Using ASR Technology in Language Training for Specific Purposes: A Perspective from Quebec, Canada

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ABSTRACT

For many patients throughout the world, access to healthcare depends on the patients' and healthcare providers' ability to communicate efficiently in each other's language. One way to reduce linguistic barriers to healthcare access is to increase the number of linguistically and culturally competent healthcare professionals. Conspicuously absent in the literature on second language (L2) training of healthcare professionals, however, is the use of technology that combines meaningful interaction, feedback, simulation, and asynchronous access. The goal of this paper is to fill this gap by describing and evaluating the "Virtual Language Patient," a computer-based L2 training module for healthcare professionals. The module employs automatic speech recognition technology, pronunciation assessment, and video clips of a simulated medical history interview with a minority language patient. Five nurses-in-training at a French-language nursing college in Quebec reported that the module was easy to operate and that it addressed their anticipated language learning needs. More importantly, analysis of the data file automatically generated by the module revealed improvements in acceptability of the nurses' pronunciation of the medical interview questions. These findings suggest that the module can be effective in language training for healthcare professionals. Implications for the improvement of virtual dialogue systems are discussed.

KEYWORDS

Automatic Speech Recognition, Second Language, Speaking, Pronunciation, Healthcare

INTRODUCTION

Low language proficiency remains a significant barrier to healthcare access for many patients throughout the world, including Canada. Language training of linguistically and culturally competent healthcare professionals, therefore, should lead to greater healthcare access, lowered costs, better health outcomes, and improved patient satisfaction (Zambrana, Molnar, Munoz, & Lopez, 2004). One important aspect of language training (especially in healthcare contexts) involves the development of cost-effective and pedagogically-sound language training materials. Clearly, for busy doctors and nurses, such materials would have an added value if training could be deployed asynchronously and at a distance. The goal of this paper is to describe the development and testing of the "Virtual Language Pa-

tient" (henceforth, the VLP), a language-training module based on automatic speech recognition (ASR) technology.

The VLP was created to cater to the language learning needs of francophone nurses in Quebec, Canada. In Quebec, the officially unilingual French province of Canada, there is a sizeable English-speaking minority for whom access to health services in French often poses difficulties. This difficulty is associated with frequently low levels of spoken English proficiency of French-speaking medical professionals (see Bélanger, 2003; Bowen, 2001; Canadian Medical Association, 2005). The VLP uses video and audio clips in combination with the Stanford Research Institute's *EduSpeak* continuous speech, speaker-independent recognition system enhanced to support pronunciation scoring to create the illusion of a videophone conversation with a virtual patient. In using the module, nurses (whose mother tongue is not English) ask a series of medical interview questions to a virtual patient (native English speaker), and receive meaningful responses from the patient, as well as various types of feedback on their pronunciation from the speech recognizer.

In this paper, we first situate our study in the context of medical communication between healthcare providers and patients who do not share the same language. We then describe the VLP and report the findings of a feasibility study with five francophone nurses in training, who used the module at various acceptability levels, completed pre- and post-questionnaires, and were interviewed about their experience with it. Our results show that the module adequately anticipated some of the language learning needs of our participants and helped improve their ability to produce medical interview questions. We conclude by describing possible extensions of our module and point to its uses in other second language (L2) training contexts.

MEDICAL COMMUNICATION IN A SECOND LANGUAGE

Effective communication between healthcare providers and their patients is important (e.g., Charles, Goldsmith, Chambers, & Haynes, 1996). In a study of twenty-six international medical graduates, for example, a significant correlation was found between doctors' language proficiency and their patients' satisfaction (Eggly, Musial, & Smulowitz, 1999; see also Carrasquillo, Orav, Brennan, & Burstin, 1999; Fernandez et al., 2004). In another study, low-English-proficiency Korean patients over the age of sixty in the U.S. were found less likely to be satisfied with the healthcare service they received than Koreans with higher levels of proficiency (Jang, Kim, & Chiriboga, 2005). Indeed, healthcare professionals not speaking the language of the patient adds to a patient's suffering. Todd, Samaroo, and Hoffman (1993), for example, found that Hispanic patients were half as likely to receive analgesia in the treatment of their bone fractures as their English speaking counterparts. Worse still, a failure to anticipate communication problems and accommodate low-language proficiency patients can turn fatal, as was illustrated in the 2007 news story of an Albanian immigrant who killed himself, thinking his wife had been diagnosed with AIDS when hospital staff told him his wife's blood type was A-positive (The Canadian Press, 2007).

One obvious solution to increasing healthcare access to linguistic minorities is to use interpreters. Whereas the use of hospital-trained interpreters in pediatric emergency departments was found to increase parents' satisfaction with their physicians and nurses (Garcia, Roy, Okada, Perkins, & Wiebe, 2004), a reliance upon interpreters in primary care medical interviews is somewhat problematic. Aranguri, Davidson, and Ramirez (2006) observed that during regular doctor appointments with Hispanic patients about half of the words exchanged between doctor and patient were missing from the interpreters' translations. In such situations, small talk and patients' questions, known to increase patients' engagement with their own care, were either eliminated or significantly reduced.

To decrease heavy reliance on interpreters in healthcare, Zambrana et al. (2004) recommend hiring more minority, linguistically and culturally competent healthcare providers in managed care networks. They argue that having healthcare providers who speak the same language as their patients will lead to lowered costs, greater healthcare access, better health outcomes, patient satisfaction, and patient compliance. There is evidence to support this claim. One study investigating patient outcomes found that asthma patients cared for by doctors who spoke their language were more likely to take their medication, were less likely to miss office appointments, or make resource-intensive emergency room visits than patients with doctors who did not speak their language (Manson, 1988). Seijo, Girmez, and Freidenberg (1991) also found that patients whose doctors spoke their language asked more questions and had a better recall of their doctor's recommendations.

INTERACTIVE USES OF ASR IN L2 TRAINING

One way to increase the number of linguistically and culturally competent healthcare workers is to improve L2 instruction for healthcare professionals during their medical training. Several classroom-based approaches to training healthcare professionals have been described (e.g., Drouin & Rivet, 2003; Guttman, 2004). However, conspicuously absent in the literature on L2 medical communication training are the uses of technology that combine meaningful interaction, interactive feedback, simulation, and asynchronous access. An example of educational methodology that fits these criteria is the "simulated dialogue paradigm" based on ASR technology (Ehsani, Bernstein, & Najmi, 2000; Harless, Zier, Harless, & Duncan, 1999, 2003; Rypa & Price, 1999). Harless et al. (1999), for example, describe a system used by military linguists to practice their Arabic speaking skills. Working with a CD-ROM on a laptop with a microphone and a headset, the learner chooses from a limited set of three question-prompts at the bottom of the screen to interrogate a virtual character (e.g., a prisoner, a pilot). Depending on which question the student utters into the microphone, a different portion of video is played and a new set of relevant questions becomes available, thus creating the illusion of a videophone conversation.

