IMPROVING SPELLING SKILLS FOR BLIND LANGUAGE LEARNERS*
Orthographic Feedback in an Auditory Vocabulary Trainer

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Abstract: This paper describes the design and the design process of orthographic feedback in a computer-assisted vocabulary learning (CAVL) application that is targeted at blind language learners. It discusses current research findings of vocabulary and spelling acquisition, as well as special needs of blind computer users. CAVL applications often assume the user's sightedness. While it is possible for blind users to access software via screen reader or Braille line, it is argued that orthographic feedback does not translate one-to-one from visual-to-auditory (or tactile). To overcome this short-coming and thus ensure high usability for blind users, the feedback may be designed differently to be delivered via the auditory channel. Following a user-centered design approach, the orthographic feedback in an auditory vocabulary trainer is constructed and evaluated iteratively with users. The preliminary architecture that evolved out of these pre-studies is reported and discussed. In conclusion, an outlook is given as to how the final architecture will be implemented and evaluated.

1 INTRODUCTION

Blind people often use text-to-speech synthesis when they work on the computer. Using a Braille line to convert digital texts into embrossed writing is slow and requires extra hardware. Relying more on TTS technology, however, lessens blind people's exposure to the written form of words which is especially important when studying another language. The English language makes it difficult to deduce a word's orthography from its pronounciation. Consider homophones such as 'seam' and 'seem'. Is there a way for blind people to study meaning *and* form of vocabulary within an auditory CAVL application?

The aim of this paper is to explore the possibility of constructing a vocabulary trainer that is both highly usable and efficient for blind language learners. In section 2, this endeavor is motivated by providing essential background information in the fields of vocabulary acquisition, spelling acqusition, computer-assisted vocabulary learning applications, and special needs of the blind. The section ends with explicitly formulating the problem (cf. 2.4). Section3 explains the methodolody that was used in this study, one that greatly involves collaboration with the target users. Section 4 then introduces the conceptional architecture and the implementation of the program that evolved out of these user studies. Finally, section 5 presents the results of the final evaluation and section 6 summarises the key findings of this paper.

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2 MOTIVATION

2.1 Vocabulary Acquistion

Building a large vocabulary in a second language (L2) is essential to language proficiency. Especially in the beginning of learning a new language, every new sentence contains new words, making it very difficult to deduce the meaning from the context. Focusing on vocabulary acquisition in this stage is often a good way to make progress. Advanced learners also benefit from expanding the size of their vocabulary as it allows them to indulge in the language at a deeper level. Vocabulary may be acquired both *explicitly* and *implicitly* (Ma and Kelly, 2006). Ex-

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plicit vocabulary learning exercises, such as working with bilingual flashcards, are usually word-centered, decontexualised and repetitive. Implicit vocabulary exercises, such as word association games, are often more complex and provide a meaningful context for each word. Both learning styles have been addressed in the design of computer-assisted vocabulary learning tools (Goodfellow, 1995). Computerised vocabulary study can make learning more interesting and effective, through means of intelligent interaction with the user and immediate feedback. While explicit 'drill exercises' may fall into the category of "behaviourist CALL software" as coined by Warschauer (Warschauer, 1996), they may actually be more effective than applications that draw on implicit acqusition principles. Groot suggests this in the evaluation of a CAVL application that models the stages of L1 acquisition (Groot, 2000). Simple flash card methods offer many possibilities when computerised and will be the primary focus of this work. Cooley points out that "the users [should be allowed] as much manipulative freedom with computer mediated flash cards as they would have with a cardboard version" [p. 3] (Cooley, 2001). One application that implements this idea without many other gimmicks is Phase 6 (Phase6, 2009). It allows the user to enter their own learning material and organises the content according to the "Ebbinghaus curve", a model of timed repetitions necessary to retain information in the long-term memory. The users have to decide themselves whether a word they entered was correct or not, then the card is moved accordingly. eSpindle (eSpindle, 2009) is a more elaborated online application and even though the learning content is only available in English, "a strong case can be made for the appropriateness of eSpindle as a tool for L2 English learners [...]" [p. 25] (Olmanson, 2007). What makes eSpindle special is that actually teaches vocabulary and spelling, by employing feedback that is instructional as well as motivational, and by allowing to explore word contexts via hyperlinks. In this application, it is the system not the user who decides which answer is correct.

