A Speech-To-Text System's Acceptance Evaluation: Would Deaf Individuals Adopt This Technology in Their Lives?

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Abstract. The problem observed was the difficulty of people who are Deaf or Hard of Hearing (D/HH) to know what is being said or informed in an environment, especially at schools, when sign language interpreter is absent. Thus, the main goal was to investigate which variables most influence on the acceptance of a Speech-To-Text system with regard to the different profiles of people who are D/HH. For the purpose mentioned, we conducted a pilot study in two distinct field researches, in which 11 D/HH volunteers participated. During this study, we used two models as inspiration, TAM and UTAUT, for data collection, which was concerned with: written communication, educational barriers, technology use, habit of using captions and subtitles, emotions, technology acceptance, social influence, empowerment and privacy. In the case of emotions, we used Emotion-LIBRAS, an instrument for people who are D/HH to identify positive, negative or mixed emotions towards technology.

Keywords: People who are Deaf or Hard of Hearing (D/HH), Automatic Speech Recognition (ASR), Technology acceptance, Mobile app, Emotions.

1 Introduction

Picture a place, in which there is only one person who is deaf signer among many hearing individuals who are non-signers. This is a common scenario in inclusive public high-schools in Brazil. Most of the time, deaf students are helped by sign language interpreters. However, interpreters are not always with them at schools. This situation is problematic for many reasons. Deaf students who are signers: (a) may tend to communicate only with a few individuals, mostly other deaf students, forming a segregated group; (b) may involve in a communication-dependency with interpreters, not only in classroom but in other school environments; and, (c) may not know how to follow classes if interpreters are not present. Coupled with these difficulties, also, in Brazilians mainstream public schools, we do not have note-takers; there are a small

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number of interpreters to assist all deaf students; and, in some cities, only a small group of deaf persons are oralized and/or can do lip-reading.

Taking this information into account, you may note that we cannot generalize a specific characteristic of groups of people who are Deaf or Hard of Hearing (D/HH). They are a diverse community concerning with their communication skills. In Table 1, the combination of three types of communication that deaf individuals may use: sign language, text reading and writing, and orally speaking with lip reading. This combination resulted in eight modes of communication. Thus, someone might use sign language and written text, another might use three types, and so on.

Table 1. Profiles of people who are D/HH

Sign Language (SL)	**Read and Write texts (RW)**		**Oralization and Lip reading (OL)**
	Yes	**No**	
Yes	[Profile1] SL+RW+OL	[Profile5] SL+OL	**Yes**
Yes	[Profile2] SL+RW	[Profile6] SL	**No**
No	[Profile3] RW+OL	[Profile7] OL	**Yes**
No	[Profile4] RW	[Profile8] *Null*	**No**

This diversity has stimulated interest in research regarding the possibility of acceptance of a speech-to-text system. This research can bring up some controversial discussions, such as: reduction of jobs for interpreters, or the devaluation of the mother tongue of people who are D/HH. However, we are trying to offer one alternative for situations in which deaf individuals are at a disadvantage in an environment communicatively uncomfortable for them. The problem observed was the difficulty of people who are D/HH to know what is being said or informed in an environment, especially at schools, when sign language interpreter is absent.

Thus, the main goal was to investigate which variables most influence on the acceptability of a speech recognition system with regard to the different profiles of people who are D/HH (Table 1). For this purpose, we conducted a pilot study in two distinct field researches, in which 11 D/HH volunteers participated. During this study, we used two models as inspiration, TAM and UTAUT, for data collection, which was concerned with: written communication, educational barriers, technology use, habit of using captions and subtitles, emotions, technology acceptance, social influence, empowerment and privacy. In the case of emotions, we used Emotion-LIBRAS [7][8], an instrument for people who are D/HH to identify emotions towards technology.