The virtual dialogue applications of the kind described by Harless et al. (1999) represent a significant departure from earlier uses of ASR in CALL, both in terms of tasks used and their pedagogical goals. Earlier uses of ASR were often non-interactive in nature and followed a sequence in which learners read or listened to a prompt and then repeated it, receiving feedback on their pronunciation (as in pronunciation drills). For instance, an ASR-enabled dedicated reading tutor described in Mostow and Aist (1999) checks each word read aloud by the young learner from on-screen sentence prompts. If the learner gets stuck or mispronounces a word, the application interrupts the learner with a cough or another unobtrusive sound and underlines the misread word. If the learner misreads the item again, the application plays an audio prompt. In contrast, interactive applications based on virtual dialogues attempt to replicate authentic interaction with an interlocutor. In earlier approaches to ASR, the goal has been to get explicit, usually graphical feedback on the form of the learner's utterance: its segmental content or prosody (e.g., Dalby & Kewly-Port, 1999; LaRocca, Morgan, & Bellinger, 1999). On the contrary, virtual dialogues have communication as their primary goal, and feedback on language form is used to prompt repair as a step toward successful communication.

More recent developments in ASR-enabled interactive CALL exploit three-dimensional microworlds populated with virtual characters (e.g., Hill et al., 2001; Johnson, 2007; Johnson et al., 2004; Morton & Jack, 2005). However, for our research, we chose to adopt the virtual dialogue videophone approach for several reasons. Interactive application of ASR-based technology, tailored to the needs of medical professionals, appears to be a technologically

feasible, pedagogically sound, and also situationally appropriate way of providing L2 instruction to them. Therefore, we set about to build and test a virtual dialogue system of our own that specifically targets some of the language training needs of French-speaking nurses who serve English-speaking linguistic minority patients in Quebec.

THE VLP MODULE

The VLP is an ASR-based dialogue system that was inspired by the virtual dialogue paradigm described by Harless et al. (1999). The VLP employs a closed-response design with a linear question-answer sequence, modelled on a medical history interview. Taking a patient's medical history is one of the most common and important diagnostic tasks performed by healthcare practitioners (Hampton, Harrison, Mitchell, Pritchard, & Seymour, 1975; Sherman & Fields, 1988). The core elements included in the interview are questions about the patient's personal data, medical history, family history, daily living, and a review of systems (e.g., cardiovascular, gastrointestinal).

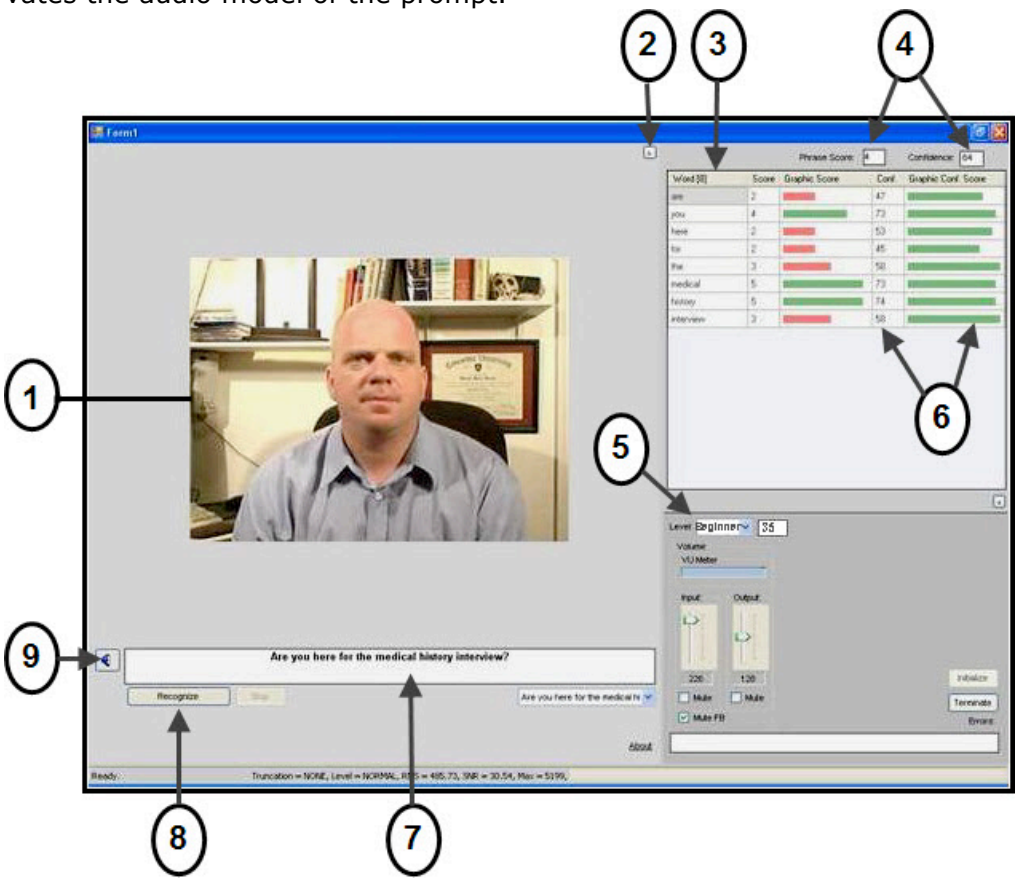
Briefly, the VLP consists of a software package that includes digital audio and video databases and a speech recognition component installed on a laptop computer. The VLP simulates a medical history interview between a healthcare professional and a patient. Upon launching the software, a video of an English-speaking male patient appears in the center of the screen. Under the video, there is a text prompt with a medical history question in English next to a button labelled *recognize*. To activate the system, the learner simply clicks the *recognize* button, and reads the question (e.g., *Are you here for the medical history interview? What is your blood type? Do you have high blood pressure?*). Figure 1 shows an image of a user interacting with the VLP.

