Can Speech-Enabled Phraselators Improve Healthcare Accessibility? A Case Study Comparing BabelDr with MediBabble for Anamnesis in Emergency Settings

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Abstract

Language barriers are an important problem when it comes to healthcare services for minority groups, such as refugees or sign language users. Interpreters are not always available, especially in emergency settings. Alternatives, such as online machine translation, are unsatisfactory in terms of the languages they cover as well as their data confidentiality and translation reliability. To fill this gap, phraselators were developed in collaboration with medical staff. While these produce reliable translations, they remain unsophisticated systems: doctors have to search for questions using menus or keywords. To improve on this, the Geneva University Hospitals (HUG) have developed BabelDr, a speech-enabled phraselator. To see if speech improves functional suitability and usability, this study compares BabelDr against a phraseslator without speech (MediBabble). This is done by asking doctors to find precise information about a patient using the two tools in a crossover design. Results show that BabelDr allowed participants to collect most of the information in a faster and easier way than without speech.

1 Introduction

In the context of the current European refugee crisis, hospitals are more and more frequently forced to deal with patients who have no language in common with the staff, and who may also not share the same culture. For example, at the Geneva University Hospitals (HUG), Geneva's main hospital, 52 % of the patients are foreigners and 10 % speak no French at all. In 2015, the languages which caused the most problems were Tigrinya, Arabic and Farsi (HUG, personal communications). The problems are not only linguistic. Cultural differences mean that these patients may have different conceptualizations of medicine, health care (Hacker et al. 2015), illness and treatment (Priebe et al. 2011). These issues arise not only in the context of migrant languages, but also in that of sign languages. In recent years, research in the area of sign language has shown the challenges that deaf patients face when they need access to medical information through sign language. Middleton et al. (2010), in the United Kingdom, and Iezzoni et al. (2004), in Hong Kong, collected data from deaf and hard of hearing people and showed that a significant number of survey participants reported problems – in particular, a lack of awareness of deafness among medical personnel. A situation of this kind, with barriers in language, culture and medical understanding, creates serious problems for the quality, security and equitability of medical care, as has been pointed out by several researchers (see for example Flores et al. 2003 and Wassermann et al. 2014). Others underline the negative impact these issues have on health care costs (Jacobs et al. 2003).

To respond to this urgent communication need in hospitals, different solutions exist. Interpreters play a key role in patients' understanding of medical information, but they are considered to be very expensive by decision makers and are not always available, especially for minority languages and in emergency settings where there are time constraints (see Major 2012).

In the absence of qualified interpreters, a number of other solutions are available today, but each of them have their drawbacks. Phone-based interpreter services are expensive (3 CHF/minute in Switzerland), not always available for some languages, and known to be less satisfactory than face-to-face interaction through a physically present interpreter (Wu et al. 2014). Google Translate (GT) and other machine translation (MT) tools, used increasingly often by medical staff when no other alternatives exist, remain unreliable for medical communication despite their recent progress (see Patil et al. 2014, and more recently, Bouillon et al. 2017). They also do not offer the most important languages for hospitals (for example Tigrinya or sign languages) and are not easy to adapt to new languages. Moreover, the use of these online tools raises ethical concerns, since they do not ensure data protection. Phraselators such as MediBabble (medibabble.com) and Universal Doctor (www.universaldoctor.com) are another possible alternative. These tools, specifically designed by medical staff for the medical diagnosis scenario, consist in a set of pre-translated canonical sentences (questions and instructions). They allow medical professionals to perform a preliminary medical examination dialogue, using a decision tree method. As opposed to MT, phraselators have the advantage of providing a reliable translation as well as being easier to port to new languages/domains. However, they only translate a limited set of sentences and remain technically unsophisticated; the user has to search for the exact sentence using menus or keywords, making the interaction with the patient quite artificial.

In this paper, we present BabelDr, a phraselator that enables speech interaction (see also Bouillon et al. 2017). We propose an ISO-based evaluation to compare this system with a traditional phraselator. Our main goal in this study is to see if speech improves the doctor-patient interaction. We expect that, for similar content, speech makes the communication faster, easier and more pleasant. We first present the BabelDr system (Section 2) and the ISO-based quality model used for the evaluation (Section 3). We move on to describe the experiment (Section 4) and the results (Section 5), and then draw our conclusions (Section 6).

