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Serious Games for Healthcare:

Applications and Implications

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Chapter 14
Improving the Identification of Medication Names by Increasing Phonological Awareness via a Language-Teaching Computer Game (Medicina)

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ABSTRACT

This study tests the effectiveness of a language-teaching computer game called Medicina that seeks to improve the ability of English as a Second Language (ESL) nursing students to hear and identify medication names in class and clinical placement. This aim is achieved through a hypothesised improvement in phonological awareness and an increase in listening skills. The study uses a triangulation of quantitative and qualitative methods to ascertain the degree to which the aims of Medicina is achieved and the validity of the theoretical assumptions. It will be shown that significant improvements in listening skills were gained, with very large effect sizes. Some influence from memorisation and exposure to word form was also found. Finally, qualitative comments reveal the personal impact the game has on listening ability and the wider educational experience. Throughout the chapter, qualitative and quantitative data are used to evaluate the contribution of a computer game in a health education context.

INTRODUCTION

Every language has its own phonemic inventory, a basic set of meaningfully distinct sounds that combine to form the words used in that language. English has 44 basic phonemes (Mannell & Cox, 2009). The phonemic inventories of two different languages may closely match each other, thus producing few problems with second language (L2) listening and speaking. However, if the phonemic inventories of two languages are quite different, then a greater amount of effort is required to listen and speak in L2. An example of this occurs in Asian languages, where 8 vowels and 7 conso-

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nants have been identified as causing problems for perception and pronunciation (Shackle, 2001, pp. 229-230). Serious difficulties can occur at a cognitive level, when the mind is not accustomed to distinguishing unfamiliar phonemes. The most common strategy used by language learners is to relate as many L2 phonemes as possible to those they already recognise in their first language (L1) inventory. However, if there are disparities between the phonemes of the L1 and L2, this strategy can result in imprecise phonological awareness and less efficient communication skills. For example, learners may erroneously interpret an L2 sound as being an L1 phoneme, as seen among Chinese ESL students who interpret 'n' for 'l'. Another example is when learners utilise a 'best fit' option where two L2 phonemes are categorised as a single L1 equivalent, which is seen among Japanese ESL students who initially perceive 'r' and 'l' as equivalents (Cutler, Weber & Otake, 2006, p. 280). In these situations, phonological awareness must be improved.

The term 'phonological awareness' refers to knowledge of the entire phonological system – knowing not only the range of sounds and phonemes used in a language, but also their articulation, permissible sequences and variations, assimilation rules, and more. In approximately the first year (perhaps even less) of a learner's immersion in a L2 environment, significant changes occur in their phonological awareness (Best & Tyler, 2007, p. 20; Bundgaard-Nielsen, Best, & Tyler, 2011b, p. 64; Tsukada et al., 2005). This is the period when the learner is theorised to be assimilating new sound forms and expanding their overall phonological repertoire to include L2 input. However, after the first year of immersion in an L2 environment, the process of rephonologization eventually settles (Bundgaard-Nielsen, Best, & Tyler, 2011a, p. 457). Partly, this is thought to be a function of an expanding vocabulary, since the contrasting sounds of new words is the means by which phonological awareness is honed (Best & Tyler, 2007, p. 32). Also, by this time, if the student's English is already "good enough" for most general purposes, the impetus for further improvement is weak (Bundgaard-Nielsen et al., 2011a, p. 457). This sense of competence deactivates the perceived need for phonological growth. It is theorised that once phonological fossilization occurs, the L2 learner often settles on a non-standard accent that will probably stay with them for the remainder of their life (Bundgaard-Nielsen et al., 2011a, p. 436; Piske, 2008, p. 162).

Solid English language skills are related to good academic performance among nursing students (Choi, 2005, p. 265; Salamonson, 2008, p. 92). However, for those undertaking a nursing degree, a significant number of international students show insufficient improvement in their English language skills to become competent professionals (Benzie, 2010, p. 454; Birrell, 2006, pp. 61-2; Bretag, 2007, p. 16; Choi, 2005, p. 263; Müller, 2011). There are many reasons for this, but in terms of listening skills, the problem is that many students are rapidly passing, or have passed, the intense period of perceptual change for phonological awareness. This issue becomes more urgent when a profession demands comprehensive phonological awareness, partly so that a wide variety of patient speech can be understood.