Figure 1
A user interacting with a virtual patient

The system displays a feedback panel after each successful recognition, providing feedback on recognition confidence ratings and pronunciation scores associated with each word and the whole utterance (as seen in Figure 2). Pronunciation scores for words that fall below a threshold of acceptability are displayed in red, otherwise in green. The learner can thus get a sense of which words he or she needs to say more clearly. If the learner's utterance falls below the system's confidence acceptance threshold, a video clip is triggered in which the patient asks the learner to try again. Help is provided to the learner in the form of another

clickable button that activates an audio recording of a native speaker reading the question at a natural rate. If the learner subsequently pronounces the question acceptably, a video clip plays with the patient providing the requested information, and the learner is prompted with the next in the series of medical history questions. The learner uses this information to complete a paper-based questionnaire. This procedure repeats 72 times, until all of the questions have been successfully asked and the virtual patient's information has been recorded on the questionnaire (for details on the features and content of the VLP, see Walker, Cedergren, Trofimovich, & Gatbonton, under review).

Figure 2
The graphical user interface of the VLP: (1) video of patient, (2) feedback pane toggle, (3) words in the utterance, (4) pronunciation and confidence score, (5) difficulty setting, (6) numeric and graphical representations of recognizer confidence scores for each word in the utterance, (7) question prompt, (8) the "Recognize" button, (9) the speaker icon that activates the audio model of the prompt.



To explore the VLP's suitability for its intended learner population, a proof-of-concept feasibility study was conducted. In this study, we investigated four questions:

1. What were the participants' perceptions of the importance of English in their nursing career, particularly with respect to the medical interview task?
2. How easy was the VLP for the participants to use?
3. Was there any effect of the VLP use on the participants' pronunciation?
4. Did using the VLP have any effect on the participants' perceived confidence in using English in the workplace?

METHOD

Participants

The participants in this study were five female French native-speaking students (ages: 23-45) enrolled in a three-year nursing program at a French junior college in a predominantly French-speaking area of Quebec, Canada. Upon admission to the college, each participant was placed into one of three English levels based on the results of an English proficiency test: false-beginner (learners who remain at the beginner level after years of instruction), low-intermediate, or high-intermediate. All had started learning English in primary or secondary school (range: 8-12 years) and taken two mandatory 45-hour, 4-skills general grammar courses at the nursing college. None of the participants reported that they had attended a pronunciation course before this study.

Participant 1, the only high-intermediate speaker in this study, had completed her second year of the nursing program. Participants 2 and 4 (both at a low-intermediate level) and Participant 5 (a false-beginner) had completed their third year of the program and were about to graduate. Participant 3 (also a false-beginner) had the least clinical experience and training in the group, having only completed one full year of the program. Two of the participants had considerable contact with English speakers. Participant 1 spent 12 years working in an English-speaking environment in the province of Ontario and continues to have contact with English-speaking friends. Participant 4 had an English-speaking boyfriend living in Kansas with whom she had regular contact by phone and visited during holidays. The two false-beginners, Participants 3 and 5, reported having had only limited exposure to English outside the classroom. Participant 2 provided little information on her language experience.

Materials

Two electronic questionnaires given immediately before and after using the VLP (Appendixes 1 and 2), a semi-structured exit interview (Appendix 3), and a language experience questionnaire sent later by e-mail were used to collect the participants' career information and attitudes toward both language learning and the VLP. The pre-questionnaire, administered just before the participants' experience with the VLP, sought information about their proficiency levels, levels of nursing knowledge, attitudes toward the utility of English in the workplace, impressions of their own language accuracy, confidence in their communicative ability to interview an English-speaking patient, and motivation to improve their English ability. The post-questionnaire given to the participants just after taking the medical history from the virtual patient repeated questions relating to the participants' self-perceived confidence in their English language ability, attitudes to the task, their general impressions of the VLP, and the challenge posed by using the system with reference to their preferred difficulty settings for the system. Given another ten minutes to use the dialogue and manipulate the VLP's three confidence threshold settings freely, the participants took part in a semi-structured interview conducted to collect further impressions of the system and invite participants to share any opinions and ideas for its improvement. As a follow-up, the participants were contacted by e-mail to answer an on-line language experience questionnaire.

Items in the questionnaire related to the participants' exposure to English and English language instruction.

Procedure

The study was conducted with one participant at a time in a quiet room within the nursing college. The testing session, videotaped for later analysis, proceeded according to this schedule:

1. The participant had approximately five minutes to complete the computerized pre-questionnaire.
2. The VLP was initialized and set to *beginner* level (35% confidence threshold that learner utterance is indeed what is expected by the system). The participant had 10 minutes to ask the first 20 questions.
3. The VLP setting was changed to *intermediate* (45% confidence threshold). The participant had 10 minutes to ask questions 21-40.
4. The VLP was set to *advanced* setting (55% confidence threshold). The participant had 10 minutes to complete questions 41-72. Each participant completed the VLP at three different settings of the confidence threshold so that the impact of recognizer severity (from more forgiving of pronunciation difficulties at 35% to more demanding at 55%) could be analyzed for each participant. The three confidence thresholds were determined through testing in the development stages of the VLP and were found to provide an adequate challenge for learners of different L2 proficiency levels.
5. The participant completed the computerized post-questionnaire.
6. The participant was allowed to experiment with the VLP freely, setting his or her preferred confidence threshold.
7. Finally, the participant was asked four general questions as part of a semi-structured exit interview.

Throughout the session, the VLP automatically generated a log file from the speech recognition engine. Each utterance spoken to the virtual patient was recorded and stored as a digital audio file.

Data analysis

To answer the first question targeted in this study (importance of English), we analyzed the participants' responses to closed-response questionnaire items in the pre-questionnaire (Appendix 1). These items elicited the participants' opinions on several issues (e.g., importance of English in the workplace, willingness to train in English, confidence in using English). To address the second question (ease of operability), we analyzed subjective impressions collected from the participants in the post-questionnaire (Appendix 2) and the exit interview (Appendix 3), where the participants were asked to give general impressions about the VLP in addition to specific evaluations of features of the user interface and materials. In addition, we also examined several objective measures of the participants' difficulties with task items by identifying the most problematic questions and words in terms of system rejections of the participants' utterances and recognizer confidence scores. To answer the third question (effects of VLP use on pronunciation), we looked at objective measures of the participants' reactions and behaviour in using the VLP from the log files generated by the speech recognition engine. For example, we counted the rejection rates for each participant's attempt to produce a medical history question at each threshold setting as well as at each setting chosen by the participant herself when given freedom to do so. To determine the VLP's potential efficacy in affecting the participants' pronunciation, we examined the system-generated pronunciation scores for each medical question. Finally, to address the fourth question (perceived confidence) we examined the participants' responses on the pre-

and post-questionnaires (Appendixes 1 and 2) to evaluate the participants' confidence in their ability to perform a real-life medical interview after using the VLP.