2 BabelDr

BabelDr is a joint project of the Faculty of Translation and Interpreting (FTI) at the University of Geneva and the Geneva University Hospitals (HUG) that specifically addresses the lack of qualified interpreters for languages spoken by refugees and for sign languages in emergency settings. The BabelDr application can be described as a flexible speech-enabled phraselator (Rayner et al. 2016; Ahmed et al. 2017). Like all phraselators, the system relies on a pre-specified list of human-translated sentences and is thus limited to that set of sentences. The main difference to existing phraselators is that doctors can find these sentences by speaking to the system, using a wide variety of paraphrases and stylistic variations, instead of having to search in a list.

When the doctor asks a question, the system uses speech recognition to recognize what was said and automatically maps this recognition result to the closest canonical sentence using linguistic rules (synchronized context-free grammar, Rayner et al. 2015). The canonical sentence is then translated for the patient. Since it is not an exact translation of the doctor's utterance, but rather a translation of the corresponding canonical sentence, the canonical sentence is always echoed back to the doctor so that he or she can verify what the system understood. The translation is thus only produced for the patient after the validation of the canonical sentence by the doctor. Canonical sentences therefore play a very important role in the system since they are both the pivot for the translation and the way to show the doctor what will be translated for the patient. They were selected with the help of HUG so as to always be the least ambiguous and the most explicit possible. For example, a sentence such as "avez-vous l'impression d'être fiévreux ?" (*do you feel you're running a temperature?*) is mapped to "avez-vous de la fièvre ?" (*do you have a fever?*). Similarly "où va la douleur ?" (*which way is the pain going?*) corresponds to "pouvez-vous montrer avec le doigt où irradie la douleur ?" (*could you show me with your finger the direction in which the pain is radiating?*). Target language utterances are realized in their spoken form either using Text-to-Speech (TTS) or using pre-recorded multimedia files. This functionality is needed for low-resource languages, such as Tigrinya, which currently lack TTS engines, and for translation into sign language (Ahmed et al. 2017). The platform is entirely web-based. It can be compiled and used on the web, as described in Rayner et al. (2016).

The central design goals of BabelDr are to ensure that a) translations are reliable, b) new target languages can easily be added, which enables flexibility in the face of changing patient demographics, and c) content can be adapted to new patient profiles. However, creating the content is not a trivial task, due to several factors. The grammar-based nature of the system's architecture, which is necessary for the efficient creation of broad coverage, requires a specific structured data format that is not easily accessible to translators. Moreover, the medical discourse, which describes symptoms and pathologies, is in itself difficult to translate, especially in terms of lexical choices where a balance between precision and understandability on the part of patients must be found (Cardillo 2015). To facilitate the translators' task, and thereby ensure the quality and coherence of the translations, we have developed a translation platform.

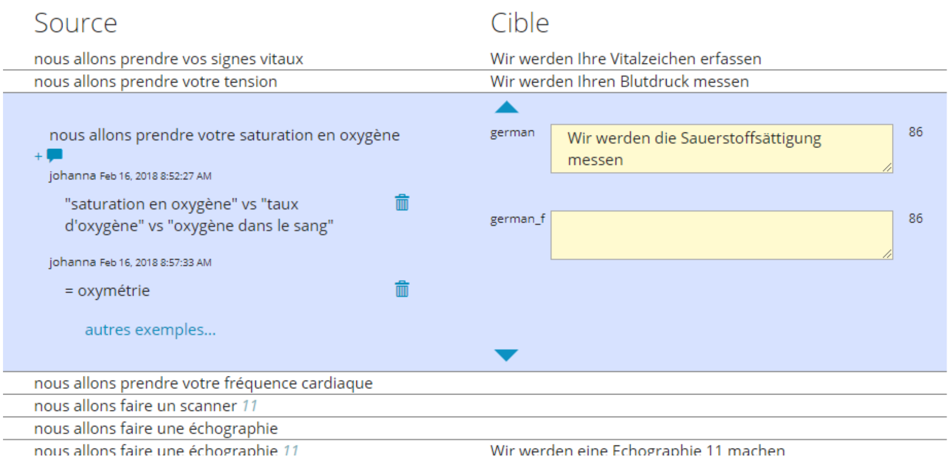

Figure 1: Translation interface

This web-based platform presents translation and revision tasks in a simple interface so that translators and revisers do not have to edit grammar files directly. Once a task is complete, the platform generates valid grammar files which can then be incorporated into the BabelDr system. To ensure translation consistency and accelerate the translation process, the platform includes a translation memory. Since the difficulties encountered by translators in different languages are often similar, we have also included an annotation function, which allows translators to share their insights and translation choices by appending comments to the individual canonical sentences. In addition to written translation, the platform includes a video-recording module to capture translations into sign language. Figure 1 shows a screenshot of the translation interface.