The remainder of the paper is organized as follows. Section 2 describes the theoretical foundation on technology acceptance models; In Section 3, related works about educational use of STT systems concerning with deaf students are briefly described. In Section 4, methods and materials are presented; Section 5 report results and discussion; and, in Section 6, conclusions are evidenced.

2 Technology Acceptance Models

Elements from two technology acceptance models were used in this research; the first model is the Technology Acceptance Model (TAM) proposed by Davis, Bagozzi and

Warshaw [2] to understand information systems usage behavior, using 02 constructs as the main predictors: *perceived usefulness* and *perceived ease of use*; and, the second model, called Unified Theory of Acceptance and Use of Technology (UTAUT), was proposed by Venkatesh *et al* [12] in order to unify eight existent information technology acceptance models. UTAUT model concerns with 04 constructs: *performance expectancy*, *effort expectancy*, *social influence*, and *facilitating conditions*.

Pan *et al* [4] carried out a research using real-time transcription for computer-mediated communication tested with 24 Chinese university students who are non-native English speakers. Their model constructs included: (a) Response accuracy; (b) Participant's confidence of the answer's correctness; (c) User satisfaction; (d) Cognitive load; and, (e) Perception of speech recognition errors. Tests were conducted, by [4], considering three transcription conditions: no transcript, perfect transcript, and transcript with low recognition rate. As results, Pan *et al* [4] reported that (a), (b), and (c) were significantly better in perfect transcript condition than the others; with respect to cognitive load, it was not found significant user perceived task difficulty and that participants felt recognition errors caused interference in understanding.

Papadopoulos and Pearson [5] developed the Semantic and Syntactic Transcription Analysing Tool (SSTAT) in order to improve text transcription from automatic recognition systems, and conducted an acceptance evaluation of the system with 26 undergraduate and postgraduate students as participants (03 were D/HH). Research constructs used were: (a) Perception of transcription quality; (b) Perceived acceptance of transcripts; and, (c) Usefulness and perceived usability. As results, Papadopoulos and Pearson [5] informed general findings, not specifying by type of disability, in which constructs (a) and (b) are related to transcription accuracy; also participants found ASR useful (c) as an alternative of conventional note taking.

Rodríguez, Caminero and Van Kampen [11] proposed the SignSpeak, an assistive technology for people who are deaf, which recognize and translate continuous sign language to text. Authors refers to acceptance models (TAM, UTAUT and TPC), however results from an acceptance evaluation by people who are deaf are not shown.

3 STT System for Educational Use by Deaf Students

Motivated by Liberated Learning Project (LLP)[1], the sixteen following works investigated the use of STT systems in classroom settings by hearing students and students who are D/HH: Bain et al [1], Primiani, Tibaldi and Garlaschelli [9], Ranchal et al [10], Wald [13], Wald [14], Wald and Bain [15], Wald [16], Wald and Bain [17], Wald [18], Wald [19], Wald and Yunjia [20], and, Zhili, Wanjie and Cheng [21].

Among these works, only four ([10], [19], [20], [21]) actually carried out field researches with D/HH participants and used synchronized medias (videos and classes

[1] "In 1998, Saint Mary's University (SMU) in Nova Scotia, Canada, proposed a project [LLP] to create a more fully accessible learning environment. […] In the resulting Liberated Learning courses, instructors use ASR [*Automatic Speech Recognition*] to display spoken language as text." ([1], p. 592).

slides) along with automatic speech transcription. In [10], [19], [20] target users were undergraduate and graduate students, carried out in U.S.A. and Canada; and in [21] were deaf students from primary and secondary special schools, conducted in China. With respect of acceptance evaluation, none of researches used any acceptance model.

Ranchal *et al* [10] used a SR-mediated lecture acquisition (SR-mLA) taking two situations into account: (a) real-time captioning (RTC); and, (b) post-lecture transcription (PLT) using synchronized media; during an entire semester. Comparing these two situations, with respect to: technical feasibility and reliability of classroom implementation, instructors' experiences, word recognition accuracy, and student class performance; PLT showed better results for all compared factors. Also, emotional feedback of some students was the sense of minimizing the concern during note taking and of relaxing to pay more attention to the teachers.

