predetermined meeting point (home, or at an external, relaxed atmosphere environment like a café), or the participant corresponded through texting or email. The structure of the interview follows a question and answer protocol, where the researcher asks a question about voice-to-text that is predetermined, and the participant responds. Each response was recorded underneath of the corresponding question, and everything was compiled into “take home points” that summarized findings that the researcher deemed as important. The full interview’s structure is included in Appendix A.

The interview’s script followed a linear set of questions that were predetermined. The first question in the interview asks the participant’s age. The second interview question asks if the participant has ever used the voice-to-text feature on their phone. The third question asks the participant how they discovered or learned about the voice-to-text feature. The fourth question asks the participant which devices they use that have the voice to text feature. The fifth question explores if the participant does not use voice to text, why they do not use the feature. Sub-question related to question five asks if there are any times where the participant might not want to use the voice-to-text feature, and if there is anything that might want to make the participants use the feature in the future. A sixth question asks if the participant knows someone who uses the voice-to-text feature, the situations and environments in which they use the feature, and that person’s age and if they use voice-to-text around that participant. A seventh question asks the participant to describe and experience using the voice-to-text feature, and if there are other scenarios or circumstances that the participant would use the feature in, which situations the voice-to-text feature is helpful, if the participant feels that using the feature is a convenience or an inconvenience, what the participant thinks can improve the voice-to-text feature, and what they like about voice-to-text. An eight questions asks if the participant uses voice-to-text alone or around other people. Depending on the participant's answer, the interviewer would then ask why the participant chooses to use the feature while they are alone or around others. A ninth question again asks if the participant can change anything about the voice-to-text feature, what would they change and why.

After the interview, we thanked the participants for their time.

Experiment One: Results

The qualitative survey illuminated some important beliefs the participants hold about using voice-to-text systems.

A major issue for the infrequent use of voice to text was because of the participants' concern for their privacy. Another negative belief the participants hold about voice-to-text involves social etiquette, or how the participants believe what others think about them. One participant, upon being asked whether you use the feature while alone or with others, replied, "Don't want people to think I am a crazy person". I have extracted that this participant is concerned that talking to their phone without another person talking back would be seen as odd to other people. Another participant responded to the same question, "Honestly I would feel awkward, maybe a little embarrassed, to use it around other people." Furthermore, a different participant explained that they do not use voice-to-text in public because "he doesn't like to bother other people, "and I don't like others to hear my texts.". I have extracted from these statements that multiple participants hold the same belief that the decreased use voice-to-text is due to privacy issues.

Another negative belief the participants held about using voice-to-text was that using voice-to-text was inaccurate at transcribing their voices. I have extracted this negative belief from the statement, “The forced dictation one must employ to ensure accuracy in V2T can become annoying in the company of others, especially when inevitable errors in transcription are made and repetition is necessary”. Another participant stated they would like to use voice to text more often, “...if it was better at understanding my voice. The system does not seem to learn more as it is used and stays static.”, showing that this participant also does not believe voice-to-text transcription is accurate.

Experiment One: Discussion

A main point that was found from conducting the qualitative interview was that multiple participants revealed the reason for not using voice-to-text or using it infrequently was because of privacy concerns. One participant described voice-to-text as, “odd, annoying, other people shouldn’t have to listen to my texts, and it’s a breach of privacy”. I have extracted avoidance of using voice-to-text around others as a violation of privacy from this statement. Other participants have also cited privacy concerns, as well as not wanted to disturb others around them by talking to their phone to use voice-to-text as a violation of social etiquette. The participant who stated having to repeat what they say in public because the system did not recognize their voice is embarrassing explains a potential reason why users see voice input as a violation of social etiquette.

The interview also highlighted the context people would use voice-to-text in, like while driving a vehicle, or in a situation where your hands are dirty (while cooking). This affirms an assumption I had that people typically use voice-to-text in the context of having their hands occupied. One participant mentioned that their aunt heavily used voice-to-text input because they are visually impaired, so exploring the use of voice-to-text with those who are physically disabled would further be useful.

While we received information regarding preferences of using voice-to-text, Another limitation of this study was many of the participants described the qualitative interview's questions as redundant, asking the same questions over and over again, potentially causing boredom with the interview, decreasing the quality of subsequent responses, or having an opposite effect where the participant would add more information each time the question was asked.

Due to a low sample size, we decided a survey would need to be formulated in order to understand more information about V2T usage to get more quantifiable and more qualitative data from younger users and older users.

Experiment Two: Qualitative Survey

After the qualitative interview was conducted, we then formulated a qualitative survey based on our initial assumptions about voice-to-text. Additionally, potential questions were presented among the class via Slack's chat function and were selected for the final survey depending relevancy to the research questions posed.

Experiment Two: Methods

Participants

We surveyed 59 total participants using the Qualtrics platform in order to reach a wider audience, resulting in a larger sample size. These participants were recruited through distributing the link to the survey through social media, email, and word of mouth through convenience sampling.

Materials

The survey that was conducted was comprised of 23 different items divided into four blocks. The first block serves as an introduction to the survey, one item long. The second block asks for demographic data from the participants, which is comprised on 11 different questions., the second block asks the participants about phone usage and whether they use voice to text the third block of questions asks about the context of using of voice-to-text as well as their ranking of features in terms of importance.

Procedure

The survey, in its entirety, is provided in Appendix B.

The structure of the interview begins with the first few questions, which asked the participants about their demographics, including how old they are, is English their native language, and a self-evaluation of their English language ability.

The structure then moves into questions about their beliefs and behaviors involving the use of cell phones. These questions ask how the participant types on their phone, if they have dexterity issues which makes typing on a cell phone difficult, how important their cell phone is to them, their cell phone upgrade behaviors, and which electronic communication devices the participants own. The questions also ask if the participants know about and use the personal dictionary feature on their phone, asks for a self-report of how quickly they can type on their phone, and how many text messages they send per week and per day.

Next, the structure of the interview assesses the participants knowledge about voice-to-text. These questions ask if the participants have ever used V2T, and if they have not, why they do not use it, which devices they have used for voice-to-text, how often they use V2T, their personal experience with using V2T, and which situations people are more or less likely to use V2T. The participants are then asked to estimate the speed of V2T compared to manual text entry, then finally, asked to rank how features determine whether the participant uses or does not use voice-to-text.

Experiment Two: Results

For the age question, three participants (5.08%) reported being in the below 18 years old bracket, 24 participants (40.68%) comprised the biggest age bracket of 18-29 years of age, 9 (15.25%) participants are between the ages of 30-39, 3 participants (5.08%) are between the ages of 40-49 years of age, 8 (13.56%) of participants were between the ages of 50 and 59, 9 participants (15.25%) were between the ages of 60-69, and finally, there were three (5.08%) participants who were above 70 years of age, totaling 59 participants.

When asked if English was the participant's first (native) language, 54 (91.53%) of respondents replied "yes", and 5 participants (8.47%) replied "no".

When asked about their dexterity and visual disorders, 47 (79.66%) participants have no problems that impair the use of their hands, while 16 (27.12%) complained of hand pain. 23 participants (39.66%) report that they have excellent vision, while 27 participants (45.76%) report not being able to see without their glasses.

Regarding typing speed, 34 (57.63%) of participants report typing faster than the average user on a computer keyboard, 21 participants (35.59%) report being able to type faster than the average user on a smartphone. 26 participants out of 59 (44.83%) report often not hitting the right key when typing on a smartphone.

When asked if the participants' cell phone was important to them, 39 (67.24%) of participants agreed. 32 participants (55.17%) agreed that that they were very good with technology, while 11 participants (19.30%) agreed that they usually rely on others to help them with technology. Only 18 out of 59 participants (31.03%) love the idea of virtual assistants being able to be controlled by voice.

We found that most of the participants own an iPhone (43, 74.14%), while 20 participants (40%) use an android device. 53 (92.98%) participants own a laptop computer, 33 (61.11%) participants own a desktop computer, 32 participants (59.26%) own a tablet or iPad, and 17 (34.69%) participants own a virtual assistant (Alexa, Google Home, etc.)

35.5% of participants surveyed have added custom words or phrases to the personal dictionary, 32..2% know about the feature, but do not use it, and 32.2% of the participants do not even know what that feature means, an almost complete split.

When asked to compare their cell phone typing speed against the average person, 16 (27.12%) participants answered that they typed "extremely well", 12 (20.34%) reported "very well", 20 (33.90%) reported "moderately well", 9 (15.35%) reported "slightly well" and two (3.39%) reported "not well at all".

Participants were asked how they type on their phone. 14 participants (24.14%) reported that they always type with one index finger, six (10.34%) participants reported always typing with one thumb, 33 participants (55.93%) reported always typing with both thumbs, three participants (5.26%) reported typing with multiple fingers and thumbs, four participants (6.90%)

reported typing using SWYPE instead of touch tapping, and one participant (1.72%) uses a different method for manual text entry.

Participants were asked how often they send messages using smart devices. The answers were split, six participants (10.17%) reported sending text messages less than once a week, six participants (10.17%) reported sending text messages a few times a week, seven participants (11.86%) send 1-2 text messages a day, 13 (22.03%) participants send less than ten text messages per day, 16 (27.12%) participants send less than 50 text messages a day, and 11 participants (18.64%) report sending more than 50 text messages in a day.