At the time of this study, the BabelDr system includes four main domains, organized according to different body parts (abdomen, head, chest and kidneys/back). Each of these domains has a coverage of around 2500-3000 canonical sentences, with an associated grammar that uses a vocabulary of about 2500 words and expands to approximately tens of millions of surface sentences. This grammar is used for both rule-based speech recognition and mapping to canonicals. The system supports translation from French to Arabic and Spanish, and there are partial sets of translations for Tigrinya, English, Italian, LSF-CH (Swiss French Sign Language) and Auslan (Australian Sign Language). Ongoing work on the project includes adding new migrant languages (Albanian) and improving the Swiss-French Sign Language version by including professional-quality signed videos. As for the other languages that were already available in the system, it was important to us that there should be close collaboration between the medical staff and those employed in sign language translation in order to achieve optimal translation (Hale 2007). For this reason, signed videos are currently being recorded in a professional setting by a sign language interpreter and a deaf nurse. A doctor familiar with sign language helps to explain the meaning of questions and technical terms where necessary.

In the following sections we describe the ISO-based evaluation of two phraselators (see also Boujon 2017).

3 Quality model

The goal of this experiment is to compare two phraselators, one with speech (BabelDr) and one without speech (MediBabble). We decided to conduct an ISO-based evaluation (Estrella/Tsourakis 2016). Since our goal was to see if speech improves doctor-patient interaction, we focused on two main criteria: functional suitability (does speech help to provide the correct result?) and usability (does speech make the system more usable?). For usability, we selected three ISO sub-characteristics: operability (does speech make the system easier to operate?), learnability (does speech help to learn how to use the system?) and user interface aesthetics (does speech make the interface more pleasant for users?). These four criteria are measured both with subjective and objective measurement methods, as summarized below:

Functional suitability

(1) number of successful interactions with the system

(2) questionnaire

Operability

(1) time to complete an action (i.e. an interaction with the system)

(2) number of mouse clicks to complete an action (i.e. an interaction with the system)

(3) questionnaire

Learnability

(1) difference in time needed to complete an action in two successive sessions

(2) difference in mouse clicks needed to complete an action in two successive sessions

(3) questionnaire

User interface aesthetics

(1) questionnaire

Our hypotheses are that, for similar performance, 1) time and mouse clicks will be reduced when speech is available since doctors can directly ask their questions and translate them, 2) the learning curve is less steep for a speech-enabled system, so there will be less difference in terms of time and clicks between first and second uses, and that 3) speech will improve user satisfaction.

4 Methods

4.1 Task

We used a crossover design, as illustrated in Table 1. Both systems (BabelDr, System 1, and MediBabble, System 2) were used twice by ten medical students in order to find precise information about the patient, based on two different scenarios (A and B). The students had to find out, for example, if the patient had fever or if the pain radiated somewhere. Each scenario contained ten elements the students should find. The order in which the systems were presented to them was balanced among the participants (5 students began with BabelDr and 5 with MediBabble), each participant performing a total of 4 tasks, two with System 1 and System 2 in scenario A (Session 1), and two others with System 2 and System 1 in scenario B (Session 2). A task was finished when the students had found all ten elements.

Session1		Session 2	
Task 1	Task 2	Task 3	Task 4
BabelDr	MediBabble	MediBabble	BabelDr
Scenario A	Scenario A	Scenario B	Scenario B

Table 1: Crossover design

The anamnesis information elements to be found were selected by a person external to the project and no tuning was done before the experiment. The questions were expressed in an abstract way in order to avoid participants simply reading the sentence (for example “fever?”, “appendicitis?”). In each scenario, answers were provided by a standardized patient (for example fever: yes).

4.2 Languages

The language pair used in the study was French (doctor) to Spanish (patient).