Wald [19]; and, Wald and Yunjia [20] have been evaluating Synote for note taking during classes and for content reviewing, since 2008. During 04 years, it was evidenced improvements on: learning, attention, motivation, pleasure, and obtaining results. Zhili, Wanjie and Jiacheng [21] reported that distractions occurred when transcribed texts contain errors, reducing enthusiasm. According to Bain *et al* [1], transcription errors can be barriers in acceptance of STT systems.

4 Methods and Materials

First, we defined research's hypotheses and technology acceptance model, which are presented in Fig. 1. We used TAM [2] as the model structure and some ideas of UTAUT [12]'s constructs to formulate hypotheses.

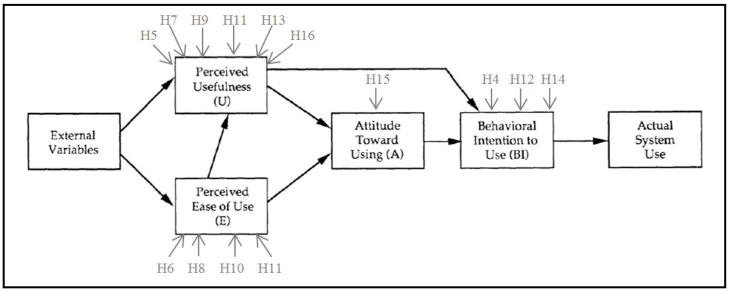

Fig. 1. Model and hypotheses of this research

Second, we prepared materials, specially elaborating questions (Pre-test (PeTQ) and Post-test (PoTQ) questionnaires[2]) taking hypotheses as the start point. Hypotheses are described in Subsection 5.1, where we report results and discussion. Third, materials were organized to be used in six stages of field research procedure. In Field research 1 and 2, the script followed the same order: (a) term of consent, explaining

[2] Available in: `http://goo.gl/Qw6IRw`,
file names: "Pre_test_PrietchSouzaFilgueiras.pdf" and "PostTest_and_EmotionLIBRAS.pdf".

research procedures and objectives, and asking for image authorization; (b) mood status sheet3, including 40 emoticons (with its respective words in Brazilian Portuguese), taken from Facebook (‘How are you feeling?’); (c) pre-test questionnaire; (d) test, which consisted in a repetition the following three steps for each participant: one researcher read one phrase for audio capture and recognition processing, using a Samsung GalaxyNote GT-N7000; SampleVoiceApp from Nuance Dragon Mobile [3] deliver transcripted text; and, one participant read the transcripted text and communicate it in sign language what he/she understood without help; (e) Emotion-LIBRAS4, to identify emotions of participants concerning with experience of using a STT system; and, (f) post-test questionnaire was elaborated with inspiration in [2],[6],[12].

5 Results and Discussion

Table 2 refers to characteristics of pilot field researches, whose are displayed in. It is worth to inform that all questions and options of answers were read by the researcher and communicated in sign language by interpreters to participants. In Field research 2, participants responded in sign language and interpreters translated to oral Portuguese in order to assistants take note on paper.

Table 2. Characteristics of pilot Field research 1 and 2

	Field research 1	**Field research 2**
Date	October 7th of 2013	October 30 of 2013
Place	Computer Lab1 at UFMT	Alfredo Marien School[5]
Participants	05 (01 female, 04 males)	06 (01 female, 05 males)
Research team	01 interpreter, 02 assistants	02 interpreter, 03 assistants
Questionnaires type	Online (GoogleDrive Form)	Paper
Number of questions	PeTQ = 29, PoTQ = 14	PeTQ = 20, PoTQ = 14
Phrases	Average of 12.8 words	Average of 11.73 words