2.2 Spelling Acquisition

Vocabulary knowledge requires knowing both, a word's meaning and its spelling. Orthography may be a tough subject to master, especially when it comes to "the English language [that] has so many exceptions to its rules that the rules themselves become meaningless" [p. 18] (Arter and Mason, 1994). There are differences for those who learn English as a first language and those who learn it as a second language. The first group will acquire literacy alongside with orthography, while the second group will already have a language that is likely to influence acquisition of English spelling to some extent. This work assumes existing literacy and is concerned primarily with improvement of spelling or acquisition of spelling in a new language. Studies that are concerned with orthography acquisition point out the visual nature of this task (Torbe, 1977), (Arter and Mason, 1994), (Warda, 2009). Indeed, people form "mental orthographic images (MOI)" of words (Warda, 2009) and for those who are not blind or otherwise visually impaired, these mental images are likely to be *visual* representations of words. A word can 'look right', which is why people tend to write down a word when uncertain of its spelling. In fact, it has been shown that the storage of these MOI's is so strong, that exposure to "incorrect versions of [...] particular words can interfere with subsequent spelling accuracy" [p. 492] (Brown, 1988). This is why, in general, it is better to confront learners mainly with correct spellings, hence avoiding discrimination exercises of correctly and incorrectly spelled words. Additionally, in the spelling acquisition process it may be helpful to highlight difficult letter patterns within words and that are continually misspelled, as is suggested by Arter (Arter and Mason, 1994). This idea is realised in eSpindle, the CAVL tool that was mentioned earlier. Feedback for misspelled words locates the exact position of errors by showing correct letters and replacing wrong letters by lines.

2.3 Challenges for Blind Language Learners

Blind and visually impaired people often have a well-trained memory to make up for the lack of vision (Couper, 1996). This often makes them superior language learners as they can easily retain vocabulary. However, especially in the L2 classroom, they may also be "notoriously bad spellers" [p. 9] (Couper, 1996). Learning the orthography of new language requires blind students to learn a new variation of Braille script of that language. Letters in Braille often have differing representations in other languages, i.e. accents in French and umlauts in German. Braille also commonly uses shortened words to save space and these abbreviations vary in different languages. Blind students thus face quite a challenge when learning how to spell in a different language; mental orthographic images of words are only accessible in combination with mastering a new Braille variation. However difficult this may be, Braille is often the perferred choice medium for blind students who study vocabulary, as it allows them to read with their hands just as sighted people use their eyes. Unfortunately, there is "a great shortage of [printed] materials suitable for learners requiring non-visual methods" [p. 1] (Boguslaw, 2000) and, what might be even more of a handicap, if a teacher or a student wishes to use different learning material, it has to be made available first. One solution to this problem might be to use the Braille line of a PC, a piece of hardware that translates the screen into embrossed writing, one line at a time. However, the Braille line makes navigation and skipping through information rather difficult which is why blind computer users often prefer to work with text-to-speech technology. Not only is such software universally available on most PC's, it allows working with texts at the same speed as sighted users and even much faster (Moos and Trouvain, 2007). While the blessings of this development are undeniable for the blind community, there are two major downsides when working with screen readers. First, "simply replacing one interaction mode, such as the display of text on a screen with a functionally equivalent mode as in speaking thext aloud, is not necessarily equivalent from the point of view of user experience" [p. 65] (Shinohara, 2009). So blind people miss out on some of the information presented on screen. And second, exposure to the written word is lacking almost entirely. Spelling acquisition must then become even more of a conscious effort for blind language learners and with available CAVL tools aimed primarily at sighted users, the design of such software must also be conscious if it is to include blind users. A so-called 'design for all' approach might not be the ideal solution, however, since "[p]roviding access to people with certain types of disability can make the product significantly more difficult to use by people without disabilities, and often impossible to use by people with a different type of disability" (Newell and Gregor, 2000) as cited in (Shinohara, 2009).