Participants were asked whether they have used the voice-to-text feature. 12 participants (20.34%) report that they have never used V2T, 29 participants (49.15%) report using V2T a few times, and 18 participants (30.51%) report often using voice-to-text. The participants who reported not using voice-to-text received a follow up question asking to describe why they did not use V2T, participants reported the following: "I often want to be quiet when I am texting (the environment may be sensitive, like a public setting, restaurant, or while i am watching tv with others). Voice-to-text would require me to speak aloud - and cause a disruption. Also, I am quite fast at typing manually, so I don't see a need to use voice-texting. The one thing that would be convenient enough to make me consider using voice-to-text would be if I could do so while my phone is out of reach. I may do that while driving or while doing other tasks (cooking, caring for children, etc)", "I have played with the feature before, but it doesn't always pick up what I am saying. Also, the feature isn't really good at picking up words/combination of words if they aren't "everyday words" (words that are used in specific fields, like engineering, computer science, medial)[...] The only way that I see myself using it is if I am forced to use it (meaning there is no other way to operate/use the device) or if enough things around my everyday life is using the feature. Or if something happens and I am physically needing the feature.", "Did not think to use", "Never really needed to. I can't really think of one other than if I like lost my ability to type", "Didn't see it available. The availability should be evident.", There is often errors in the voice to text speech and I feel if I type then I am in control of what is written or spelled out.", "Didn't know my phone had the capability a d (sic.) the voice recognition doesn't always match what was typed." I have extracted privacy issues, accuracy issues with transcription, and discoverability issues from these statements.

Participants were asked which devices they use for V2T. 15 (32%) of respondents used their phone, while two (6.45%) participants used their tablet, and one participant used their computer (2.27%). No other respondents answered the question.

When the participants were asked how often they use V2T, 10 participants (21.28%) report using it often, 32 participants (68.09%) use V2T sometimes, and five participants (10.64%) reported using V2T never. When asked how often the participants needed to correct errors before sending a message, 26 participants (55.32%) reported sometimes needing to correct errors, while 17 participants (36.17%) report often needing to correct errors. Additionally, 29 (61.70%) respondents reported that they often check for errors after using voice-to-text. When asked whether participants enjoyed using voice-to-text, 12 participants (26.09%) reported often enjoying V2T, 28 participants (60.87%) reported sometimes enjoying V2T, and six participants (13.04%) reported never enjoying voice to text.

When the participants were asked if they think that voice-to-text is slower overall than regular texting, 16 participants (34.78%) reported that they agree, 14 participants neither agreed nor disagrees, and 16 participants disagreed. When asked whether voice to text is more efficient to use, 10 participants (21.74%), agreed, 23 participants (50%) neither agreed nor disagreed, and 13 (28.26%) disagreed.

When asked whether the participants modify what they say to make it easier for the voice-to-text system to understand them, 30 participants (65.22%) agreed. In addition, 30 participants (65.22%) and 24 participants (52.17%) speak more slowly and louder respectively when they use voice-to-text.

When asked whether the participants find the accuracy of voice-to-text good, only 7 participants (15.22%) agreed, 27 participants (58.70%) neither agreed nor disagreed, and 12 participants (26.09%) disagreed with the statement.

When the participants were asked where they are most likely to use voice-to-text, 48 (82.76%) of participants use V2T while driving alone, 13 (22.41%) reported while driving with a friend or family member, 25 (43.10%) participants reported when sending a short message, 24 (41.38%) participants reported when sending a long message, two participants (3.45%) reported while using public transportation, 10 participants (17.24%) reported while taking a walk in nature, eight participants (13.79%) reported while shopping, and 34 participants (58.62%) report using V2T while home alone, and 36 participants (62.07%) report using V2T while cooking.

Experiment Two: Discussion

The survey provided interesting results about users' beliefs about voice-to-text technology and manual text entry.

Analyzing the question which asked how the participants typed on the phone, we found that over 24% of the participants type using one index finger, which is a surprising result given how slow the text entry is. Looking even further into the data, I have discovered that every response that selected that they “always” use one index finger to type also fits into the 31 years of age + bracket. This highlights the need for voice-to-text input for these users, as using voice input versus manual input is hypothesized to result in faster input than typing each letter serially. In addition, almost a third of participants complain of hand pain. The cause of the hand pain is unclear; however, this can be hypothesized by using devices like cell phones and computer keyboards, or disorders and diseases like Lupus and Arthritis. This information might be a deciding factor of speed between the age groups, where young people tend to type with two thumbs. How fast the participants actually create and send text messages using voice-to-text will be discussed in the third study.

Almost half of the participants reported often making errors while typing on a cell phone. A further study will include the participant’s error rate typing via manual text entry versus voice-to-text because we postulate that the amount of errors for voice-to-text entry will be actually less than errors made while manually texting.

About a third of the participants did not know about the personal phone dictionary feature on cell phones, which could be extrapolated to their knowledge of voice-to-text, and the breadth of voice commands available to them. This draws the question of how discoverable these voice-to-text commands are. A surprising 20% of participants have never used voice-to-text entry, meaning there is an issue with discoverability with the feature, as my assumption going into the survey was that most people have at least tried voice-to-text out. The results of the fill in the blank question by participants who have never use voice-to-text also confirm this suspicion, as multiple participants reported not even knowing that the feature was available to them on their phone.

Issues with the accuracy of transcription of voice-to-text was brought up multiple times by the participants' responses, showing that the participants hold negative beliefs regarding the amount of accuracy V2T has. Over half of participants also agree that they must enunciate more slowly when using voice-to-text, showing that the participants believe that slowing their enunciation will also help increase the accuracy of transcription. In addition, over 65% of participants report modifying their speech to make the device transcribe speech more accurately. This brings up an issue of if the amount of added effort involved in modifying natural speech to be picked up by the V2T system makes it less likely for people to use the system. Over half of the participants reported needing to correct errors manually after using voice-to-text, also showing how inaccurate the system is in the participant's experience.

The participants also illuminated privacy issues of having others around them hear what they say into their phone, which mirrors the results from the qualitative interview. The questions asking the environment participants use voice-to-text, they report using it mostly when they are alone, whether driving alone, while cooking, or home alone in general, and use V2T less when in the presence of strangers like while using public transportation, or while shopping.

It was found that most participants use their phone to use voice-to-text, which confirms assumptions that the primary device where voice-to-text is used is a cell phone.

In order to explore our research questions more quantifiably, an experimental research study was developed to assess the performance and efficiency of typing with both manual text entry and voice-to-text entry. During this stage of our research, our research began to focus on age as an important construct involved in voice-to-text usage, so we developed the experimental study with this information in mind.

Experiment Three: Experimental Study

The third and final portion of our overall study on voice-to-text was an experimental study to explore different age groups' (young versus old) efficiency during a manual text entry condition, and a voice-to-text entry condition. Efficiency refers to both the speed and accuracy of text entry. This study was conducted to avoid biases involved in only measuring the constructs with a single method.

Experiment Three: Methods

Participants

37 participants were recruited by students of the PSYC 512: Research Methods class. The participants were classified as either young or old, with participants over 31 years of age classified as "old", and participants under the age of 31 classified as "young". There were 22 members of the age category "young" and 15 participants who were coded to be in the "old" category. The participants were friends and family of the students, with each student recruiting at least two participants, one young (under 31 years of age) or older (over 31 of age) through convenience sampling. There was no random assignment in the experimental design. The participants were all able bodied, and all owned and were familiar with using their own cell phones.

Materials

The materials used in the study included a stopwatch or a device with a stopwatch function that could record time up to a tenth of a second. Additionally, sheets of white letter paper for printing out text messages used in this experiment was required.

Each participant used their own cell phone with voice-to-text available. We have decided that cell phone familiarity among the participants were more important than using a single model of cell phone.

The participants were asked to input six different text messages, three which invite the participant to use abbreviations, and three which do not. Each text message is about 60-70 characters in length, to control for one text message being substantially longer than another text message, making the message with more characters inherently longer to type out. To also account for disparities in input time, the messages were constructed specifically to be unoffensive and neutral in tone and included relatively common words in the English language to account for differences in recognition by the devices.

Procedure

First, the researcher must prepare the materials before assessing the participant. The two practice text messages and the text messages used during the 12 trials must be randomized to control for any order effects. This was done either manually through writing down the question numbers on scraps of paper and drawing them randomly, through excel, or through another digital random generator. Once the message order number is randomized, the researcher must print the text messages out on white sheets of ANSI letter paper. The order of the questions and whether the trial will involve manual entry or voice-to-text is recorded onto a data matrix sheet that is handwritten then transcribed into the Excel spreadsheet, or typed directly into the Excel spreadsheet, depending on the experimenter’s preference.