Answers from mood status sheet show, in total, 26 (19 positive and 07 negative) types of emotions selected. Top three positive emotions were: happy (09); great (05); and wonderful (05); and most voted negative emotions were: tired (04); and, indifferent/meh (02). P1-P5 and P10-P11 marked only positive emotions; in Field research 1, participants selected only one option each. In Field research 2, Participants P6 and P7 marked many types of emotions (13 and 19), however, they made confusing options, for example, <indifferent/meh> and <curious or amused>. Participants from P8 to P11 also marked many options (14 and 15), however they made sense, for example, P8 selected 12 positive and 02 negative, in which negative emotions were tired and lost, among happy, blessed, amused, and others. In general, deaf students were interested in participating of research, raising emotions such as, happiness; on the other hand, 06 of them (P4, P6-P8, P10-P11) never participated in researches involving technology before, raising emotions such as, feeling lost.

3 Available in: `http://goo.gl/Qw6IRw`, file name: “MoodStatusSheet.pdf”.
4 Available in: `http://goo.gl/Qw6IRw`, file name: “EmotionLIBRAS.pdf”.
5 This public regular school is specialized on youth and adult education (adult literacy).

Participants' age ranged from 17 to 43 years old, with average of 28; Among 11 participants, 04 are enrolled in primary school, 04 in high school, 02 concluded high school, and 01 is currently in higher education. From their self-report about modes of communication, in PeTQ, we identified profiles (Table 1) as follows: [Profile1] = 1 participant; [Profile2] = 4; [Profile5] = 3; [Profile6] = 3. Profiles 3, 4, 7 and 8 were not evidenced; none of these 04 profile types included sign language.

5.1 Responding Hypotheses

Each hypothesis[6] was tested using answers from pre-test and post-test questionnaires. Software used for statistical analysis was R[7]. In the case of hypotheses: H1-H3, chi-squared tests for independence were used, in order to understand the relation between categorical variables; for hypotheses: H4-H12, H14, H16, Kruskal-Wallis tests were conducted, since variable are ordinal; and, for hypotheses H13 and H15, Pearson Correlation Coefficient was used, in order to measure the level of correlation between variables, also the significance of the correlation was calculated. For all tests, we considered 10% of significance, in other words, null hypothesis was rejected when p-value turns out to be less than 0,10.

H1: "The level of hearing impairment is related to reading and writing texts as the favorite communication mode, independent of gender or age". It was observed a statistically significant relationship between 'level of difficulty to follow subtitles in movies' and 'level of hearing impairment' (p-value=0,06); also, even though we had a low number of participants, if we consider dependence by gender, it was found that among males this results are also significant (p-value=0,04). Another statistically significant relationship was found between 'level of confidence in signing documents without help' and 'level of hearing impairment' (p-value=0,08).

H2: "The higher the level of education, higher the written language proficiency, independent of communication mode". It was observed a statistically significant relationship between 'level of confidence in signing documents without help' and 'level of education' (p-value=0,06), indicating independence from deaf persons' profiles. Four participants enrolled in primary school and 03 high school students do not feel confident in signing written documents without help, indicating that in lower levels of education people who are D/HH tend to have more difficulty in these situations. During Field research 1 and 2, all participants needed interpreter's help to explain and to sign term of consent.

H3: "The higher the educational level of the D/HH person's mother, higher the influence on written language proficiency, independent of communication mode". In this case, it was not found any statistically significant relationships between variables. However, it is worth noting that 06 mothers of participants dropped out from primary school, 01 completed primary school, 01 dropped out from high school, 01 completed higher education, and 02 participants did not know the education level of their mothers. These information present a scenario that may not offer motivation for

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6 Available in: `http://goo.gl/Qw6IRw`,
file name: "Hypotheses_PrietchSouzaFilgueiras.pdf"

7 The R Project for Statistical Computing. Available in: `http://www.r-project.org/`.

mothers to help their children studying at home. The only one mother with completed higher education, her deaf son was one of most easy to communicate and to understand questions quickly, even though he is profoundly deaf.