4.3 Tools

MediBabble was used on a tablet and BabelDr on a laptop. In both systems, TTS was used for speech output. In BabelDr, an interaction consists of pressing the Recognition button, speaking, checking the canonical form and pressing the Translation button for speech output (Fig. 2). The user was also able to consult the list of canonical sentences to learn system coverage, but all interactions with the system were spoken.

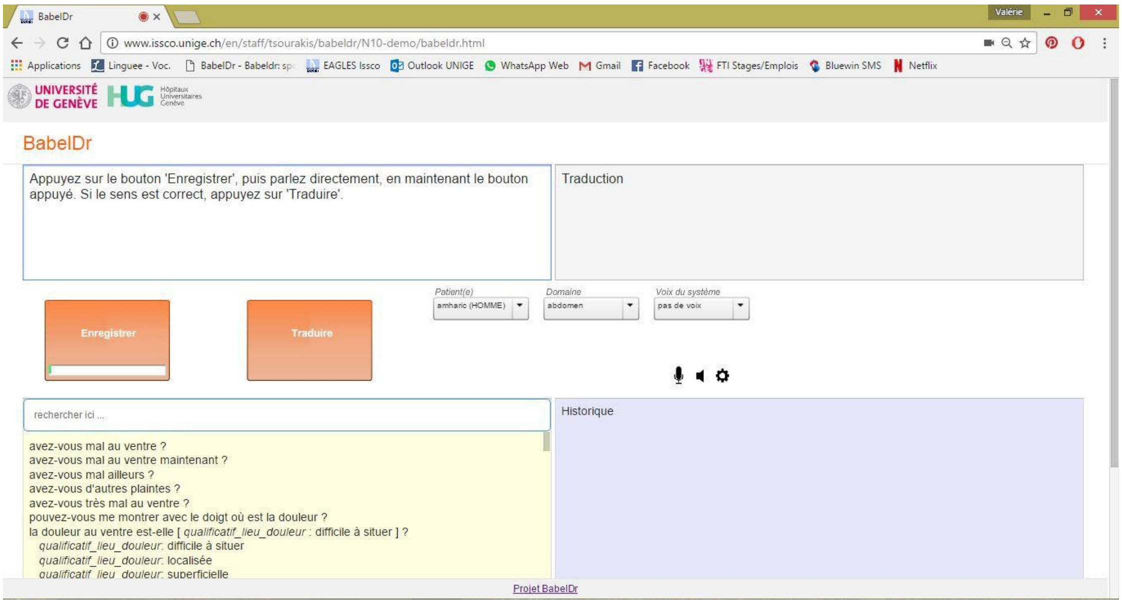

Figure 2: BabelDr

In MediBabble, the interaction consists of navigating in the tree (for example, selecting introduction → greetings → "bonjour" or Physical Exam → Abdomen → "please lay down") or of searching with keywords in the search menu and then clicking on a sentence for its translation (Figure 3).

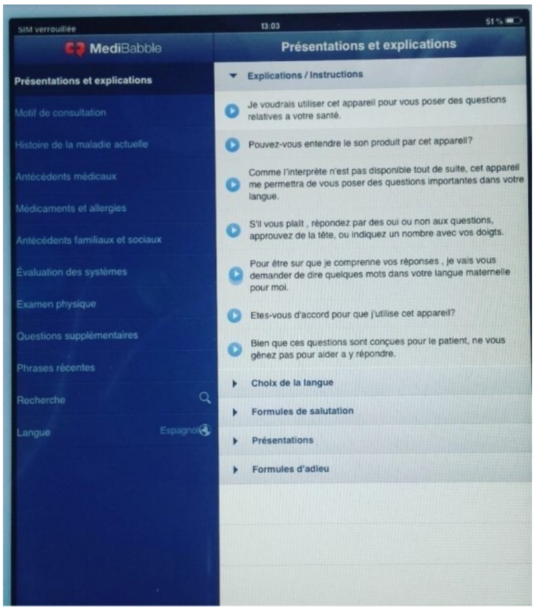

Figure 3: MediBabble

4.4 Participants

All participants were recruited at the HUG and were paid for the task:

Spanish-speaking patients: two standardized Spanish patients, both females

French-speaking doctors: ten French-speaking medical students

The doctors were all medical students, 5 of them advanced and 5 juniors (with less than 4 years of training). They were all French speakers and had no prior knowledge of the systems. Some of them (N=4) had already been confronted with patients who did not speak the same language.