The participants are informed that they will enter simple text messages into their voice using both manual input, and voice-to-text, and must complete this task as quickly and as accurately as they can. In addition, the participants were informed that they may abbreviate the text messages provided, but only if the abbreviation results in the same punctuation and the same reading as the original message. For example, for the message, “I am looking forward to seeing you tomorrow. Talk to you later”, “I am looking 4ward 2 seeing you tmw. TTYL” is acceptable, but “looking 4ward 2 seeing you” is not because it does not include punctuation (the period) and does not contain all of the words of the original message (no “Talk to you later.” is included).

The participant is instructed before each trial to use either manual text entry with their fingers/thumbs on a trial or use voice-to-text input. After the message is inputted, the participant then sends the text message to the experimenter through SMS. Four practice trials were conducted prior to the 12 experimental trials, where the participant must use voice-to-text on two different sentences and two practice trials involving the same two sentences using manual text entry.

During each of the 12 experimental trials, the experimenter recorded participant data on a data matrix in Excel. This includes information about the experimenter’s name, the participant’s age, how many texts the participant sends per day, if the participant uses voice-to-text, which phone the participant uses to type on, and how the participant physically types on the phone. These questions were selected from the previous study’s survey for the experimenters to have with them for reference.

The experimented timed each participant on their speed while inputting text for each trial, and promptly recorded the time in the data matrix, then moved onto the next trial until all 12 experimental trials were complete. Before thanking the participants for their time, the experimenter asked for any comments about the experiment, which were recorded in a text box below the participant’s data. Any comments the experimenter had about the study were recorded in the comments text box as well.

After the study was conducted, the experimenters later recorded the messages that were sent to them in the data matrix, as the participants being present was not necessary. The number of abbreviations used per message, if any, and number of errors made compared to the original message were recorded as well.

Experiment Three: Results

Age Category Against Texting Mode and Message Type

We performed a 2 x 2 x 2 MANOVA for this study, with the within-subjects factors being the texting time for the different modes of input (voice-to-text vs. manual text entry) and the message type (message type 1: does not invite abbreviations vs. message type 2: invites abbreviations), and the between-subjects factor is age category (young participants vs. older participants).

Descriptive statistics were run for the MANOVA. The younger participants’ manual text entry type 2 (invites abbreviations) speed was higher than their manual text entry type 1 speed (does not invite abbreviations), $M = 13.95$ $SD = 3.03$ versus $M = 14.11$ $SD = 3.9$. Older participants overall had lower manual text entry speeds for both type 2 and type 1 message types than the younger participants, with message type 2 showing faster texting speeds than type 1. $M = 26.25$ $SD = 6.96$ for message type 2 and $M = 28.67$ $SD = 8.39$ for message type 1.

The younger participants’ texting time for V2T entry, message type 2 variant was lower ($M = 5.96$ $SD = 1.43$) than their V2T entry message type 2 speed ($M = 6.73$ $SD = 1.75$). Old participants had larger texting times for V2T text entry, compared to the young participants. For older participants, their texting time using V2T was also lower during trials using message type 2 (M= 8.10 SD= 2.62) than during trials using message type 1 (M= 8.69 SD= 2.78).

The main effect of texting mode was significant, F(1,35)=208.70, p<.001, eta-squared = .86.

The main effect of whether the text message was able to be abbreviated was also significant (coded as “Abbrevability”), F(1,35)=13.67, p<.001, eta-squared = .28.

The interaction effect of texting mode and the age category (young vs. old) was significant, F(1,35)=37.72, p<.001, eta-squared = .52.

The interaction between whether the message could be abbreviated and the age category was found to be not statistically significant, F(1,35)=3.7, p>.05, eta-squared = .98.

The interaction between the texting mode and abbrevability was found to be not significant, F(1,35)= 1.25, p>.05, eta-squared = .34.

Finally, the interaction between the texting mode, the abbrevability, and the age category was found to be statistically significant, F(1,35)= 4.99, p<.05, eta-squared = .13

Descriptive Statistics				
Texting Time	Age Category	Mean	Std. Deviation	N
Manual Message Type 1	Young	14.112575757575755	3.925465487420479	22
	Old	28.673555555555556	8.393018022999327	15
	Total	20.015675675675677	9.429271205779310	37
Manual Message Type 2	Young	13.950909090909091	3.030322626199267	22
	Old	26.253555555555554	6.961193619901448	15
	Total	18.938468468468470	7.854897528411718	37
V2T Message Type 1	Young	6.728030303030304	1.755296341850927	22
	Old	8.693111111111111	2.778588903795646	15
	Total	7.524684684684685	2.399253029263850	37
V2T Message Type 2	Young	5.956515151515150	1.425432813607399	22
	Old	8.104888888888887	2.621848029529379	15
	Total	6.827477477477477	2.236512718304803	37

Table 1. Descriptive Statistics of texting time against texting mode, message type (1=message does not invite abbreviations, 2=message invites abbreviations), and age category.

Multivariate Tests[a]					
Effect		Value	F	Hypothesis df	Error df
Texting Mode	Pillai's Trace	.856	208.696[b]	1.000	35.000
	Wilks' Lambda	.144	208.696[b]	1.000	35.000
	Hotelling's Trace	5.963	208.696[b]	1.000	35.000
	Roy's Largest Root	5.963	208.696[b]	1.000	35.000
Texting Mode * Age Category	Pillai's Trace	.519	37.726[b]	1.000	35.000
	Wilks' Lambda	.481	37.726[b]	1.000	35.000
	Hotelling's Trace	1.078	37.726[b]	1.000	35.000
	Roy's Largest Root	1.078	37.726[b]	1.000	35.000
Abbrevability	Pillai's Trace	.281	13.660[b]	1.000	35.000
	Wilks' Lambda	.719	13.660[b]	1.000	35.000
	Hotelling's Trace	.390	13.660[b]	1.000	35.000
	Roy's Largest Root	.390	13.660[b]	1.000	35.000
Abbrevability * Age Category	Pillai's Trace	.098	3.786[b]	1.000	35.000
	Wilks' Lambda	.902	3.786[b]	1.000	35.000
	Hotelling's Trace	.108	3.786[b]	1.000	35.000
	Roy's Largest Root	.108	3.786[b]	1.000	35.000
Texting Mode * Abbrevability	Pillai's Trace	.034	1.249[b]	1.000	35.000
	Wilks' Lambda	.966	1.249[b]	1.000	35.000
	Hotelling's Trace	.036	1.249[b]	1.000	35.000
	Roy's Largest Root	.036	1.249[b]	1.000	35.000
Texting Mode * Abbrevability * Age Category	Pillai's Trace	.125	4.988[b]	1.000	35.000
	Wilks' Lambda	.875	4.988[b]	1.000	35.000
	Hotelling's Trace	.143	4.988[b]	1.000	35.000
	Roy's Largest Root	.143	4.988[b]	1.000	35.000

Table 2. Multivariate tests for the factors texting mode (manual vs V2T), abbrevability (message invites abbreviations or not), and age category.

Multivariate Tests[a]				
Effect		Sig.	Partial Eta Squared	Noncent. Parameter
Texting Mode	Pillai's Trace	.000	.856	208.696
	Wilks' Lambda	.000	.856	208.696
	Hotelling's Trace	.000	.856	208.696
	Roy's Largest Root	.000	.856	208.696
Texting Mode * Age Category	Pillai's Trace	.000	.519	37.726
	Wilks' Lambda	.000	.519	37.726
	Hotelling's Trace	.000	.519	37.726
	Roy's Largest Root	.000	.519	37.726
Abbrevability	Pillai's Trace	.001	.281	13.660
	Wilks' Lambda	.001	.281	13.660
	Hotelling's Trace	.001	.281	13.660
	Roy's Largest Root	.001	.281	13.660
Abbrevability * Age Category	Pillai's Trace	.060	.098	3.786
	Wilks' Lambda	.060	.098	3.786
	Hotelling's Trace	.060	.098	3.786
	Roy's Largest Root	.060	.098	3.786
Texting Mode * Abbrevability	Pillai's Trace	.271	.034	1.249
	Wilks' Lambda	.271	.034	1.249
	Hotelling's Trace	.271	.034	1.249
	Roy's Largest Root	.271	.034	1.249
Texting Mode * Abbrevability * Age Category	Pillai's Trace	.032	.125	4.988
	Wilks' Lambda	.032	.125	4.988
	Hotelling's Trace	.032	.125	4.988

Table 3. Multivariate tests for the factors texting mode, abbrevability, and age category.

Significance and Partial Eta Squared included.

Abbreviation Rate Against Age Category and Texting Mode

A second MANOVA was run, this time using the factor abbreviation usage rate against age category and texting mode.

Descriptive Statistics

	Age Category	Mean	Std. Deviation	N
Abbreviation Rate for Manual Message Type 1	Young	.030303030303030	.098081647722750	22
	Old	.066666666666667	.186870636860463	15
	Total	.045045045045045	.139712274047485	37
Abbreviation Rate for Manual Message Type 2	Young	.318181818181818	.430051956099126	22
	Old	.244444444444444	.387639717088626	15
	Total	.288288288288288	.409472426016292	37
Abbreviation Rate for V2T Message Type 1	Young	.090909090909091	.210361698633673	22
	Old	.022222222222222	.086066296582387	15
	Total	.063063063063063	.172809711908397	37
Abbreviation Rate for V2T Message Type 2	Young	.00	.000	22
	Old	.00	.000	15
	Total	.00	.000	37

Table 4. Descriptive statistics for the second MANOVA, factors are abbreviation rate, texting mode, and age category.