H4: "Written language proficiency influences 'BI' of a STT system". It was verified that relation between 'in general, it is useful' and different intensity (yes, very much; and yes, sometimes) of 'frequency written language use with family' is statistically significant (p-value=0,02). From this, we conclude that people who are D/HH who communicate in written from with family tend to consider the STT app more useful, consequently raising behavioral intention to use, than those who do not use this mode of communication at home.

H5: "'U' of a STT system is more evident for D/HH adults, considering each of the profiles (Table 1)"; H6: "'E' of a STT system is more evident for younger people who are D/HH, considering profiles". In these cases, it was not found any statistically significant results; neither for total sample, nor for any type of profiles.

H7: "'U' of a STT system is more evident for D/HH males"; H8: "'E' of a STT system is more evident for D/HH females"; both considering profiles. It was noted statistically significant difference of perceived usefulness among gender only in Profile2 (p-value=0,08). Again, even though we had a low number of participants, this result shows that male participants find STT app more useful than do female participants, considering Profile2 (SL+RW).

H9: "'U' of a STT system is more evident for people who are D/HH in higher education levels, considering profiles"; H10: "'E' of a STT system is more evident for people who are D/HH in lower education levels, considering profiles". In these cases, it was not found any statistically significant results; neither for total sample, nor for any type of profiles.

H11: "'U' and 'E' of a STT system are more evident for people who are D/HH with advanced knowledge of computing, considering profiles". Only in the case of Profile2 (SL+RW), it was observed statistically significant difference of perceived ease of use between participants that use and those who do not use computer even if they do not have Internet connection (p-value=0,10). Participants who are D/HH who use computer even if they do not have Internet connection had higher ease of use perception of STT app. That means theses users may be more familiar to different kinds of systems, than those who just use computers for navigating on Internet.

H12: "Social influence influences 'BI' of a STT system by D/HH persons, considering profiles". It was not found any statistically significant differences.

H13: "Positive emotions influence 'U' of a STT system by people who are D/HH, considering profiles". For Profile2 and Profile6, it was observed high correlation, respectively, (r=1) and (r=-1), both are significant with p-value less than 0,0001. This means that the greater participants of Profile2 agree with the statement 'in general, it is useful', greater they feel satisfied (positive and significant correlation equal to 1); and, the opposite occurred for participants of Profile6, in which the greater they agree with the statement, lesser they feel satisfied, relaxed and amused (r = -1). Besides Emotion-LIBRAS, we also asked what level of 'positively surprised' participants felt during test conduction. In Field research 1, all participants answered to be extremely surprised; and, in Field research 2, 05 participants were extremely surprised and 01 felt very surprised. Also, we asked in what level they felt 'frustrated', answers were: 04 felt highly frustrated, 02 little frustrated, 01 average, 04 did not feel frustrated.

H14: "User empowerment influences 'BI' a STT system by D/HH persons, considering profiles". It was not found any statistically significant differences.

H15: "Privacy influences 'A' a STT system by people who are D/HH, considering profiles". For Profile2 and Profile6, it was observed high correlation, respectively, (r=1) and (r=-1), both are significant with p-value less than 0,0001. This means that the greater participants of Profile2 agree with the statement 'if someone's secret is transcripted, it can raise privacy issues', greater they worry about their own privacy (positive and significant correlation equal to 1); and, the opposite occurred for participants of Profile6, in which the greater they agree with the statement, lesser they worry about their own privacy (negative and significant correlation equal to -1).

H16: "The use of a STT system by people who are D/HH, considering profiles, can influence mitigation of educational barriers in classrooms". A statistically significant difference of means (p-value=0,08) was detected with respect to participants' understanding about 'It [a STT app] can favor understanding of classes, if teachers use it' and 'Group work's formation in school classroom'. This result shows that participants consider that group work statistically influence on how D/HH persons may think the use of a STT app in classroom can favor their understanding of classes.