4.5 Location and duration

The study took place at the Faculty of Translation and Interpretating at the University of Geneva. It took place in one room and lasted a total of three days. All participants had one hour to complete the four tasks.

4.6 Data collected

The following data were collected during the experiments: video recordings of the room, screen capture videos, information collected from the doctors after each session, demographics and satisfaction questionnaires. Time and mouse clicks were extracted from the screen capture videos. They were calculated for each interaction and correspond to the time and number of clicks between the first action of the interaction and the end of the speech output in Spanish.

5 Results

5.1 Successful interactions

Both phraselators made it possible to collect most of the required information from the patients in the time allocated. In the two sessions, participants collected 195/200 correct elements with MediBabble and 198/200 with BabelDr. This shows that both phraselators allowed the doctors to obtain the correct answers to the medical questions. The two systems are thus closely matched in terms of functional suitability.

5.2 Time

Table 2 shows the average time in seconds needed to find the required information for each task and system. The average time was lower for BabelDr in both sessions. With BabelDr, the time was similar in the first and second sessions (20s and 19s), while in MediBabble it increases (30s and 37s), tending to show that MediBabble is not necessarily easier to use the second time.

	first use	second use
BabelDr	20	19
MediBabble	30	37

Table 2: Average time per request in s

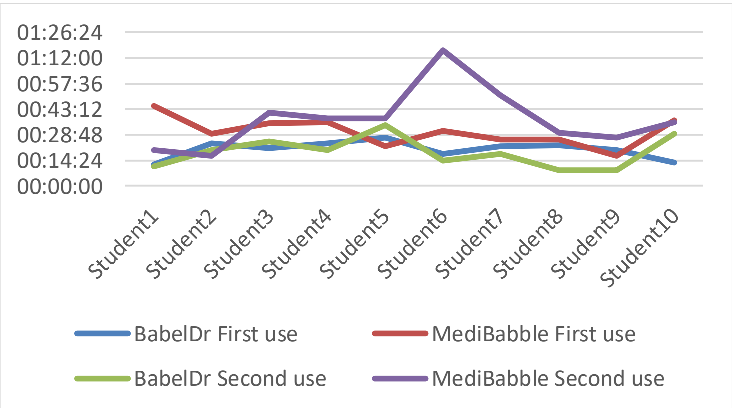

Figure 4: Average time per request for each participant

Figure 4 shows the measured times of each student for each system and task. Apart from three exceptions, the time needed was always lower for BabelDr than for MediBabble, which shows that, overall, interaction through speaking is quicker. This seems to be the case regardless of which system was used first. We also observe that there is less variation in terms of interaction time with BabelDr than with MediBabble. This suggests that the users encountered less time-consuming difficulties with BabelDr.

5.3 Clicks

Mouse clicks confirm the findings regarding time. As illustrated in Figure 5, the average number of mouse clicks is always lower for BabelDr than for MediBabble, with the exception of student 2. With BabelDr, the number of clicks remains similar for both sessions, while for MediBabble there is more variation. Table 3 shows the average number of clicks for all users. In BabelDr, an ideal interaction would require two clicks (one for recognition and one for translation). The average measured was 3.3 in both tasks, indicating that users were not always satisfied with the first recognition result, either because recognition was incorrect, or because mapping towards the canonical sentences did not match the user’s expectations. In these cases, users either had to speak again or search for the intended sentence in the list of canonical sentences.