Descriptive statistics were run on this MANOVA. The younger participants' abbreviation rate for trials using manual text entry message type 1 (message does not invite abbreviations) was lower (M =.03 SD= .09) than the abbreviation rate for the trials using manual text entry message type 2 (message invitees abbreviations) (M = .32 SD= .43). Older participants had a similar result, where the abbreviation rate of manual text entry type 1 was M= .07 SD= .19, and abbreviation for manual entry type 2 was M= .24 SD= .39.

For V2T entry, the abbreviation rate for younger participants was higher for message type 2 (M = 0 SD= 0) than type 1 (M =.09 SD= .21). The abbreviation rate for V2T text entry in older participants was also higher for message type 2 (M= .02 SD= .09) than for message type 1 (M= 0 SD= 0).

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df
Abbreviation Rate	Pillai's Trace	.246	11.400[b]	1.000	35.000
	Wilks' Lambda	.754	11.400[b]	1.000	35.000
	Hotelling's Trace	.326	11.400[b]	1.000	35.000
	Roy's Largest Root	.326	11.400[b]	1.000	35.000
Abbreviation Rate* Age Category	Pillai's Trace	.001	.037[b]	1.000	35.000
	Wilks' Lambda	.999	.037[b]	1.000	35.000
	Hotelling's Trace	.001	.037[b]	1.000	35.000
	Roy's Largest Root	.001	.037[b]	1.000	35.000
Texting Mode	Pillai's Trace	.163	6.839[b]	1.000	35.000
	Wilks' Lambda	.837	6.839[b]	1.000	35.000
	Hotelling's Trace	.195	6.839[b]	1.000	35.000
	Roy's Largest Root	.195	6.839[b]	1.000	35.000
Texting Mode * Age Category	Pillai's Trace	.003	.094[b]	1.000	35.000
	Wilks' Lambda	.997	.094[b]	1.000	35.000
	Hotelling's Trace	.003	.094[b]	1.000	35.000
	Roy's Largest Root	.003	.094[b]	1.000	35.000
Abbreviation Rate * Texting Mode	Pillai's Trace	.283	13.802[b]	1.000	35.000
	Wilks' Lambda	.717	13.802[b]	1.000	35.000
	Hotelling's Trace	.394	13.802[b]	1.000	35.000
	Roy's Largest Root	.394	13.802[b]	1.000	35.000
Abbreviation Rate * Texting Mode * Age Category	Pillai's Trace	.036	1.317[b]	1.000	35.000
	Wilks' Lambda	.964	1.317[b]	1.000	35.000
	Hotelling's Trace	.038	1.317[b]	1.000	35.000
	Roy's Largest Root	.038	1.317[b]	1.000	35.000

Table 5. Multivariate Tests for abbreviation rate, texting mode, and age category.

Multivariate Tests[a]				
Effect		Sig.	Partial Eta Squared	Noncent. Parameter
Abbreviation Rate	Pillai's Trace	.002	.246	11.400
	Wilks' Lambda	.002	.246	11.400
	Hotelling's Trace	.002	.246	11.400
	Roy's Largest Root	.002	.246	11.400
Abbreviation Rate * Age Category	Pillai's Trace	.848	.001	.037
	Wilks' Lambda	.848	.001	.037
	Hotelling's Trace	.848	.001	.037
	Roy's Largest Root	.848	.001	.037
Texting Mode	Pillai's Trace	.013	.163	6.839
	Wilks' Lambda	.013	.163	6.839
	Hotelling's Trace	.013	.163	6.839
	Roy's Largest Root	.013	.163	6.839
Texting Mode * Age Category	Pillai's Trace	.760	.003	.094
	Wilks' Lambda	.760	.003	.094
	Hotelling's Trace	.760	.003	.094
	Roy's Largest Root	.760	.003	.094
Abbreviation Rate * Texting Mode	Pillai's Trace	.001	.283	13.802
	Wilks' Lambda	.001	.283	13.802
	Hotelling's Trace	.001	.283	13.802
	Roy's Largest Root	.001	.283	13.802
Abbreviation Rate * Texting Mode * Age Category	Pillai's Trace	.259	.036	1.317
	Wilks' Lambda	.259	.036	1.317
	Hotelling's Trace	.259	.036	1.317
	Roy's Largest Root	.259	.036	1.317

Table 6. Multivariate Tests for abbreviation rate, text mode, and age category. Significance and eta squared values.

The main effect of abbreviation rate was significant, $F(1,35)= 11.4$, $p<.002$, eta-squared = .25.

The main effect of text mode was found to be statistically significant, $F(1,35)= 6.83$, $p<.05$, eta-squared = .16.

The interaction between abbreviation rate and text mode was found to be statistically significant, $F(1,35) = 13.80$, $p < .001$, eta-squared = .28.

The interaction between abbreviation rate and age category was found to be not statistically significant, $F(1,35) = .04$, $p > .05$, eta-squared = .001.

The interaction between text mode and age category was also found to be not statistically significant, $F(1,35) = .09$, $p > .05$, eta-squared = .003.

The interaction between abbreviation rate, text mode, and age category was found to be not statistically significant, $F(1,35) = 1.31$, $p > .05$, eta-squared = .03.

Error rate Against Age Category

A third MANOVA was conducted to examine the factor of error rate across different age categories and texting modes.

Descriptive statistics were run on this MANOVA (see Table 7). The error rate for manual text entry message was higher during trials using message type 1 was M=.80 SD= 1.00, compared to the error rate for manual text entry message type 2 (M = .62 SD= .74). For older participants, the error rate of manual text entry type 1 was higher (M= .91 SD= 1.12) than the error rate for manual entry message type 2 (M= .71, SD= .91).

Descriptive Statistics				
	Age Category	Mean	Std. Deviation	N
Errors for Manual Message Type 1	Young	.803030303030303	1.000841396867407	22
	Old	.911111111111111	1.123109817148644	15
	Total	.846846846846847	1.038144696599537	37
Errors for Manual Message Type 2	Young	.621212121212121	.743902583266824	22
	Old	.711111111111111	.916053185766765	15
	Total	.657657657657658	.806939372661386	37
Errors for V2T Message Type 1	Young	.818181818181818	.732663999932122	22
	Old	.888888888888889	1.066567455703641	15
	Total	.846846846846847	.869917672401680	37
Errors for V2T Message Type 2	Young	.575757575757576	.921132372943677	22
	Old	.733333333333333	1.196555904145741	15
	Total	.639639639639640	1.028538392359707	37

Table 7. Descriptive statistics for the third MANOVA, error rate.

For the younger participants, the error rate for V2T entry type 1 was higher than the error rate for V2T entry type 2, M= .81, SD= .73 versus M= .58 SD= .92 respectively. For the old participants, the error rate for V2T entry type 1 was higher than the error rate for V2T entry type 2, M= .89 SD= 1.07 versus M= .73 SD= 1.19 respectively.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df
Texting Mode	Pillai's Trace	.000	.002[b]	1.000	35.000
	Wilks' Lambda	1.000	.002[b]	1.000	35.000
	Hotelling's Trace	.000	.002[b]	1.000	35.000
	Roy's Largest Root	.000	.002[b]	1.000	35.000
Texting Mode * Age Category	Pillai's Trace	.000	.002[b]	1.000	35.000
	Wilks' Lambda	1.000	.002[b]	1.000	35.000
	Hotelling's Trace	.000	.002[b]	1.000	35.000
	Roy's Largest Root	.000	.002[b]	1.000	35.000
Errors	Pillai's Trace	.046	1.706[b]	1.000	35.000
	Wilks' Lambda	.954	1.706[b]	1.000	35.000
	Hotelling's Trace	.049	1.706[b]	1.000	35.000
	Roy's Largest Root	.049	1.706[b]	1.000	35.000
Errors * Age Category	Pillai's Trace	.000	.013[b]	1.000	35.000
	Wilks' Lambda	1.000	.013[b]	1.000	35.000
	Hotelling's Trace	.000	.013[b]	1.000	35.000
	Roy's Largest Root	.000	.013[b]	1.000	35.000
Texting Mode * Errors	Pillai's Trace	.000	.001[b]	1.000	35.000
	Wilks' Lambda	1.000	.001[b]	1.000	35.000
	Hotelling's Trace	.000	.001[b]	1.000	35.000
	Roy's Largest Root	.000	.001[b]	1.000	35.000
	Pillai's Trace	.001	.035[b]	1.000	35.000

Texting Mode * Errors * Age Category	Wilks' Lambda	.999	.035[b]	1.000	35.000
	Hotelling's Trace	.001	.035[b]	1.000	35.000
	Roy's Largest Root	.001	.035[b]	1.000	35.000

Table 8. Multivariate Tests for error rate, text mode, and age category.