2.4 Problem Formulation

Summarising the research findings from the previous sections allows formulating the problem more concretely. Language learners are well advised to study vocabulary, that is meaning and spelling of words, in a focused and decontextualised fashion. CAVL tools may support learners in this process. Blind language learners, who face great challenges when acquiring orthography, cannot access the orthographic feedback in existing CAVL applications to the same extent as sighted learners. They have to rely either on the Braille line, which is inconvenient since it is slow and an extra piece of hardware, or on a screen reader, which is suboptimal for information such as orthographic feedback that is designed to be conveyed visually. A nearby solution would then be to design orthographic feedback to be conveyed via the auditory channel. Katz has shown that "the many similarities found in recognising orally spelled words and in reading suggest that the abilities depend on the same [lexical and] nonlexical procedures" [p. 215] (Katz, 1989). Katz explains that when recognising orally spelled words, the letters are processed serially rather than simultaneously as in reading. This indicates that people piece together single letters to form a word in their mind. Orthographic feedback in CAVL applications might then be given in form of oral spelling when vision is impaired.

3 METHODOLOGY

3.1 Three Phase Approach

The goal of this work is to create a tool that is highly *usable* for blind users, i.e. a tool that is useful, efficient, effective, satisfying, and accessible according to Rubin's definition of usability [p. 16] (Rubin and Chisnell, 2008). This is why a user-centered-design (UCD) approach has been adopted to construct a system architecture in collaboration with users. "When a product or service is truly usable, the user can do what he or she wants to do the way he or she expects to be able to do it, without hindrance, hesitation, or questions" [p. 4] (Rubin and Chisnell, 2008). Usability thus implies some sense of *invisibility*, when something is usable it serves as an intuitive tool that allows people to accomplish their tasks easily and effortlessly.

The UCD approach that has been chosen for this study consists of three phases, where the last two rely heavily on user involvement. The first phase serves merely to get a clear understanding of the problem and gather knowledge from related studies. In the second phase, the architecture is designed and immediately tested with a user in a qualitative evaluation. The architecture is then adapted accordingly and tested again until a satisfactory design is found. The last phase consists of implementing the final architecture and evaluating it under sophisticated testing conditions. This model has been adopted from Microsoft's UCD approach (Harper et al., 2008) that suggests a cycle of the following five phases: understanding, study, design, build, evaluate. However, the aim of this work is merely to evaluate the concept of auditory orthographic feedback which when applying Microsoft's design cycle, would mean completing the cycle only once. To allow iterative testing nevertheless, the approach has been adopted as described.

3.2 Completed Phases

The three phases include understanding the problem, designing a solution in collaboration with users, and finally building and evaluating a demo system. All three phases have been completed at the time of writing. First, the problem has been explored in the context of related research as was described in section 2. Secondly, a preliminary solution has been tested and gradually improved with seven target users, with some users participating in the study more than once. Thirdly, a demo version has been implemented in JAVA and finally been evaluated with 15 pupils from a special school for the blind.

In the following, section 4 describes the system architecture. Section 5 presents the results from the final evaluation phase.