5.2 Analysing Other Criteria of STT System's Acceptance

For pilot tests, SampleVoiceApp [3] was adjusted to recognize Brazilian Portuguese (pt_BR), and also was trained using the 30 selected phrases, taken from known authors, popular sayings or music pieces; and, for each participant a phrase was randomly designated. From Field research 1 to 2, new phrases replaced those 05 used before.

After pilot tests, video recordings were analyzed by two experienced interpreters[8] that, (#1) read the eleven original written Portuguese phrases (one phrase for each one of the eleven participants) and translate to a written Portuguese in LIBRAS structure; (#2) analyzed each participant video and write in Portuguese the translation from LIBRAS; and, (#3) compared results from step #1 and step #2 and assign a performance index[9] for each participant (Table 3).

Observing Table 3 we can notice that 09 participants (P2, P4-P7, P8-P11) were classified with indexes less than cutoff score (50%); 01 participant (P1) was classified with regular performance; and, 01 participant (P3) reached the higher index. However, it is important to highlight that, during the test in Field research 2, we noticed 08 phrases used metaphors and this kind of text is hard for people who are D/HH to understand. This perception was confirmed by interpreters when they analysed phrases

Table 3. Performance index of each participant

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Interpreter1	C	D	A	E	E	E	E	D	D	E	E
Interpreter2	C	E	A	E	E	E	E	C	E	E	D

8 *Interpreter1* and *Interpreter2* are certified by Pró-LIBRAS, a national SL exam, and, respectively, they have 10 and 05 years of professional experience.

9 As a standard, we used Brazilian Academic Performance Index: A (Excelent) [90-100%]; B (Good) [80-89%]; C (Fair) [60-79%]; D (Fail) [50-59%]; E (Bad) [0-49%].

and videos afterwards. On the other hand, phrases translated by P6, P8 [Profile2], and P9 [Profile1] were the simplest ones, and they had a bad performance index; and, P3 (Profile5) translated a phrase containing metaphors and had an excellent performance.

Four participants that informed to feel highly frustrated using the STT app also were assigned to have bad performance index for translating phrases from Portuguese to LIBRAS; 02 of them were participants who marked most negative options in the mood status sheet at the beginning of procedures of Field research 2; and, 03 of them where classified as being in Profile2 (SL+RW) according to their answers about mode of communication preferences, which is inconsistent with their performance results.

None of participants knew any STT system before. They were very surprised and curious to see how it worked. Results were interesting to observe, such as: they were very interested in having the STT app "Where can I buy?", "How much does it cost?". After test, we gave them some time "to play" with the STT app and they liked to read what they spoke, they had an excited time (laughing and making fun of each other) when they found out that many words were transcripted differently from what they meant to say. In Field research 2, participants did not show such excitement as the group from Field research 1, but they expressed that this kind of STT system could be a great tool to practice pronunciation of words, improving oralization.

6 Conclusion

In total, only seven hypotheses (H4, H7, H8, H11, H13, H15, H16) had outcomes that showed statistically significant results. Our conclusion is that people who are D/HH, even though they have difficulties to understand written language, they are willing to adopt a STT system and have perception of its usefulness, not only at schools but in daily life, mostly because they considered it important as an alternative of communication and they like to use technological products. At least half of participants would have the STT app installed at the same date as researches happened. However, long-term, difficulties with written language may be a decision factor to discontinue using the STT app, after the excitement period using "the new toy" ends.

Since this paper reports pilot tests with a reduced number of participants, we could not study the total variety of deaf persons' profiles and also a representative number by gender. Also, we noticed that classifying participants in different profiles according their self-report of communication mode preferences is not the most suitable form. In future works, we intend to investigate a broader diversity and find other forms of classifying participants' profiles.

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