Multivariate Tests[a]

Effect		Sig.	Partial Eta Squared	Noncent. Parameter
Texting Mode	Pillai's Trace	.965	.000	.002
	Wilks' Lambda	.965	.000	.002
	Hotelling's Trace	.965	.000	.002
	Roy's Largest Root	.965	.000	.002
Texting Mode * Age Category	Pillai's Trace	.965	.000	.002
	Wilks' Lambda	.965	.000	.002
	Hotelling's Trace	.965	.000	.002
	Roy's Largest Root	.965	.000	.002
Errors	Pillai's Trace	.200	.046	1.706
	Wilks' Lambda	.200	.046	1.706
	Hotelling's Trace	.200	.046	1.706
	Roy's Largest Root	.200	.046	1.706
Errors * Age Category	Pillai's Trace	.909	.000	.013
	Wilks' Lambda	.909	.000	.013
	Hotelling's Trace	.909	.000	.013
	Roy's Largest Root	.909	.000	.013
Texting Mode * Errors	Pillai's Trace	.977	.000	.001
	Wilks' Lambda	.977	.000	.001
	Hotelling's Trace	.977	.000	.001
	Roy's Largest Root	.977	.000	.001
Texting Mode * Errors * Age Category	Pillai's Trace	.852	.001	.035
	Wilks' Lambda	.852	.001	.035
	Hotelling's Trace	.852	.001	.035
	Roy's Largest Root	.852	.001	.035

Table 9. Multivariate Tests for error rate, texting mode, and age category. Significance and Eta squared values.

The multivariate tests performed showed no statistically significant results for any of the two main effects (text mode, errors), nor the four interaction effects (text mode and age category, errors and age category, text mode and errors, and text mode/errors/age category).

Experiment Three: Discussion

The main effects for both texting mode and abbrevability were found to be statistically significant, moreover, the interaction between text mode and age category was also found to have clear, statistical significance. Therefore, the results of the first MANOVA confirms our first hypothesis that voice-to-text entry is faster than manual text entry (See Table 1)

In addition, the clear interaction between age and texting time and mode also confirmed our hypothesis that younger people enter text more quickly than older people (see Figure 1). The means of manual text entry times between young and old participants varied greatly. Voice to text also differed, with lower mean text entry times again being lower than old participants, however the amount of variability between the groups was remarkably smaller between them, compared to the manual text entry condition.

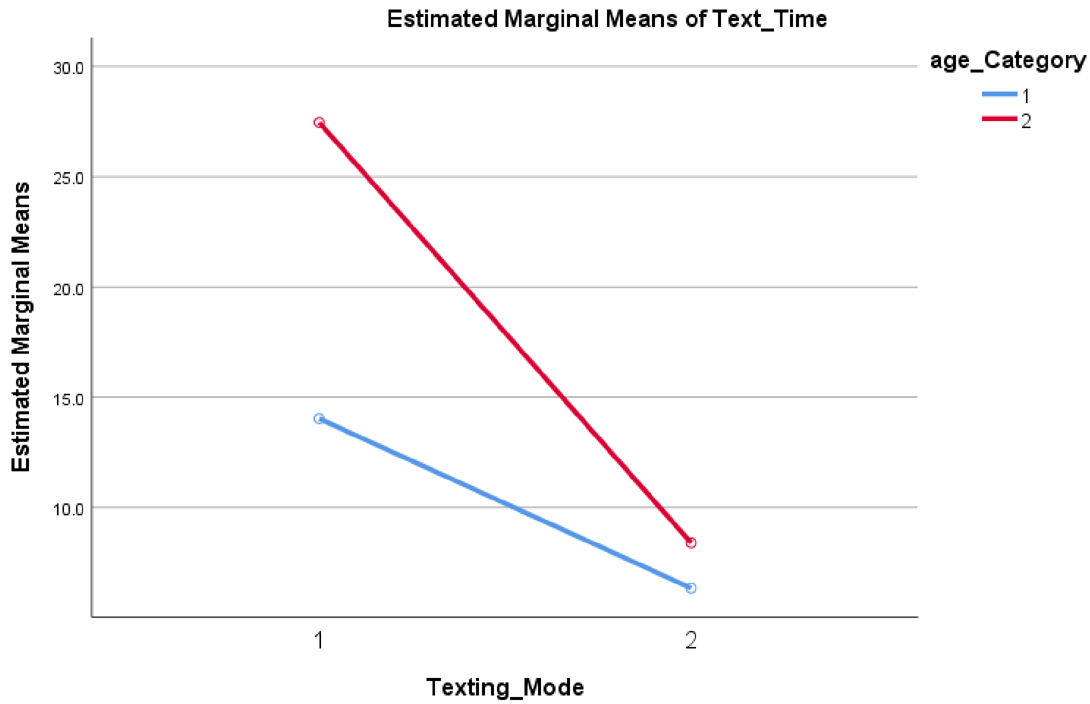

Figure 1. Interaction between texting mode (1=V2T, 2= manual text entry) and age category (1= young, 2=old). The dependent measure was texting time.

An interesting finding was that abbreviations were rarely used, even for the text message type 1 condition, where using abbreviations was invited by the structure of the message. Additionally, these abbreviations were even less frequently used for the voice-to-text conditions. Foreseeably, none of the participants used text message abbreviations for the text message type 2 condition, where the message structure did not invite the use of text message abbreviations. The findings of the second MANOVA confirms our third hypothesis that using abbreviations in text result in faster texting times than not using them.

Another finding that I found interesting was that the amount of errors did not differ significantly between texting modes or age. These findings are disparate with the negative belief of the accuracy being worse with voice-to-text compared to manual text entry.

A limitation of this study has to do with the formulation for the text messages the participants had to type during each trial. According to the results, the participants did not use abbreviations as often as we expected in neither manual text entry, nor voice-to-text. This shows that there is an issue with the construct validity for the text messages which invite abbreviations, and text messages that do not invite abbreviations. Having a manipulation check in a pilot study would have identified issues with the text messages formulated for this study. A suggestion for improving this experimental study is to look at young people's text messages and find potential patterns of their use of abbreviations to improve the validity of this construct. The choice of abbreviations was pulled from an article from Slate magazine. Perhaps the issue with the text message abbreviations selected were not natural because of changing use of abbreviations in young people. For example, a teen might not use "ROTFL" and think the abbreviation is outdated, while a fourty-year-old person might use that abbreviation daily, or think younger people use abbreviations that way.

Another limitation of the study was ambiguity in the study's protocol, especially in coding errors. A few students brought up questions of whether "Im" versus "I'm" is an error due to a missing apostrophe, or adding an extra letter is one error, or multiple errors due to misaligning the rest of the word with the prompt. This is an issue of the researchers having disagreeing operational definitions of what an error is, which in a future study, should be defined more clearly in the protocol.

Another issue was the use of homophones in the supplied text messages, which should have been avoided in order to reduce ambiguity while inputting data via voice-to-text. One of the text messages had the word "You are", which in some cases in the trial, the voice-to-text system transcribed as "Your", creating an error.

Overall Discussion

Going into this research study, my assumption was that the context in which voice-to-text is used matters. I postulated that voice-to-text is not typically used in an environment where the user has use of both of their hands, and they are not taking place in tasks which divide visual attention, but rather in an environment where the user's hands are occupied, and their visual attention is divided among tasks, such as while driving or cooking. Additionally, I assumed those with disabilities involving a decrease in hand dexterity will use voice-to-text more often.

All three proposed hypotheses were confirmed by the first experimental study. Text entry for both voice-to-text and manual input was faster for younger people than for older people, but the difference between means were more significant during the manual text entry condition than the voice-to-text condition. This was surprising because the older people and the young people had disparate times for manual text entry, for example mean text time for manual text entry message type 1 was 14.11s for young people, and a larger mean, 28.67s for older people. This could be explained by a multitude of factors, such as decrease in hand dexterity, or texting style. Interestingly, according to the survey data, every participant who reported using only one index finger to type were a part of the old age category, potentially explaining the higher texting speed for older participants. These findings allude to advertising to people of all ages how fast voice-to-text entry is, compared to manual text entry. While we found that users typically will not use voice to text in a public environment due to privacy concerns and not disturbing others, voice-to-text entry can be used in private to send text messages more quickly.

The use of abbreviations in the text messages during the experimental study were lower than expected. The text messages formulated for this study were done so in a way that one type of message was able to be abbreviated, based on a list of common texting abbreviations from Slate magazine, and the second message type was formulated to disallow usage of texting abbreviations. We were surprised by the lack of abbreviation usage, especially in the manual texting condition. As discussed earlier, there most likely is a problem with construct validity for the abbreviations used in formulating the text messages, indicating that these abbreviations are not natural for users. This could be due to the sources used in message formulation that did not accurately capture actual text abbreviations in use today.

An interesting finding in this study was while people hold negative beliefs about using voice-to-text systems, entering text through using voice-to-text was found to be significantly faster than manual text entry for both age groups, and was found to have similar amounts of accuracy. What many of the classmates, including myself, have found was that some of the participants who took part in the experimental study did not know or realize that voice input is significantly faster compared to manual text entry. One participant, who only typed using one index finger, explained in the comment box that, “V2T seems faster for these sentences”.