4 SYSTEM ARCHITECTURE

4.1 Conceptual Architecture

The goal of the design is to make orthographic feedback within a CAVL application fully available to blind computer users who work with text-to-speech technology. Drawing on the research findings discussed in section 2, the design should satisfy the following system requirements:

1. employ a flash card style study method
2. give positive and encouraging feedback and limit negative feedback
3. confront the user only with correct spellings and point out the position of errors
4. function with a normal keyboard and TTS technology
5. achieve the same learning outcome as visual orthographic feedback would

In eSpindle, spelling mistakes are corrected as follows: when the user enters a misspelled word, for example 'a[k]qui[z]ition', the word is deleted immediately from the screen and 'a_qui_ition' is displayed instead. The user is then asked to enter the word again. While this *could* be translated one-to-one using a screen reader, it is not very practical. When 'a_qui_ition' is spelled auditorily without visual feedback, one has to remember the position of the errors, figure out which letters were right and which ones were wrong, and finally find the correct letter—all in the mind! So even though blind students tend to be mind jugglers, this exercise is not intended to improve memory skills but rather orthographic skills. So how could orthographic feedback be given auditorily in a way that serves its purpose better? This was the guiding question in phase II (cp. section 3) of the design construction. The main result was that people who orally correct spelling mistakes for each other, slow down where the error had occured and use a different pitch. 'a[k]qui[z]ition' will most likely be corrected by spelling the word in its appropriate form, 'a[c]qui[s]ition', and highlighting the positions of the errors, in this case [c] and [s]. People also point directly to the mistake by saying 'acquisition' is spelled with 'c', not a 'k'. However, these types of corrections vary greatly with the type of mistake and simply spelling out the entire word is a safe bet when it comes to design consistency. The following reports the architecture that is in line with the system requirements and was considered most usable by the seven test subjects who took part in the design. Figure 4.1 illustrates the process.

The system initiates the interaction by giving the German definition of a word (G*i*). It then responds to three types of user input, namely:

Correct: the system gives positive feedback and moves on to the next word.

Not correct: the system gives short and unintrusive negative feedback and says the word in German (G*i*) and English (E*i*). The user can then attempt to spell the word.

Partially correct: the system gives encouraging feedback and spells the word by changing the pitch where errors occurred (prosodically enhanced spelling). The user can then enter the word anew.

In case the user needs more then one attempt, the system adopts the response for 'not correct' as follows':

Not correct: the system gives short and unintrusive negative feedback, pronounces the word in English (E*i*), and spells the entire word. The user can then enter the word.

The system only moves on to the next word when the correct answer has been given. The user can at any point in the interaction access the German word by typing 'G', the correct English translation by typing 'E', and the spelled version of the English word by typing 'S'. Words are classified as 'learnt' when they are translated and spelled correctly after the first prompt, otherwise they are repeated in a loop.

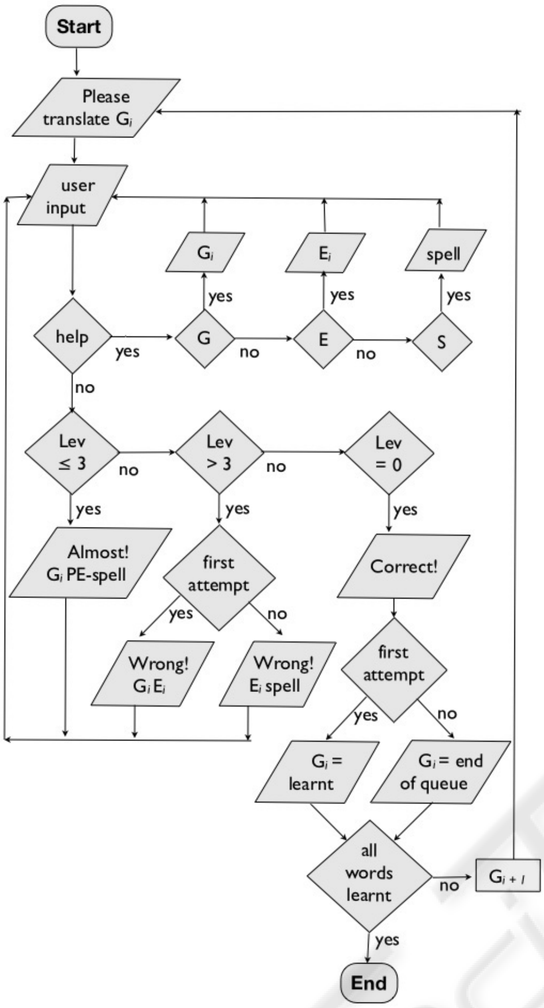

Figure 1: Flowchart of the System Architecture.