One area of concern that students report as being most difficult is listening to medication orders (Blackman & Hall, 2009, p. 179). This is echoed in the literature: "nursing is highly dependent on accurate verbal communication and much of the information and many orders are passed on verbally" (Guhde, 2003, p. 113). Anecdotal evidence from local clinical facilitators specifically point to student confusion over medication names. For instance, it is not uncommon for a student to confuse pethidine with betadine, which are two medicines which, if confused, would have serious medical consequences. Other examples of confusable names are fluoxetine/paroxetine, Differin/Difflam, and Capoten/Gopten (Australian Council for Safety and Quality in Health Care, 2002, pp. 75-6). This is a cause for concern,

particularly when considering the students' ability to assimilate other similarly difficult medical terminology. These reasons alone indicate a need for phonological awareness training, not only to improve skills in listening to medication names, but also for general performance in the medical arena. The question then is, how might a period of rephonologization be reactivated when the student has settled on a less-than-optimal phonological awareness for their academic studies? To answer this, we first need to understand the nature of phonemes, since they are the basic meaningful units of spoken language.

Developing an understanding of a language's phonemic inventory is a difficult process. Phonemes are complex in many ways. First and foremost, phonemes have no standardised form. Often there is a wide tolerable variation in how a phoneme can be pronounced and this further varies according to factors such as position within the word, speed of speech production, and register. Between speakers, phonemes vary according to factors such as age, gender, and dialect. Furthermore, the sound of a phoneme will vary according to the other phonemes surrounding it. This co-articulation occurs as the mouth moves from one articulatory position to the next, distorting the sounds produced. A second difficulty with phonemes is that they have no precise boundaries in their articulation, and while native speakers might believe they hear gaps between sounds and words, these mostly do not exist in reality. Speech is delivered in a continuous form, not obviously divided into discrete units. This contrasts to writing, where letters are delivered as discrete units with the spaces clearly delineating each word.

While being able to perceive the sounds may seem difficult enough, being able to comprehend speech demands further skills. A listener needs to engage in simultaneous acts of bottom-up perceptual and top-down conceptual processing. Perceptual processing involves foundational acts such as perceiving audio input as phonemes, forming syllables, and parsing whole words from the stream of speech. Top-down conceptual processing involves complex cognitive acts such as phonemic restoration when a sound or word is misheard, deducting meaning from sentence position, and using contextual cues to anticipate and overlay meaning onto what is heard. Also, listening is often a once-off opportunity presented in a time-delineated context, and repeated listening is only sometimes available to the learner.

This is not to say that there is no opportunity to replay something that is heard. It is a well-supported theory in working-memory studies that we use a phonological store and articulatory loop for sub-vocal rehearsal (Baddeley, 2003, pp. 830-3). Thus, we can play back a small amount of auditory information to help us process what we hear or read, since reading is partly considered to be a process of transferring written words into phonological form in this articulatory loop (Baddeley, 1992; Sadoski & Paivio, 2004, p. 38). An important point for the argument in this paper is that phonological working memory itself can be improved by phonological awareness training (van Kleek et al, 2006). This is probably due to an increased ability of the working memory to draw upon long-term memory resources (prior knowledge) in order to free up processing space that will allow it to deal with other activities involved in listening (DeKeyser, 2001, p. 138; Strange, 2011). Furthermore, greater phonological awareness results in faster processing speed, particularly of perceptual input, allowing the learner to rapidly and correctly identify L2 speech (Walter, 2008, pp. 470-1).

Training is a key element in improving phonetic sensitivity (Piske, 2008, p. 162). It has been demonstrated that giving students an opportunity to consciously attend to novel phonetic forms may be a way to enhance their learning (Pederson & Guion-Anderson, 2010). This, and the above discussion, provides evidence for the establishment of a learning resource which supports phonological awareness. The result is a computer game, called *Medicina*, which sets a task where learners must

correctly process audio input to choose an answer among five similar medication names. After hearing the pronunciation of the word, the learner will need to mentally rehearse the L2 sounds used until an exact match is found. Those who rely on passive listening will be less successful at the game because they will need to choose between similar answers occupying densely populated phonological space. Since real words are used, *Medicina* has the further benefit of increasing familiarity with the type of word forms found within medication names. Indeed, it is theorised that repeated exposure is essential to learning skills at the level of word form that includes elements of sound, spelling, and meaningful clusters or word parts (Hulstijn, 2006, pp. 708-9). A benefit of increasing knowledge at the level of word form is that it is generalisable to novel words, allowing easier assimilation of new forms and quicker language processing.