RESULTS

Importance of English in the Workplace

The goal of the first analysis was to investigate the importance the participants placed on using English in their work, thus estimating the fitness of purpose of the VLP as a tool for training French-speaking nurses to conduct medical history interviews in their L2. To address this goal, we examined the participants' responses to the pre-questionnaire statements regarding the importance of using English in their nursing careers. Overall, the participants believed it would be "very useful" (n = 4) or at least "somewhat useful" (n = 1) to use English on the job. They also indicated that their primary need for English would most likely involve face-to-face oral exchanges rather than phone conversations or having to give monologic presentations in English, confirming the findings of prior research (Lear, 2005; Lepetit & Cichocki, 2002). All five also indicated that they wanted to improve their ability to interview patients in English. The following anecdote told by one of the participants during the exit interview exemplifies some of the reasons why nurses need to be able to speak or, at least, be able to discuss medical matters with their patients.

> I'm working right now at the hospital as a *préposée* [nursing assistant], and I think it's pathetic because some people speaks English and they don't even speak English to them. And there was a lady once. They thought that she couldn't speak, that she was mute. She wasn't mute! She was English! When I read her name, it was something like [a common English last name] or something, and I started to speak English with her, and she was the most happy patient in the world. Oh my God! But here we don't have very much English. But for my part, to become a nurse you should have at least two languages that you can currently speak, or be willing to do so, you know? Maybe not learn English, but learn the medical vocabulary. Because when people are sick, they need confidence, they need to be reassured. I thought it was sad.

As the anecdote illustrates, this participant witnessing the relief and happiness that her patient felt at being addressed in English underscored the importance for her to be able to use the patients' language in discussing their medical problems. Taken together, the evidence we obtained from the participants' questionnaires justifies the development of pedagogical tools, including the VLP, to help French-speaking nurses improve their L2 speaking skills.

Ease of Operability

The goal of the following analyses was to determine the ease of operability of the VLP, with two specific aspects investigated: participants' subjective impressions of the system difficulty and objective measures of task difficulty. In general, all five participants reported that they found the VLP software easy to use, that it took them very little time to understand how to operate the system, that the question prompts were easy to read, and that the quality of the compressed videos of the virtual patient was good overall. However, two problems with the system were identified. Both Participants 3 and 4 found the natural speech rate of the native speaker audio models "too fast", which hindered them from attending to the precise pronunciation of individual words and sounds. The same two participants also indicated that lack of opportunity to get the patient to repeat his answers hampered their ability to record all of the patient's medical history information on the questionnaire. Participant 4, for example, made the following comment:

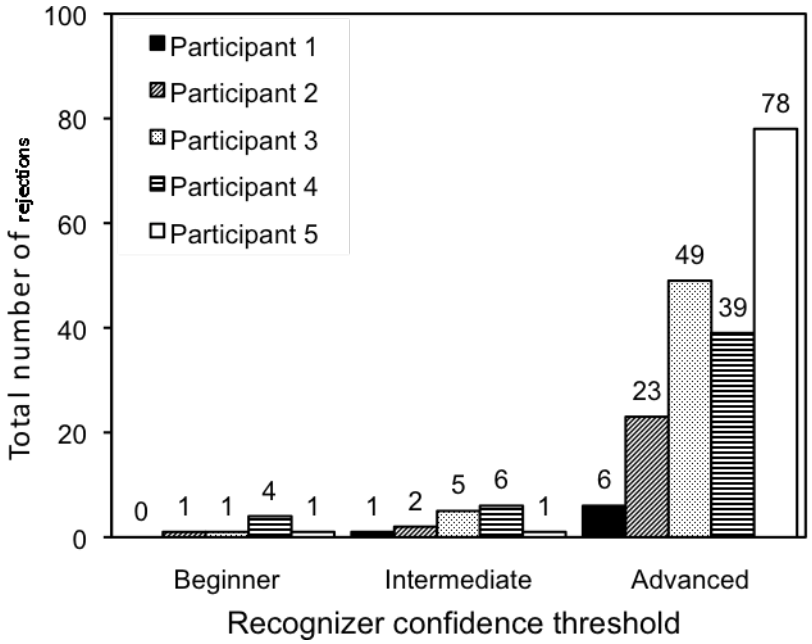
> There is no rewind. There is answers I would like to ask him again, or part of the answer he gave me that I need and I didn't write and I just didn't know

> how to get it again. It would be really great to be able to say "Could you say that again?" to really get all the information I need.

In fact, it was possible to get the patient to repeat his answer by scrolling back to the previous question with the mouse and repeating the question. However, none of the participants seemed aware that they could do this and none of them did. This finding suggests that clarification phrases requesting patients to repeat (e.g., *I didn't get it, please say it again*), which Lear (2005) identified as an important part of the medical professionals' speech repertoire, would have helped the learners.

To measure task difficulty objectively, we tallied the number of utterance rejections to each script item for each participant at each of the three difficulty settings (beginner, intermediate, and advanced). Based on these totals, at least two observations can be made. As expected, lower-proficiency learners, compared to higher-proficiency learners, received more utterance rejections (utterances that scored below the recognizer confidence threshold), triggering a clarification request instead of the answer. Second, the three settings (beginner, intermediate, and advanced levels) proved to be effective at managing task difficulty in terms of triggering more utterance rejections and feedback on pronunciation accuracy as the setting level increased. This indicates a clear relationship between starting proficiency and the total number of utterance rejections each participant ultimately received. Figure 3 shows this finding graphically by displaying the total number of utterance rejections for each participant at the three levels of the recognizer confidence threshold.