An interesting concept to explore is why people hold such negative beliefs of voice-to-text. There may be a possibility that people who have used voice-to-text a decade ago, when speech recognition technology was not as refined, may have held negative beliefs about voice-to-text from their previous experiences or word of mouth from others who have interacted with more primitive speech technology, causing an anchoring effect.

We have also discovered an issue with discoverability of voice-to-text, where participants indicated during the interviews that they never heard of using voice-to-text. Perhaps there is little advertising of voice-to-text, showing how quick and reliable it is as a text input method.

Participants have indicated that other people, like their friends or children have shown them how to use the feature.

On both the survey and the experimental study, the gender of the participants was not disclosed, but during the structured qualitative interview, gender was one of the questions asked. A future study can not only look at age and voice-to-text usage, but also gender and voice-to-text usage. Would those identifying as female be more likely to use voice-to-text due to sociocultural reasons? Would females be quicker at text entry than males? Understanding the underlying reasons for voice-to-text usage more in depth across more dimensions will allow the technology to become more widespread and known.

A major limitation to this study was that there was confusion amongst the experimenters regarding protocol, where an experimenter would run an experiment using one revision of a protocol, but another would run participants through trials using a newer version of the protocol. Another inconsistency with protocol was coding errors during the experimental study. The protocol was vague in how to score errors, potentially altering the validity for the data representing the number of errors during each trial. Due to the time limitations of this study, this was unavoidable, but during future studies, having a consistent protocol across all participants and experimenters will be important. If we had more time to complete the project, the limitations discussed previously would most likely be eliminated.

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Appendix A

Voice to Text (V2T) Qualitative Interview

1. What is your age?
2. Have you ever used the voice to text feature on your phone? For example, like dictating a text message?
3. How did you discover or learn about the voice to text feature?
4. What are some devices you use that have the V2T feature?
5. If you never used V2T, can explain as to why you don't use the feature.
    a. Can you think of any times when you might want to use it?
    b. Is there anything that might make you want to use this feature?
6. Do you know someone who uses the V2T feature? When do they use it (situations)? What is their age? Do they use it around you?
7. Can you describe an experience using the voice to text feature?
    a. Are there other scenarios or circumstances that you would use this feature?
    b. Which situations do you find the V2T feature helpful?
    c. Do you feel using the V2T is a convenience or inconvenience for you?
    d. What do you think you could improve while using voice to text?
    e. What do you like about the feature?
8. Do you ever use the feature around other people or alone?
    a. Depending on answer, ask them: (1) why do you choose to use the feature while you are alone or with others?
9. If you can change anything about the voice to text feature, what would it be and why?

Appendix B

Survey Structure

512 Project - V2T survey

Survey Flow

Block: Default Question Block (1 Question)
Standard: demographic block (11 Questions)
Standard: Block 2 (6 Questions)
Standard: Block 3 (3 Questions)

Page

Break

Start of Block: Default Question Block

Q1

Thank you for participating in this survey on Voice-to-text features. This survey is part of a class project and all of your data will be collected anonymously and will not be used for purposes outside of this course project. The survey will take about 10-15 minutes to complete. Thank you very much in the name of all of the students in the class!

The survey will start with some general information about you, and then ask more specific questions about your use of technology and your experience and feelings about voice-to-text.

End of Block: Default Question Block

Start of Block: demographic block

Q2

How old are you?

- <18 (1)
- 18-29 (2)
- 30-39 (3)
- 40-49 (4)
- 50-59 (5)
- 60-69 (6)
- 70+ (7)

Q20 Is English your first / native language?

- Yes (1)
- No (3)

Display This Question:

If Q20 = No

Q21 How would you rate your English language ability?

- ○ basic (1)
- ○ conversant (2)
- ○ fluent (3)
- ○ like a native speaker (4)

Display This Question:

If Q20 = No

Q22 Please fill out the remainder of the survey in relation to the language you mainly use for texting. If you mainly converse in Spanish, for example, then think of how well Voice-to-Text works for you in Spanish.

Q3 Some questions about you...

	Agree (1)	Neither agree nor disagree (2)	Disagree (3)
I find the text on modern phones is often too small to read (1)	○	○	○
I have no problems that impair the use of my hands (2)	○	○	○
I sometimes have pain in my hands (3)	○	○	○
I have good dexterity in my fingers (4)	○	○	○
I have excellent vision (5)	○	○	○
I prefer reading on a digital device over a book or magazine (6)	○	○	○
I can't read without my glasses or contacts (7)	○	○	○
I often watch movies or videos on my phone instead of a tv (8)	○	○	○
My phone is within reach most of the day (9)	○	○	○
I check my phone all the time (10)	○	○	○
I can type faster than the average person on a computer keyboard (11)	○	○	○
I can type faster than the average user on a smartphone (12)	○	○	○

I often don't hit the right key when typing on a smartphone (13)	○	○	○

Q4 Some questions about your phone and technology ...

	Agree (1)	Neither agree nor disagree (2)	Disagree (3)
My phone is very important to me (1)	○	○	○
I always try to upgrade my phone as soon as possible (2)	○	○	○
I don't care what phone I use (5)	○	○	○
I love the idea of virtual assistants that one can control with one's voice (8)	○	○	○
I am very good with technology (11)	○	○	○
I help others with their devices (12)	○	○	○
I usually rely on others to help me with technology (13)	○	○	○

Q18 Which of these devices do you own or use regularly?

	Yes (1)	No (4)
iPhone (1)	○	○
Android Phone (2)	○	○
Windows Phone (3)	○	○
Virtual Assistant (like Alexa) (4)	○	○
Desktop computer (5)	○	○
Laptop (6)	○	○
Tablet computer / iPad (7)	○	○

Q23 Have you ever added words or phrases to the personal dictionary on your phone?

○ Yes (1)

○ No, but I know about this capability (2)

○ No, I don't even know what that is (3)

Q13 Compared to the average person, I can type on my phone ...

- ◯ Extremely well (1)
- ◯ Very well (2)
- ◯ Moderately well (3)
- ◯ Slightly well (4)
- ◯ Not well at all (5)
- ◯ I don't type on my phone (9)

Display This Question:

If Q13 != I don't type on my phone

Q24

How long do you think it would take you to manually text this line of text (without quotation marks)?

"I am going to meet you at the supermarket at 5 pm tomorrow afternoon"

	0 10 20 30 40 50 60
Estimated time in Seconds ()	

Display This Question:

If Q13 != I don't type on my phone

Q12 How do you type on your phone?

	Always (1)	Sometimes (2)	Never (3)
I type only with one index finger (1)	○	○	○
I type only with one thumb (2)	○	○	○
I type with both thumbs (3)	○	○	○
I type with multiple fingers and thumbs (4)	○	○	○
I use SWYPE instead of tapping (5)	○	○	○
I use a different method for manual text entry (6)	○	○	○

End of Block: demographic block

Start of Block: Block 2

Q5 How often do you send messages using smart devices such as your phone or virtual assistant. Please choose the closest option.

○ Less than once a week (1)

○ A few times a week (2)

○ 1-2 per day (3)

○ <10 per day (4)

○ <50 per day (5)

○ 50+ a day (6)

Q6 Have you ever used voice-to-text on your phone or another device?

○ I have never used it (1)

○ I have used it a few times (2)

○ I often use it (3)

Display This Question:

If Q6 = I have never used it

Q17 You indicated that you have never used the Voice-to-Text feature on phones or computers. Please explain why you have never used them and what might make you change your mind and use them in the future.

____

____

____

____

____

Display This Question:

If Q6 != I have never used it

Q16 Which of these devices have you used for Voice-to-Text and how frequently have you used those?

	Often (1)	Sometimes (2)	Never (3)
My computer (1)	○	○	○
My phone (2)	○	○	○
My tablet / iPad (3)	○	○	○
Another device: please specify (4)	○	○	○

Display This Question:

If Q6 != I have never used it

Q7 Some questions about your use of Voice-to-Text

	Often (1)	Sometimes (2)	Never (3)
How often do you use Voice-to-Text in general? (1)	○	○	○
How often do you check for errors before sending a message using Voice-to-Text? (2)	○	○	○
How often do you need to correct errors manually after using Voice-to-Text? (3)	○	○	○
Do you use Voice-to-Text while driving? (4)	○	○	○
Do you use Voice-to-Text when you are alone at home? (5)	○	○	○
Do you speak differently when using Voice-to-Text? (6)	○	○	○
Do you enjoy using Voice-to-Text? (7)	○	○	○

Display This Question:

If Q6 != I have never used it

Q8 Your experiences with Voice-to-Text ...