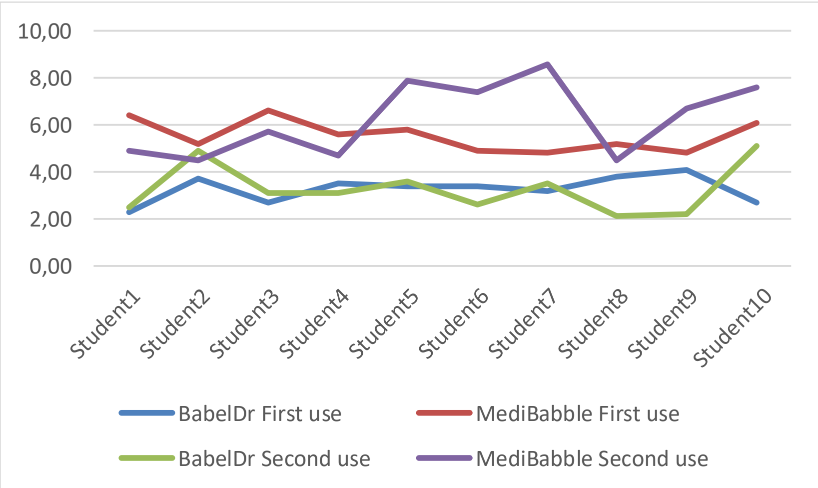

Figure 5: Average number of clicks per request for each participant

	first use	second use
BabelDr	3.3	3.3
MediBabble	5.5	6.3

Table 3: Average number of clicks per request

5.4 Questionnaire

Participants had to fill in a questionnaire after each task, which was different for the first and second session (Table 4). The first one contains 10 Likert scale questions focussing on ergonomics, in which the respondents are asked to rate statements. The second one contains 9 questions with a stronger focus on learnability.

First session	
Q1	Le système était facile à utiliser (*The system was easy to use*)
Q2	L'interface m'a plu (*I liked the interface*)
Q3	J'ai eu l'impression de bien maîtriser le système (*I felt confident using the system*)
Q4	Le système était pratique à utiliser (*The system was convenient to use*)
Q5	Le système m'a facilement permis de surmonter la barrière linguistique avec le/la patient.e (*The system allowed me to easily overcome the language barrier*)
Q6	J'ai pu poser mes questions de manière naturelle (*I was able to ask my questions naturally*)
Q7	D'une manière ou une autre j'ai pu poser toutes mes questions (*I was able to ask all my questions*)
Q8	Le système permet une certaine flexibilité dans la manière de poser les questions (*The systems allows a certain flexibility in terms of formulating questions*)
Q9	J'ai apprécié de pouvoir consulter l'historique (*I appreciated being able to access the dialog history*)
Q10	J'ai trouvé ce type de système agréable/confortable à utiliser (*I found this type of system pleasant to use*)
Second session	
Q1	Il m'était beaucoup plus facile d'utiliser le système lors de la seconde utilisation (*Using the system was much easier the 2nd time*)
Q2	Il m'était beaucoup plus rapide d'utiliser le système lors de la seconde utilisation (*Using the system was much faster the 2nd time*)
Q3	J'ai trouvé les informations plus facilement lors de la deuxième utilisation que la première (*Finding the information was easier the 2nd time*)
Q4	J'ai commis moins d'erreurs lors de la seconde utilisation que la première (*I made fewer errors the 2nd time*)
Q5	Je pense qu'il est facile d'apprendre à utiliser un tel système (*Learning to use such a system is easy*)
Q6	Je pense qu'il est rapide d'apprendre à utiliser un tel système (*Learning to use such a system is fast*)
Q7	Je savais mieux où chercher les informations lors de la deuxième tentative que la première (*I knew better where to look for information the 2nd time*)
Q8	D'une façon ou d'une autre j'ai pu poser toutes mes questions au patient (*I was able to ask all my questions*)
Q9	J'ai eu l'impression de bien maîtriser le système (*I felt confident using the system*)

Table 4: Questionnaires

Figure 6 shows the questionnaire responses after the first session. The bubble size represents the number of responses in each category. Globally, we observe that BabelDr has more positive answers than MediBabble. The two systems are fairly close in terms of ease of use (Q1-Q5), even if anecdotally doctors prefer the BabelDr interface (Q2: all doctors like the BabelDr interface while only ¾ like MediBabble) and think that BabelDr is more convenient to use (8 strongly agree for BabelDr vs 4 for MediBabble in Q4). The low score in Q6 for both systems shows that doctors had the feeling that they cannot ask questions in a natural way, even if speech seems to make a difference. In particular, doctors find that BabelDr allows for more flexibility in terms of formulating questions (Q8). All 12 doctors agree that they could ask all their questions with BabelDr, while only 10 do so for MediBabble (Q7).