Figure 3
Total number of utterance rejections for each participant at the three levels of the recognizer confidence threshold



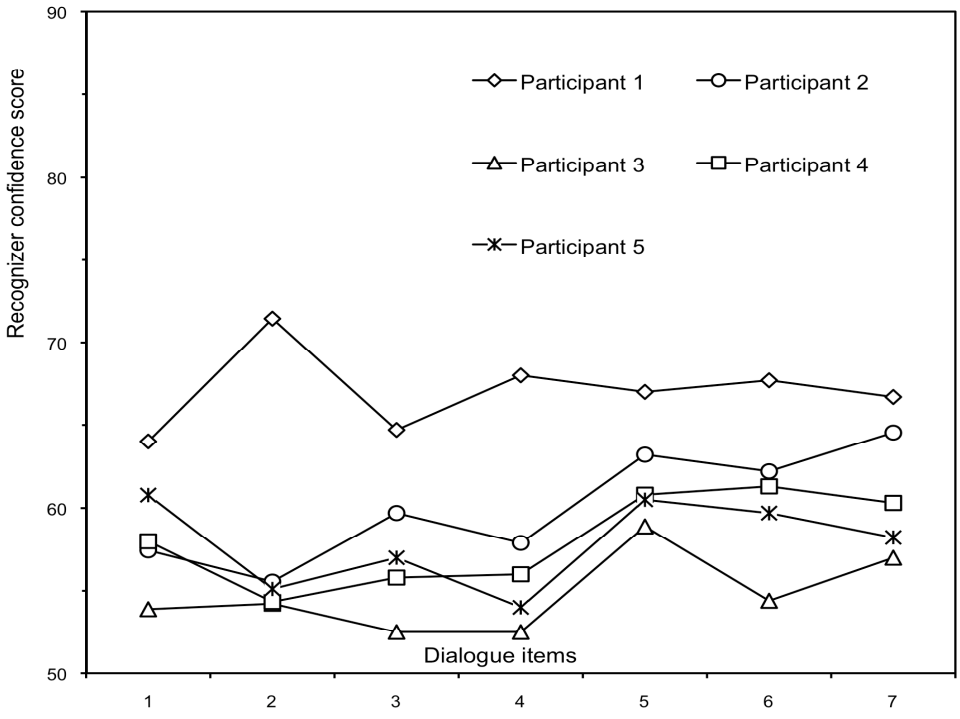
To determine an "optimal" ratio of feedback per script item, each of the participants was asked to indicate their preferred difficulty setting on the post-questionnaire (Appendix 2). By tallying the number of utterance rejections received at that preferred setting, we esti-

mated a comfort zone of about two utterance rejections on average for every three script items. Presumably, fewer utterance rejections were felt to make the task too easy, and much more made it too frustrating. A learner-adaptive method of regulating the system's difficulty setting may prove to be the best way to maintain this balance of task challenge to task frustration.

Effect of VLP Use on Pronunciation

The goal of the analyses reported in this section was to document any effects of the VLP use on the participants' L2 pronunciation. The expectation here was that the VLP should improve the acceptability of the participants' speech while they are performing a medical history interview. To investigate a training effect, changes in pronunciation accuracy were quantified in terms of the degree and number of improvements. One way to document possible improvement in pronunciation would be to analyze the recognizer confidence scores given to the participants over the course of the virtual dialogue. Confidence scores represent the recognizer's threshold for determining that a user's utterance is indeed what is expected by the system in terms of its segmental content. To calculate this measure, we averaged the recognizer confidence scores given to each participant at increments over the course of the virtual dialogue. Overall, recognizer confidence scores increased over the course of the virtual dialogue from 59.3 to 63.3, an increase of 4 points or 7%. Figure 4 shows recognizer confidence scores for each participant averaged across each 10 consecutive dialogue items (1 through 72). As this figure demonstrates, four of the five participants showed this general trend, which indicated that the global accuracy with which these participants were able to produce L2 utterances generally increased over the course of the dialogue. The largest gain was seen for Participant 2, with a 21.4% increase. Participant 5 saw no increase in recognizer confidence scores by the end of the dialogue, holding steady with 59.6 after starting with 60.2.

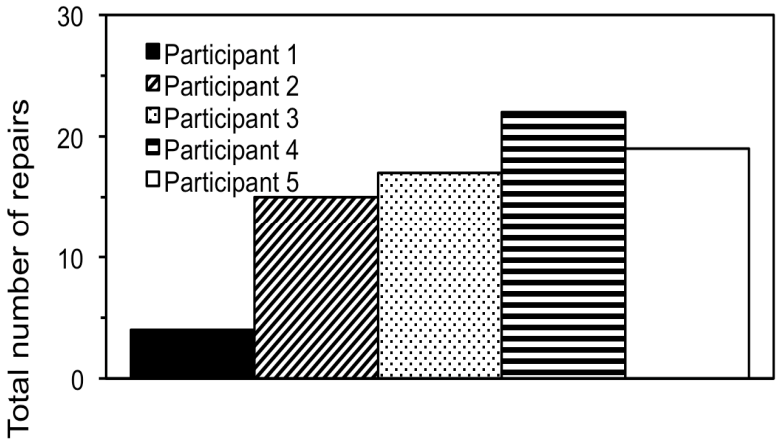
Figure 4
Recognizer's confidence threshold trends averaged across every 10 dialogue items



The gains can be attributed in part to the effect of incremental increases of the confidence rejection threshold through the manipulation of the difficulty settings. To explain, at the beginning of the dialogue (questions 1 through 19), only utterances with scores of ≤34 were rejected; in the middle of the dialogue (questions 20 through 39), only utterances with scores of ≤44 were rejected; and by the end, only utterances with scores of ≤54 were rejected. As the rejection threshold increased, participants were required to meet higher standards of accuracy. With repair, participants succeeded in meeting the higher thresholds, and so confidence scores from successful attempts tended to show an increase.

Another way to examine improvement in pronunciation over the course of the virtual dialogue is to identify the number of successful repairs (successful reformulations of questions previously produced at a level which was below the recognizer's confidence threshold) for each participant. A successful repair, indicated by an utterance acceptance after one or more rejections, thus represents a specific instance of increase in acceptability of pronunciation. As such, all of the participants improved the acceptability of their pronunciation of medical history interview questions to some extent. Participant 4 made the greatest number of improvements to her pronunciation with 22 successful repairs, while participants 5, 3, and 2 made 19, 17 and 15 successful repairs, respectively. Participant 1, by this measure, made the fewest gains in pronunciation accuracy (n = 4). The number of successful repairs made by each participant over the course of the virtual dialogue is plotted graphically in Figure 5. It should be noted, however, that this measure does not indicate the amount of the increase in accuracy with each successful repair. Where the difference between the utterance rejection and the utterance acceptance scores was small, the increase in pronunciation accuracy may be negligible. Nevertheless, our analyses of the log file data revealed some positive effects of the VLP use on the participants' pronunciation. By the end of the dialogue, the participants saw an improvement in their pronunciation in terms of average recognizer confidence scores and an increase in successful repairs based on the negative feedback (utterance rejections) provided to the participants by the speech recognizer.