	Agree (1)	Neither agree nor disagree (2)	Disagree (3)
I think that Voice-to-Text is slower overall than regular texting (1)	○	○	○
I find it difficult to make corrections to messages I have entered via Voice-to-Text (2)	○	○	○
I find it difficult to make corrections to messages I have entered via regular texting (3)	○	○	○
I find it often more efficient to use Voice-to-Text (4)	○	○	○
I think that my voice is not picked up as well by Voice-to-Text as it should (5)	○	○	○
I modify what I say to make it easier for the device to understand me. (6)	○	○	○
I have an accent or speech impairment that makes it hard to use Voice-to-Text (7)	○	○	○
I speak slower when using Voice-to-Text (9)	○	○	○
I speak louder when using Voice-to-Text (10)	○	○	○

I include explicit punctuation commands when I use Voice-to-Text (like "comma", "period" or "question mark") (11)	o	o	o
I find the accuracy of Voice-to-Text very good (13)	o	o	o
I am often annoyed by the high number of errors in Voice-to-Text (14)	o	o	o

End of Block: Block 2

Start of Block: Block 3

Q9 In general, what situations do you think people are very likely or unlikely to use Voice-to-Text features?

	likely (1)	sometimes (2)	unlikely (3)
While driving alone (1)	○	○	○
While driving with a friend or family member (2)	○	○	○
While driving with an acquaintance (3)	○	○	○
When sending a short message (4)	○	○	○
When sending a long message (5)	○	○	○
When sending a very personal message (6)	○	○	○
While using public transportation (7)	○	○	○
While taking a walk in nature (8)	○	○	○
While shopping (9)	○	○	○
While home alone (10)	○	○	○
While cooking (11)	○	○	○
While in a noisy environment (12)	○	○	○
While in a library (13)	○	○	○

Q19 Below, try to estimate the speed of Voice-to-Text compared to manual texting. The center setting indicates that there is no difference in speed. Positive values indicate that Voice-to-Text is faster. Negative values indicate that Voice-to-Text is slower than manual entry.

	-100 -75 -50 -25 0 25 50 75 100
speed difference ()	

Q11 Please rank the following features in terms of how much they determine whether you use Voice-to-Text or not (1 being the most important - please drag the items in the order you think is appropriate)

_______ Accuracy of transcription (1)

_______ Ability to use Voice-to-Text hands free (2)

_______ The ease or difficulty with which one can correct errors (3)

_______ The ease or difficulty with which one can add punctuation (4)

_______ Speed of text entry (5)

_______ The ease or difficulty of using Emojis or GIFs (6)

_______ Privacy issues (7)

End of Block: Block 3

Appendix C

Tables

Descriptive Statistics				
Texting Time	Age Category	Mean	Std. Deviation	N
Manual Message Type 1	Young	14.112575757575755	3.925465487420479	22
	Old	28.673555555555556	8.393018022999327	15
	Total	20.015675675675677	9.429271205779310	37
Manual Message Type 2	Young	13.950909090909091	3.030322626199267	22
	Old	26.253555555555554	6.961193619901448	15
	Total	18.938468468468470	7.854897528411718	37
V2T Message Type 1	Young	6.728030303030304	1.755296341850927	22
	Old	8.693111111111111	2.778588903795646	15
	Total	7.524684684684685	2.399253029263850	37
V2T Message Type 2	Young	5.956515151515150	1.425432813607399	22
	Old	8.104888888888887	2.621848029529379	15
	Total	6.827477477477477	2.236512718304803	37

Table 1. Descriptive Statistics of texting time against texting mode, message type (1=message does not invite abbreviations, 2=message invites abbreviations), and age category.

Multivariate Tests[a]					
Effect		Value	F	Hypothesis df	Error df
Texting Mode	Pillai's Trace	.856	208.696[b]	1.000	35.000
	Wilks' Lambda	.144	208.696[b]	1.000	35.000
	Hotelling's Trace	5.963	208.696[b]	1.000	35.000
	Roy's Largest Root	5.963	208.696[b]	1.000	35.000
Texting Mode * Age Category	Pillai's Trace	.519	37.726[b]	1.000	35.000
	Wilks' Lambda	.481	37.726[b]	1.000	35.000
	Hotelling's Trace	1.078	37.726[b]	1.000	35.000
	Roy's Largest Root	1.078	37.726[b]	1.000	35.000
Abbrevability	Pillai's Trace	.281	13.660[b]	1.000	35.000
	Wilks' Lambda	.719	13.660[b]	1.000	35.000
	Hotelling's Trace	.390	13.660[b]	1.000	35.000
	Roy's Largest Root	.390	13.660[b]	1.000	35.000
Abbrevability * Age Category	Pillai's Trace	.098	3.786[b]	1.000	35.000
	Wilks' Lambda	.902	3.786[b]	1.000	35.000
	Hotelling's Trace	.108	3.786[b]	1.000	35.000
	Roy's Largest Root	.108	3.786[b]	1.000	35.000
Texting Mode * Abbrevability	Pillai's Trace	.034	1.249[b]	1.000	35.000
	Wilks' Lambda	.966	1.249[b]	1.000	35.000
	Hotelling's Trace	.036	1.249[b]	1.000	35.000
	Roy's Largest Root	.036	1.249[b]	1.000	35.000
Texting Mode * Abbrevability * Age Category	Pillai's Trace	.125	4.988[b]	1.000	35.000
	Wilks' Lambda	.875	4.988[b]	1.000	35.000
	Hotelling's Trace	.143	4.988[b]	1.000	35.000
	Roy's Largest Root	.143	4.988[b]	1.000	35.000

Table 2. Multivariate tests for the factors texting mode (manual vs V2T), abbrevability (message invites abbreviations or not), and age category.

Multivariate Tests[a]

Effect		Sig.	Partial Eta Squared	Noncent. Parameter
Texting Mode	Pillai's Trace	.000	.856	208.696
	Wilks' Lambda	.000	.856	208.696
	Hotelling's Trace	.000	.856	208.696
	Roy's Largest Root	.000	.856	208.696
Texting Mode * Age Category	Pillai's Trace	.000	.519	37.726
	Wilks' Lambda	.000	.519	37.726
	Hotelling's Trace	.000	.519	37.726
	Roy's Largest Root	.000	.519	37.726
Abbrevability	Pillai's Trace	.001	.281	13.660
	Wilks' Lambda	.001	.281	13.660
	Hotelling's Trace	.001	.281	13.660
	Roy's Largest Root	.001	.281	13.660
Abbrevability * Age Category	Pillai's Trace	.060	.098	3.786
	Wilks' Lambda	.060	.098	3.786
	Hotelling's Trace	.060	.098	3.786
	Roy's Largest Root	.060	.098	3.786
Texting Mode * Abbrevability	Pillai's Trace	.271	.034	1.249
	Wilks' Lambda	.271	.034	1.249
	Hotelling's Trace	.271	.034	1.249
	Roy's Largest Root	.271	.034	1.249
Texting Mode * Abbrevability * Age Category	Pillai's Trace	.032	.125	4.988
	Wilks' Lambda	.032	.125	4.988
	Hotelling's Trace	.032	.125	4.988

Table 3. Multivariate tests for the factors texting mode, abbrevability, and age category.

Significance and Partial Eta Squared included.

Descriptive Statistics				
	Age Category	Mean	Std. Deviation	N
Abbreviation Rate for Manual Message Type 1	Young	.0303030303030 30	.0980816477 22750	22
	Old	.0666666666666 67	.1868706368 60463	15
	Total	.0450450450450 45	.1397122740 47485	37
Abbreviation Rate for Manual Message Type 2	Young	.3181818181818 18	.4300519560 99126	22
	Old	.2444444444444 44	.3876397170 88626	15
	Total	.2882882882882 88	.4094724260 16292	37
Abbreviation Rate for V2T Message Type 1	Young	.0909090909090 91	.2103616986 33673	22
	Old	.0222222222222 22	.0860662965 82387	15
	Total	.0630630630630 63	.1728097119 08397	37
Abbreviation Rate for V2T Message Type 2	Young	.00	.000	22
	Old	.00	.000	15
	Total	.00	.000	37

Table 4. Descriptive statistics for the second MANOVA, factors are abbreviation rate, texting mode, and age category.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df
Abbreviation Rate	Pillai's Trace	.246	11.400[b]	1.000	35.000
	Wilks' Lambda	.754	11.400[b]	1.000	35.000
	Hotelling's Trace	.326	11.400[b]	1.000	35.000
	Roy's Largest Root	.326	11.400[b]	1.000	35.000
Abbreviation Rate* Age Category	Pillai's Trace	.001	.037[b]	1.000	35.000
	Wilks' Lambda	.999	.037[b]	1.000	35.000
	Hotelling's Trace	.001	.037[b]	1.000	35.000
	Roy's Largest Root	.001	.037[b]	1.000	35.000
Texting Mode	Pillai's Trace	.163	6.839[b]	1.000	35.000
	Wilks' Lambda	.837	6.839[b]	1.000	35.000
	Hotelling's Trace	.195	6.839[b]	1.000	35.000
	Roy's Largest Root	.195	6.839[b]	1.000	35.000
Texting Mode * Age Category	Pillai's Trace	.003	.094[b]	1.000	35.000
	Wilks' Lambda	.997	.094[b]	1.000	35.000
	Hotelling's Trace	.003	.094[b]	1.000	35.000
	Roy's Largest Root	.003	.094[b]	1.000	35.000
Abbreviation Rate * Texting Mode	Pillai's Trace	.283	13.802[b]	1.000	35.000
	Wilks' Lambda	.717	13.802[b]	1.000	35.000
	Hotelling's Trace	.394	13.802[b]	1.000	35.000
	Roy's Largest Root	.394	13.802[b]	1.000	35.000
Abbreviation Rate * Texting Mode * Age Category	Pillai's Trace	.036	1.317[b]	1.000	35.000
	Wilks' Lambda	.964	1.317[b]	1.000	35.000
	Hotelling's Trace	.038	1.317[b]	1.000	35.000
	Roy's Largest Root	.038	1.317[b]	1.000	35.000

Table 5. Multivariate Tests for abbreviation rate, texting mode, and age category.