4.2 Implementation

The goal of the demo version is to evaluate the basic concept of auditory orthographic feedback as it has been descibed in the previous section. A demo version of this architecture will be implemented in JAVA. The vocabulary lists and the spelled words will be read out by a by a text-to-speech (TTS) synthesiser while the feedback is given by a recorded voice. TTS technology is used because it eventually allows easy manipulation of words, such as slowing down when repeating a word and changing pitch when pointing to mistakes. It is the medium that blind people commonly work with. This ensures also that new words could eventually be added easily to the database but has the downside of occasionally mispronouncing words. The other feedback is given by a human. It is assumed to sound more encouraging when a person says “Well done!” with an enthusiastic voice as opposed to a robot that does not convey emotions.

A simple spell checker that can find omissions (a_quisition), insertions (acquis[s]ition) and substitutions (a[k]quisition) will be used. It will classify a word as correct if it has no mistakes, as partially correct if it has at most three mistakes, and as incorrect if it has more than three mistakes. The number of mistakes is measured via Levenshtein distance.

5 EVALUATION

The evaluation of the final architecture took place at a special school for the blind with 15 participants, aged 12 to 16. The pupils were native speakers of German, computer literate and had at least two years of formal English education. The vocabulary test was conducted following the between-group-design of traditional experiments, which includes a pretest and posttest. Test participants were randomly assigned one of two conditions: simple auditory feedback (S-AF) and prosodically enhanced auditory feedback (PE-AF). Every participant also completed two brief questionnaires, one at the beginning of the session about biographical information and study habits, and one at the end of the session to evaluate the usability of the system. Out of the 15 test participants, 5 also took part in a delayed posttest to evaluate vocabulary retention.

At the time of writing, the study was just completed and data has not been analysed yet. However, the tendencies are very encouraging. There is a huge learning gain in terms of spelling and word meaning in both testing conditions when comparing the pretest and the posttest at a glance. However, it must be noted that this is also due to the effect of the short term memory. Another interesting result is that most of the pupils greatly enjoyed working with the system and some even asked where they could buy it. 14 out 15 participants answered ‘yes’ to the question if they would use such a program in their own time to study vocabulary. In order to truly evaluate the effectiveness of the system with regard to word retention, a longitudinal study over the course of several weeks would be appropriate as it would allow to integrate a learning model of ‘timed repetitions’. Moreover, future studies should include a control group in which test subjects learn the same words using their traditional study methods.

6 CONCLUSIONS

It has been argued that orthographic feedback within computer assisted vocabulary learning (CAVL) applications should be specially designed to increase usability for blind language learners. Learning orthography and in particular orthography of a foreign language may be very challenging for visually impaired people since it often implies learning a different type of Braille script along with it. This is why well-designed auditory feedback may be an alternative solution to teach spelling within CAVL applications. A system architecture was constructed in collaboration with blind students and served as basis for the implementation of a demo system. Finally, this demo system has been evaluated with 15 pupils from a special school for the blind, producing very encouraging results.

Further research should address the content of the vocabulary trainer as well evaluation methods. While this study purely served to test an idea, that of prosodically enhanced auditory feedback, it would be very interesting to test this concept with more elaborated vocabulary such as idioms or sentences. Also, one could consider to test the effect of different types of encouraging feedback that is given when a word is entered correcty. In order to evaluate the true effect of this learning method, a study would ideally last several sessions and include a control group that learns vocabulary using traditional revision techniques.

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