Figure 5
The number of successful repairs made by each participant over the course of the virtual dialogue



Learner Confidence

To examine the effect of the VLP on the participants' confidence in their perceived ability to perform a real-life medical interview after using the VLP, differences between pre- and post-questionnaire responses were compared. Participant 1, the most highly proficient of the group in English, appeared to have lost some confidence in her own ability to conduct a medical interview entirely in English by answering "somewhat confident" to the question "*How confident would you be about communicating with a patient entirely in English?*" on the post-questionnaire after initially answering "very confident" on the pre-questionnaire. Participant 2, the low-intermediate learner, was also less certain about her interview skills after the simulation, having changed her answer to the question, "*If necessary, could you interview a patient in English?*" from "certainly yes" to "probably yes". Participant 4, the other low-intermediate learner of the group, showed the greatest loss of confidence in her English interviewing skills. She changed her answer from "certainly yes" to "probably yes" when asked if she could interview an English patient, and "very confident" to "somewhat confident" when asked about conducting the entire interview in English. Finally, when asked about her ability to use correct pronunciation, she changed "somewhat confident" to "somewhat nervous". In contrast, Participant 3 (a false-beginner) indicated on the pre-questionnaire "somewhat nervous" about her grammar and pronunciation but in the post-questionnaire selected "very confident", suggesting a gain in both areas. Participant 5 remained almost equally uncertain about her English interviewing ability before and after using the system, indicating "I don't know" when asked if she thought she could conduct an interview with an English-speaking patient and "very nervous" about her grammar and pronunciation accuracy. She changed her answer from "I would not be able to speak" in an interview conducted entirely in English to possibly being able to speak but would be "very nervous," a slight gain in self-confidence.

These effects on the participants' sense of their own preparedness to interact with English-speaking patients suggest that the VLP provides a useful simulation of a medical history interview. Participant 1 remarked that the simulation was "really, really the real thing" though without "the same impact [on the patient] because it is like TV... He is not going to get angry if you make a mistake." This fidelity to a real-life encounter achieves a twofold effect. It causes more proficient learners to re-evaluate their perhaps slightly exaggerated sense of preparedness and less proficient learners (for whom talking to English-speaking patients seemed an impossibility) to see the task as being slightly more achievable.

DISCUSSION

Summary of Findings

The purpose of this study was to design and assess the VLP, an ASR-enabled language learning tool for healthcare professionals learning spoken English. We examined the language learning priorities of the target population of learners, evaluated the ease of operability of the VLP, explored its effects on learners' pronunciation and on perceived confidence in using English in the workplace. In summary, the VLP appeared to have adequately anticipated some of the English-language training needs of the learners by targeting face-to-face oral interaction with an English-speaking patient with a focus on pronunciation training. The learners' impressions about using the VLP were also generally very positive, but with two suggested improvements. The learners wanted a method for slowing down the audio models so that individual words could be heard, and there was a suggestion for a conversational method that gets the virtual patient to repeat his answer. Excessive frustration can be avoided and motivation maintained through a learner-adaptive setting of the recognizer confidence threshold to limit corrective feedback to about one or two rejections per script item. Using the VLP also appeared to produce some positive effects on the learners' pronunciation. The learners tended to produce utterances that were more acceptable in terms of

their match to the segmental content of the recognizer's language dictionary (as shown by increases in recognizer confidence scores received by the learners) and to successfully repair most of those utterances whose score initially fell below the recognizer's confidence threshold. Finally, the VLP gave the learners a more realistic view of the demands of the medical interview, causing them to re-evaluate their own preparedness for this task.

Looking for a Suitable Pairing of Pedagogy and Technology

These preliminary results suggest that the VLP could make a suitable language practice activity to occupy French-speaking nursing students for a few hours. The approach to language training that underlies the VLP has general advantages over earlier forms of computer-assisted training, particularly in L2 pronunciation. In no small way, the virtual dialogue approach to pronunciation training represents a significant departure from earlier, non-dialogic pairings of language pedagogy and ASR. Until recently, the usual approach to computer-assisted training in pronunciation has been a non-dialogic pairing of technology and pedagogy that follows a listen-repeat-feedback sequence of human-computer exchanges. The "machine" initiates the interaction by playing an audio model for the learner to listen to, repeat, and then receive feedback on (see Léon & Martin, 1972, and Wohlert, 1984, for classic examples, and Wachowicz & Scott, 1999, for a review). This sequence of moves, though well-intentioned, has been sending a subtle, unspoken message to listen first, silencing the learner, dismissing prior pronunciation knowledge of the target language and emphasizing learner receptivity and passivity. In contrast, the virtual dialogue's interactive approach begins by inviting the learner to test a pre-existing hypothesis about the pronunciation of a sentence. The learner speaks first, and more appropriately, the system remains passive and receptive.

Current thinking on good pedagogy requires that all oral repetitions occur in a genuinely communicative context, where each formulation of a repeated structure is part of a meaningful message conveyed to a receptive interlocutor (e.g., Gatbonton & Segalowitz, 2005). For a context to be genuinely communicative, the message must be meaningful. In a medical interview, real or virtual, the message will be meaningful when it works to establish a trusting and supportive relationship between healthcare provider and patient, when it gathers needed health information about the patient, or when it entails sharing new health information with the patient.

Good pedagogy will not be served, therefore, by repeating the dialogue with a virtual patient past the point where the messages exchanged in the dialogue stop being meaningful. During the study, the five participants were asked to say how many times they would like to practice the medical interview with the VLP before they would want to stop. Participant 1 said once, Participants 2 and 3 said twice, and Participants 4 and 5 said five times would be enough. Perhaps the low-intermediate learners and the false-beginners expect to understand more by listening to the patient's answers again, but ideally learners would benefit more from the opportunity to repeat the medical interview task with other virtual patients, some of whom are non-native speakers of English.