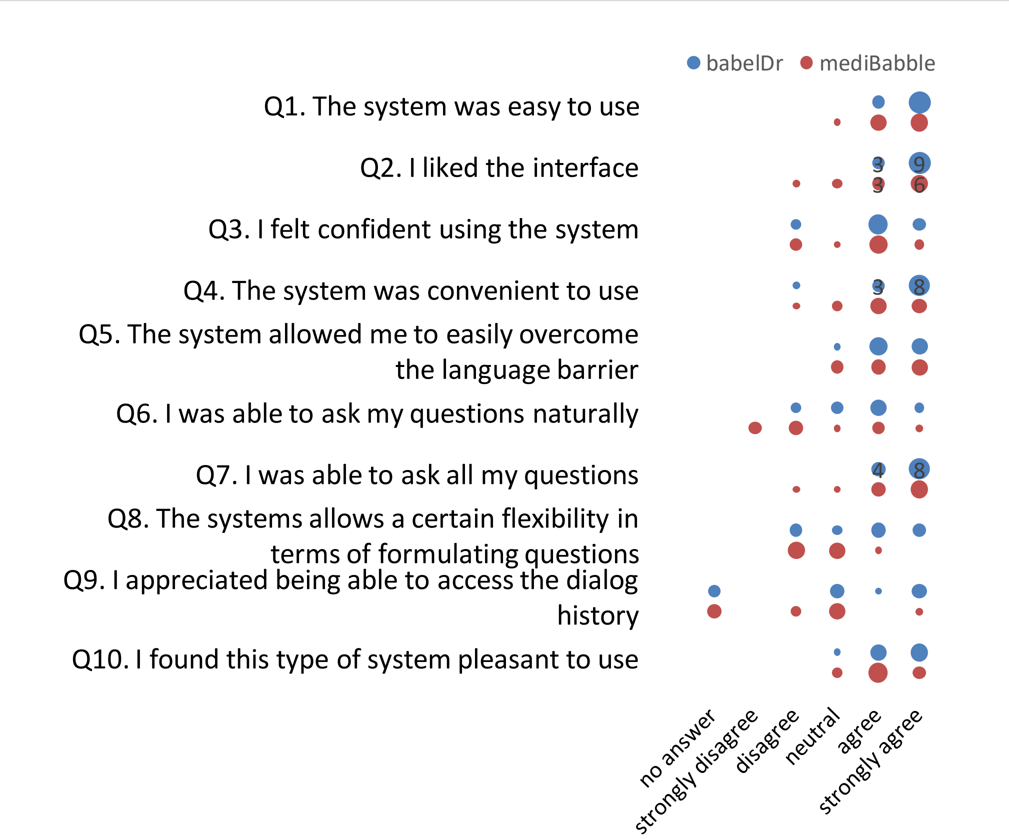

Figure 6: Questionnaire responses after the first session

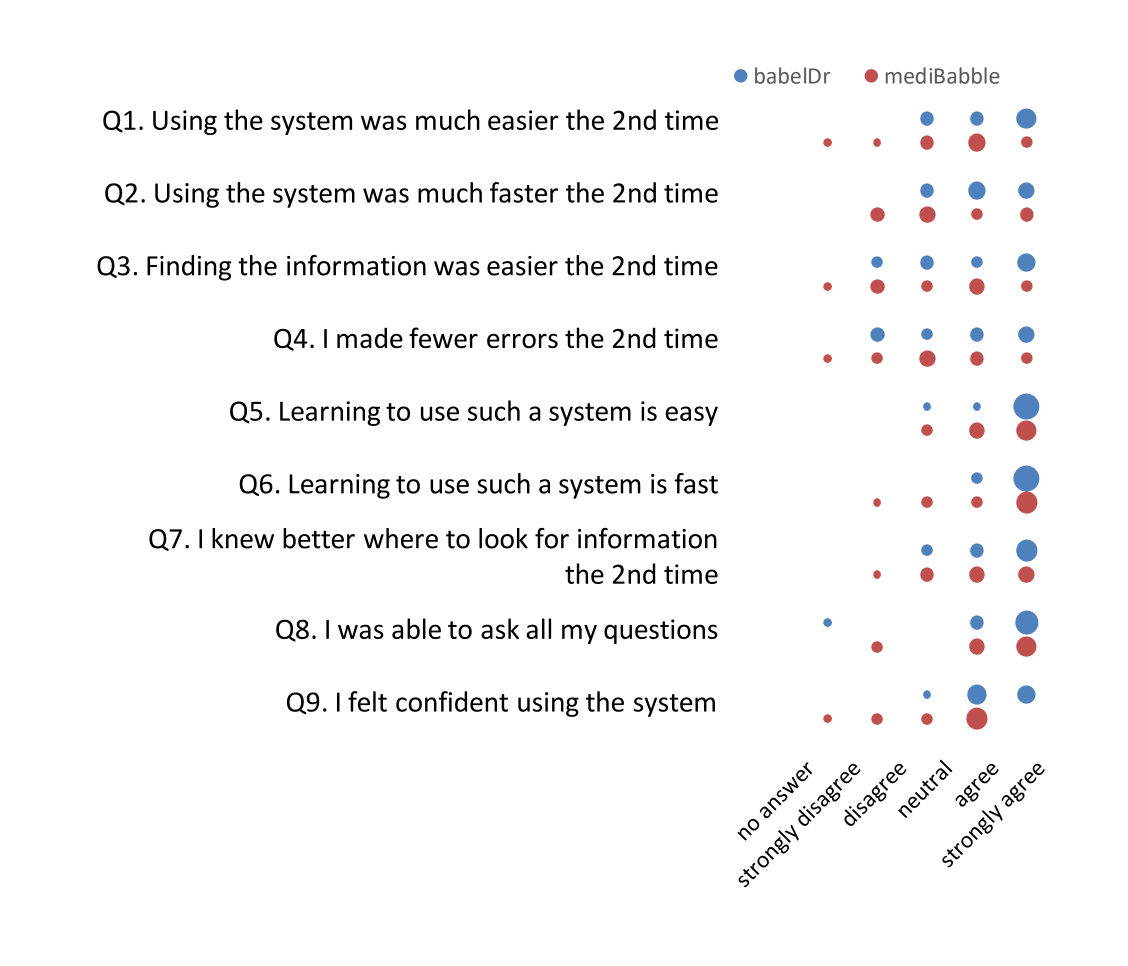

Figure 7: Questionnaire responses after the second session

The responses to the questionnaire completed after the second session are shown in Figure 7. As for the first session, results are in favour of BabelDr, with larger bubbles towards the right hand side, indicating more positive opinions. The first four questions (Q1-4), in which users were asked to compare their performance between using the system for the first and second time, show mixed results, with some users seeing improvement and others not. This suggests that the learnability of the systems is limited. The next two questions (Q5&6), relating to the user's overall impression of learnability, clearly show that users found it easier and faster to learn to use BabelDr. The two last questions (Q8&9), which were common to both questionnaires, show that for both systems, the perceived ability to ask all questions was not increased and that users felt slightly more confident using the systems the second time.

6 Discussion and conclusion

Today, language barriers represent one of the greatest problems in healthcare services for migrants. Since MT is not precise enough, other solutions should be found. We developed a speech-enabled phraselator called BabelDr. The aim of this study was to compare two phraselators, one with speech and one without speech. Doctors completed multiple scenarios using both systems with the objective of finding precise information about the patient.