Multivariate Tests[a]

Effect		Sig.	Partial Eta Squared	Noncent. Parameter
Abbreviation Rate	Pillai's Trace	.002	.246	11.400
	Wilks' Lambda	.002	.246	11.400
	Hotelling's Trace	.002	.246	11.400
	Roy's Largest Root	.002	.246	11.400
Abbreviation Rate * Age Category	Pillai's Trace	.848	.001	.037
	Wilks' Lambda	.848	.001	.037
	Hotelling's Trace	.848	.001	.037
	Roy's Largest Root	.848	.001	.037
Texting Mode	Pillai's Trace	.013	.163	6.839
	Wilks' Lambda	.013	.163	6.839
	Hotelling's Trace	.013	.163	6.839
	Roy's Largest Root	.013	.163	6.839
Texting Mode * Age Category	Pillai's Trace	.760	.003	.094
	Wilks' Lambda	.760	.003	.094
	Hotelling's Trace	.760	.003	.094
	Roy's Largest Root	.760	.003	.094
Abbreviation Rate * Texting Mode	Pillai's Trace	.001	.283	13.802
	Wilks' Lambda	.001	.283	13.802
	Hotelling's Trace	.001	.283	13.802
	Roy's Largest Root	.001	.283	13.802
Abbreviation Rate * Texting Mode * Age Category	Pillai's Trace	.259	.036	1.317
	Wilks' Lambda	.259	.036	1.317
	Hotelling's Trace	.259	.036	1.317
	Roy's Largest Root	.259	.036	1.317

Table 6. Multivariate Tests for abbreviation rate, text mode, and age category. Significance and eta squared values.

Descriptive Statistics				
	Age Category	Mean	Std. Deviation	N
Errors for Manual Message Type 1	Young	.803030303030303	1.000841396867407	22
	Old	.911111111111111	1.123109817148644	15
	Total	.846846846846847	1.038144696599537	37
Errors for Manual Message Type 2	Young	.621212121212121	.743902583266824	22
	Old	.711111111111111	.916053185766765	15
	Total	.657657657657658	.806939372661386	37
Errors for V2T Message Type 1	Young	.818181818181818	.732663999932122	22
	Old	.888888888888889	1.066567455703641	15
	Total	.846846846846847	.869917672401680	37
Errors for V2T Message Type 2	Young	.575757575757576	.921132372943677	22
	Old	.733333333333333	1.196555904145741	15
	Total	.639639639639640	1.028538392359707	37

Table 7. Descriptive statistics for the third MANOVA, error rate.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df
Texting Mode	Pillai's Trace	.000	.002[b]	1.000	35.000
	Wilks' Lambda	1.000	.002[b]	1.000	35.000
	Hotelling's Trace	.000	.002[b]	1.000	35.000
	Roy's Largest Root	.000	.002[b]	1.000	35.000
Texting Mode * Age Category	Pillai's Trace	.000	.002[b]	1.000	35.000
	Wilks' Lambda	1.000	.002[b]	1.000	35.000
	Hotelling's Trace	.000	.002[b]	1.000	35.000
	Roy's Largest Root	.000	.002[b]	1.000	35.000
Errors	Pillai's Trace	.046	1.706[b]	1.000	35.000
	Wilks' Lambda	.954	1.706[b]	1.000	35.000
	Hotelling's Trace	.049	1.706[b]	1.000	35.000
	Roy's Largest Root	.049	1.706[b]	1.000	35.000
Errors * Age Category	Pillai's Trace	.000	.013[b]	1.000	35.000
	Wilks' Lambda	1.000	.013[b]	1.000	35.000
	Hotelling's Trace	.000	.013[b]	1.000	35.000
	Roy's Largest Root	.000	.013[b]	1.000	35.000
Texting Mode * Errors	Pillai's Trace	.000	.001[b]	1.000	35.000
	Wilks' Lambda	1.000	.001[b]	1.000	35.000
	Hotelling's Trace	.000	.001[b]	1.000	35.000
	Roy's Largest Root	.000	.001[b]	1.000	35.000
	Pillai's Trace	.001	.035[b]	1.000	35.000

Texting Mode * Errors * Age Category	Wilks' Lambda	.999	.035[b]	1.000	35.000
	Hotelling's Trace	.001	.035[b]	1.000	35.000
	Roy's Largest Root	.001	.035[b]	1.000	35.000

Table 8. Multivariate Tests for error rate, text mode, and age category.

Multivariate Tests[a]

Effect		Sig.	Partial Eta Squared	Noncent. Parameter
Texting Mode	Pillai's Trace	.965	.000	.002
	Wilks' Lambda	.965	.000	.002
	Hotelling's Trace	.965	.000	.002
	Roy's Largest Root	.965	.000	.002
Texting Mode * Age Category	Pillai's Trace	.965	.000	.002
	Wilks' Lambda	.965	.000	.002
	Hotelling's Trace	.965	.000	.002
	Roy's Largest Root	.965	.000	.002
Errors	Pillai's Trace	.200	.046	1.706
	Wilks' Lambda	.200	.046	1.706
	Hotelling's Trace	.200	.046	1.706
	Roy's Largest Root	.200	.046	1.706
Errors * Age Category	Pillai's Trace	.909	.000	.013
	Wilks' Lambda	.909	.000	.013
	Hotelling's Trace	.909	.000	.013
	Roy's Largest Root	.909	.000	.013
Texting Mode * Errors	Pillai's Trace	.977	.000	.001
	Wilks' Lambda	.977	.000	.001
	Hotelling's Trace	.977	.000	.001
	Roy's Largest Root	.977	.000	.001
Texting Mode * Errors * Age Category	Pillai's Trace	.852	.001	.035
	Wilks' Lambda	.852	.001	.035
	Hotelling's Trace	.852	.001	.035
	Roy's Largest Root	.852	.001	.035

Table 9. Multivariate Tests for error rate, texting mode, and age category. Significance and Eta squared values.

Appendix D

Figures

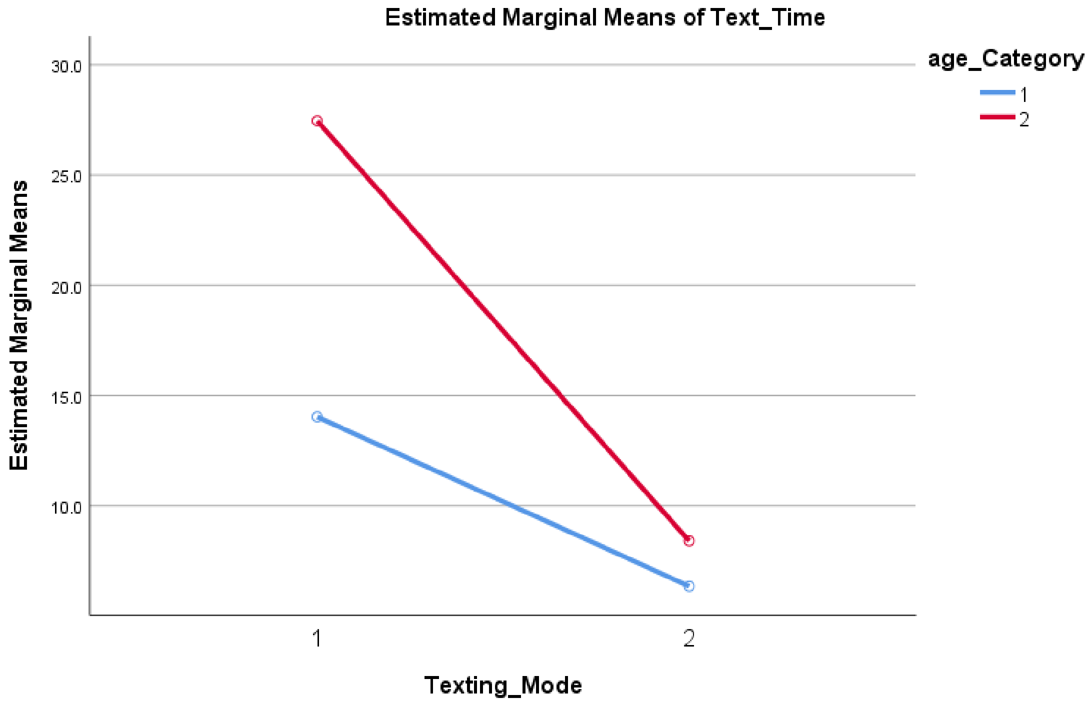

Figure 1. Interaction between texting mode (1=V2T, 2= manual text entry) and age category (1= young, 2=old). The dependent measure was texting time.