However, strict task duplication to the point of mastery is not the goal with the VLP. It is not intended to be a covert drill. Instead, improving the comprehensibility of the dialogue for lower-proficiency learners through the inclusion of question prompts that would allow the learner to get the virtual patient to slow down, repeat, or explain could have far reaching and better benefits. Apart from simply adding to the range of questions available to the learner for pronunciation practice, these clarification requests are transferable to real-life encounters, with the potential to improve the comprehensibility of the available linguistic input. Questions such as "*What does ____ mean?*" and "*Could you give me an example?*"

would provide a level of conversational control over the comprehensibility of aural input that has been absent from earlier, non-interactive language learning materials.

Adding clarification requests to the available prompts of the VLP represents an opportunity for the learner to engage in only minor digressions in an otherwise linear conversation. In contrast, the Conversim™ system described by Harless et al. (1999, 2009) used multiple prompts in a different way. At decision points within their virtual dialogues, choosing to ask one question instead of the others allowed for greater conversational digressions and led to story branching. This innovation meant that revisiting a virtual dialogue and choosing to ask a different question at that decision point might uncover new information from a virtual interlocutor about his or her personal history. Since learners in the original Harless et al. (1999) study were tasked with making a decision to trust their interlocutor or not, returning to the virtual dialogue to explore aspects of the conversation not covered previously helped the learner to make the right decision. For medical interviews, the burden of trust seems to be the other way around. It is the provider who needs to win the patient's trust in order to gather the intimate details of the patient's health history and gain a commitment of compliance with the treatment.

Providing additional prompts that allow digressions into small talk in a virtual medical history interview has the potential of helping learners develop their skill in other pragmatic aspects of L2 medical communication that goes beyond transactional exchanges, aural comprehension, and pronunciation training. It is known that social talk is often missing from L2 medical encounters even though it serves the important purpose of building rapport with patients, increasing trust, and consequently leading to a more comprehensive patient history containing more detailed answers from patients (Aranguri et al., 2006). Future virtual medical interviews could provide the learner with a variety of prompt choices that include small-talk questions to invite the virtual patient to develop a more trusting relationship. Choosing to ask those small-talk questions could lead to a branch of the virtual dialogue containing health information omitted from exchanges not prefaced with social talk, thereby helping the learner to make the correct diagnosis and develop important L2 communication skills in the process.

FUTURE DIRECTIONS AND CONCLUSION

The VLP, in its current version, fared well in terms of ease of operability, its potential positive impact on learners' pronunciation, and its fit to the perceived needs of the target population of learners—francophone nurses in the province of Quebec where English (one of the two official languages of Canada) is spoken by a minority of the population and where there is a growing immigrant population (Corbeil & Blaser, 2006). However, the role of virtual dialogues in training professionals certainly needs to be explored in other kinds of medical communication (e.g., describing pain) and in a variety of other fields, including, for example, air traffic communications, where the stakes of linguistic miscommunication are high and cognitive demands placed on interlocutors are significant (Farris, Trofimovich, Segalowitz, & Gatbonton, 2008). Such future investigations could explore virtual dialogues for their ability to focus on oral language skills, their cost effectiveness, and their potential as a portable conversational partner for L2 learners in workplace training contexts and for those far from population centers and language schools.

While good language pedagogy requires meaningful repetitions of target structures in a communicative context, better language pedagogy may require an approach to language instruction with a greater emphasis on learner motivation. In this study, nursing students were careful not to suggest that all nurses be fully bilingual, cognizant perhaps of the motivational intensity and long hours required to master an L2 in adulthood. Nursing students, it

seems, just do not have the time to devote to language learning. Luis von Ahn, a researcher of human computation at Carnegie Mellon University, approximates that in 2003 alone 6 billion human hours of computerized solitaire were played for fun (Ahn, 2006). He notes that in comparison, it took only 7 million human hours to build the Empire State Building.

While Ahn's research is directed toward capturing some of these hours of game playing to solve large-scale computational problems, the motivation to play coupled with the good pedagogy of virtual dialogues may be just what is needed to solve problems in L2 healthcare communication. If some of the time that healthcare professionals freely devote to computer game playing could be redirected toward highly social, absorbing, goal-oriented, competitive, skill-building, ego-gratifying language learning fun, solving the problem of healthcare access for linguistic minorities might be less of a challenge than it appears today. The potential of the virtual dialogue in this regard is enormous, and so it is not difficult to get carried away. Nevertheless, it remains difficult to see today what future reviewers will make of these preliminary and exploratory efforts to match good pedagogy with ASR technology. At minimum, the virtual dialogue method appears ready today to provide an interesting contrast to earlier approaches to computer-based language training and is worthy of further research.

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APPENDIX 1
Pre-questionnaire

1. What is your program of study?
   ( ) Soins Infirmiers (Nursing)
   ( ) Techniques de diététique (Nutrition)
   ( ) Techniques d'hygiène dentaire (Dental Assistance)

2. Is this your first, second, or third year of study in your program?
   ( ) I am a first year student
   ( ) I am a second year student
   ( ) I am a third year student
   ( ) Other

3. What is your level of English at the cegep?
   ( ) 100 Anglais de Base
   ( ) 101 Anglais et Communication
   ( ) 102 Anglais et Culture
   ( ) other
   ( ) I don't know

4. Do you think English will be useful to you in your career as a nurse?
   ( ) Yes, it will be very useful.
   ( ) Yes, it will be somewhat useful.
   ( ) No, it don't think I will need much English.
   ( ) No, I won't need any English.
   ( ) I don't know.
   ( ) I will not work as a nurse.

5. As a nurse, which English skills will be more important for you to learn?
   ( ) English speaking and listening
   ( ) English reading and writing

6. As a nurse, which situation do you think is most important for you to develop your English speaking skills?
   ( ) Speaking English in face-to-face conversations
   ( ) Speaking English in phone conversations
   ( ) Giving oral presentations to a group in English
   ( ) Other

7. As a nurse, which situation do you think is most important for you to develop your English listening skills?
   ( ) Listening for face-to-face conversations
   ( ) Listening for phone conversations
   ( ) Listening to oral presentations
   ( ) Listening to movies, tv, music, or radio

8. As a nurse, who do you think you will speak English to most frequently?
   ( ) Doctors
   ( ) Nurses
   ( ) Administrators
   ( ) Patients
   ( ) Other

9. If necessary, could you interview a patient in English?
   ( ) Certainly yes.
   ( ) Probably yes.
   ( ) I don't know.
   ( ) Probably no.
   ( ) Certainly no.

10. Do you agree or disagree? Outside Quebec, Francophone patients should be able to receive health services in French.
( ) I strongly agree.
( ) I somewhat agree.
( ) I somewhat disagree.
( ) I strongly disagree.