Reviewing the results in terms of the quality model defined in Section 3, we find that, both objectively and subjectively, the availability of speech in BabelDr makes this system more suitable than a standard phraselator. On the level of functional suitability, BabelDr allowed the users to find nearly all the answers to the questions. Subjectively, doctors had the feeling they could ask more questions with BabelDr. In terms of operability, the objective measures of time and number of clicks showed that less time and effort were required than with the non-speech-enabled phraselator, independent of the sessions and the users, thereby confirming our first hypothesis. Subjective results show a similar trend: users reported that BabelDr was more flexible and that it enabled them to ask their questions more naturally. They also found this system more convenient to use. In terms of learnability, we observed no decrease in time with the second use of BabelDr, and the time and number of interactions required for individual questions showed little variation. These results suggest that BabelDr is more intuitive to use than the menu-based system, i.e. that it requires very little learning time. Results for MediBabble show no learning effect and large variations in time and effort; however, further experiments would be necessary to confirm whether this could be improved by long term use . Finally, in terms of user interface aesthetics, user satisfaction is higher when speech is available, which confirms our third hypothesis. This study confirms that a speech-enabled phraselator such as BabelDr can be a good alternative for anamnesis in emergency settings when no interpreter is available.

These positive results, as well as the fact that phraselators are easy to port to new languages, make us think that this type of translation tool can fill a gap and contribute to healthcare accessibility.

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