11. Do you agree or disagree? Inside Quebec, Anglophone patients should be able receive health services in English.
( ) I strongly agree.
( ) I somewhat agree.
( ) I somewhat disagree.
( ) I strongly disagree.

12. Do you agree or disagree? Inside Quebec, Allophone patients (not Francophones or Anglophones) should be able to receive health services in English if they want.
( ) I strongly agree.
( ) I somewhat agree.
( ) I somewhat disagree.
( ) I strongly disagree.

13. If an Anglophone needed medical help, how confident would you be about communicating with him or her entirely in English?
( ) Very confident
( ) Somewhat confident
( ) Somewhat nervous
( ) Very nervous
( ) I would not be able to speak

14. Would you like to improve your ability to interview patients in English?
( ) Yes
( ) No
( ) I don't care

15. What question could you ask a patient to find out his or her name?

16. What question could you ask a patient to find out about any medication he or she is taking?

17. What question could you ask a patient to find if there is a history of heart disease in his or her family?

18. What question could you ask a patient to find if there is a history of cancer in his or her family?

19. If you had to interview an English speaking patient, how confident would you feel about your ability to use correct English grammar?
( ) Very confident
( ) Somewhat confident
( ) Somewhat nervous
( ) Very nervous

20. If you had to interview an English speaking patient, how confident would you feel about your ability to use correct English pronunciation?
( ) Very confident
( ) Somewhat confident
( ) Somewhat nervous
( ) Very nervous

APPENDIX 2
Post-questionnaire

1. If necessary, could you interview a patient in English?
   ( ) Certainly yes.
   ( ) Probably yes.
   ( ) I don't know.
   ( ) Probably no.
   ( ) Certainly no.

2. If an Anglophone needed medical help, how confident would you be about communicating with him or her entirely in English?
   ( ) Very confident
   ( ) Somewhat confident
   ( ) Somewhat nervous
   ( ) Very nervous
   ( ) I would not be able to speak

3. Would you like to improve your ability to interview patients in English?
   ( ) Yes
   ( ) No
   ( ) I don't care

4. What question could you ask a patient to find out his or her name?

5. What question could you ask a patient to find out about any medication he or she is taking?

6. What question could you ask a patient to find if there is a history of heart disease in his or her family?

7. What question could you ask a patient to find if there is a history of cancer in his or her family?

8. Grammar: If you had to interview an English speaking patient, how confident would you feel about your ability to use correct English grammar?
   ( ) Very confident
   ( ) Somewhat confident
   ( ) Somewhat nervous
   ( ) Very nervous

9. Pronunciation: If you had to interview an English speaking patient, how confident would you feel about your ability to use correct English pronunciation?
   ( ) Very confident
   ( ) Somewhat confident
   ( ) Somewhat nervous
   ( ) Very nervous

10. What did you think of this Virtual Patient system in general? (Multiple answer: choose one, more than one, or none from the list)
   ( ) I liked it.
   ( ) It is interesting.
   ( ) It is realistic.
   ( ) It is easy to use.
   ( ) It is useful.
   ( ) I would not use it again.

11. What did you think of the patient?
   ( ) Excellent
   ( ) Good
   ( ) Bad
   ( ) Terrible

12. How easy is it to use this Virtual Patient software?
    ( ) Very easy to use
    ( ) Easy to use.
    ( ) Difficult to use.
    ( ) Very difficult to use.

13. How much time does it take to learn how to use this system?
    ( ) No time--I understood how to use it immediately.
    ( ) Little time--I could understand how to use it quickly.
    ( ) Some time--I could understand how to use it after some practice.
    ( ) A lot of time--It took a lot of practice to learn how to use it.
    ( ) Too much time---It takes too long to understand how to make it work.

14. It was ___ when the system rejected my pronunciation.
    ( ) Very frustrating
    ( ) Frustrating
    ( ) A little frustrating
    ( ) Acceptable
    ( ) Good
    ( ) Great

15. It was ___ when the system accepted bad pronunciation.
(Multiple answer: choose one, more than one, or none from the list)
    ( ) Irritating
    ( ) Funny
    ( ) Stupid
    ( ) Bad
    ( ) Acceptable
    ( ) Good

16. I prefer the system when it is set to the ____level.
    ( ) Beginner
    ( ) Intermediate
    ( ) Advanced

17. Did anything bother you about the system?

18. What did you think of the video quality?
    ( ) Excellent
    ( ) Good
    ( ) Adequate
    ( ) Poor quality

19. Was the size and position of the question easy for you to read?
    ( ) Very easy
    ( ) Easy
    ( ) Difficult
    ( ) Very difficult

20. Was listening to the native speaker pronounce the question useful for you?
    ( ) Very useful
    ( ) Somewhat useful
    ( ) Not useful
    ( ) I did not use it

21. Was the graphic pronunciation feedback useful for you?
    ( ) Very useful
    ( ) Somewhat useful

( ) Not useful
( ) I did not use it

22. How many times would you like to practice with this patient?
( ) Once is enough.
( ) Twice is enough.
( ) Three times is enough.
( ) Four times is enough.
( ) Five times is enough.

23. If we make more virtual patients, what should we do differently? (Multiple answer: choose one or more from the list)
( ) One is enough. Don't make any more.
( ) Different medical problems (cancer, high blood pressure, asthma).
( ) Different English accents (US accent, British accent, Jamaican accent).
( ) Different foreign accents (Chinese accent, Russian accent).
( ) Different ages (children, old people)
( ) Include aggressive and uncooperative patients.

24. How should we improve this system?

25. What did you do when the system rejected your pronunciation? (Multiple answer: Choose one, more than one, or none of the choices given)
( ) I listened to the native speaker ask the question.
( ) I listened to the recording of my voice.
( ) I read the question carefully before trying again.
( ) I spoke more slowly.
( ) None of these.

APPENDIX 3
Semi-structured Interview Questions

Which difficulty setting do you prefer, advanced, intermediate, or beginner? Quel niveau préférez-vous, avancé, intermédiaire ou débutant?

Is the software still useful the second time using it? Est-ce que le logiciel est toujous utile à sa deuxième utilisation?

What do you think is the best and worst thing about this software? Selon vous, quelle est la meilleure et la pire des choses à propos de ce logiciel?

Can you suggest any changes we should make to the software? Pouvez-vous proposer des modifications qui devraient être apportées au logiciel?

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