While it may not exactly pair words as exactly as minimal-pair exemplars, the game extends the concept of minimal pairs, an analytical tool in linguistics, and transforms it into an educational task which draws attention to phonemic features and word form. Indeed, one of the strengths of *Medicina* is that it places the learner in a situation where they have to practice active analytical listening in a time-limited environment. This places pressure on the learner, which should help promote some degree of rephonologization. It is speculated that L2 rephonologizations are most powerfully invoked in situations where there is an "activation of several competing lexical items" (Bundgaard-Neilsen et al., 2011b, p. 437) and an impeded ability to communicate (Bundgaard-Nielsen et al., 2011b, p. 459), i.e. misunderstanding or slow processing time. According to the Perceptual Assimilation Model for second language learning (PAM-L2), this type of pressure should force an improvement in phonological awareness (Best & Tyler, 2007, p. 32). The game presents "several competing items" and the learner can fail as a result of misunderstanding or slow reaction time. This is how the game's design seeks to activate perceptual change and phonological restructuring in the mind of the learner, and hopefully produce more finely tuned phonological awareness which will support wider educational activities and clinical performance. Furthermore, improvement in phonological awareness is correlated with better production skills when speaking (Venkatagiri & Levis, 2007, p. 275). It is likely that the accented speaker is a systematic result of a perceptual 'accent' that is evident even while undertaking listening tasks (Bundgaard-Nielsen et al., 2011b, p. 51; Flege, 1993, pp. 1605-7; Flege et al., 1997, pp. 466-8; Nogita, 2010, p. 112).

If it is the case that learning new vocabulary – particularly that which occupies densely populated phonological space – can activate the process of rephonologization, then it should follow that *Medicina* will improve phonological awareness, resulting in a greater ability to distinguish between similar phonemes. Since the game seeks to both improve phonological awareness and familiarise players with word forms found in medication names, the latter may affect the outcomes of this study because participants may memorise the content, and this will need to be taken into account in the study design.

METHOD

Participants

The study contained 25 volunteer participants, predominantly female, in the first semester of their graduate nursing degree. Participants came from a range of countries: China, India, South Korea, the Philippines, Japan, Malaysia, Bangladesh, Cambodia, Thailand, Sri Lanka, Russia, and Italy. This represents a reasonably diverse spread of language backgrounds. The average age of the participants was 30 and the average length of time spent in Australia was 2 years. In terms of English proficiency, participants were

at an advanced level and had an average score of 7.0 each for the listening and reading components of the IELTS test.

Materials

This study used a word-recognition test designed specifically to ascertain phonological awareness. The same test was used as both a pre-test and post-test. This test was designed using non-words, and since these non-words did not occur in the outside world, it was not possible for participants to learn the content (even unconsciously) between tests.

Each of the 23 test items comprised two-word parts from real medication names to form a whole non-word. These non-words were checked to verify that they did not exist as real medication names. Each of the 23 non-words contained a confusable phoneme in each of the two word parts. Thus, the word parts 'cele' and 'mide' might be combined to produce 'celemide'. Next, variant items were created using the principle of minimal pairs, based upon common L1 interference phonemes from the Asia region. Therefore, 'celemide' produced variants such as 'ceremide', 'celemite', and 'ceremite'. Furthermore, participants needed to attend to both parts of the word.

During the test, the student listened to a timed audio recording which issued a new word after a three second gap. They needed to select the correct option from an answer sheet. Test marks were given for each correct part selected, which resulted in 46 pieces of data from 23 items. It should be noted that the test was designed to be considerably more difficult than the *Medicina* game in the task of choosing correct answers, because it used words which are in closer phonemic proximity than those used in the game.

The study finished with a semi-structured survey. A number of questions were asked of students in the survey. The questions relevant to this study were: "What did you think was good about the game?", "How can the game help you prepare for clinical placement?", and "What advice would you give others about playing the game, such as how to best use it?". There was also an invitation for comments.

Procedure

Participants played the *Medicina* computer game as the intervention. The game requires the student to sit at a computer to play, listen to a command to find a particular medication, and use the mouse to select an option among five labeled cartoon bottles. The student has four seconds to choose a written option, followed by feedback given about their choice by the cartoon nurse, who holds the bottle showing the name and says either "Yes" and repeats the correctly chosen name or "No" and pronounces the incorrectly chosen name. Points accumulate for correct answers. Not selecting an option, or choosing three incorrect answers, ends the game.

A strict set of selection criteria was used to choose the medication names for *Medicina*. The game draws upon the Australian Prescription Benefit Scheme list (Australian Government DHA, 2010a). Medication names were selected if they met any of the following criteria: they were a common medication (Australian Government DHA, 2007, pp. 24-6; Australian Government DHA, 2010b, p. 13; Australian Government DHA, 2010c, p.15); they had been reported as being confused in the clinical setting (Australian Council for Safety and Quality in Health Care, 2002, pp. 75-7; Chi, 2008, p. 3; Hicks, Becker & Cousins, 2008; Institute for Safe Medication Practices, 2010); or were identified as possibly confusable according to the name's similarity to the orthographic and phonetic properties of other names. Thereafter, extra medication names were introduced to complete each set of five names, according to sound and spelling similarities. Finally, four different female speakers were used to produce the game. The rationale for this strategy

was that the greater number of speakers produces better phonological competence (Sommers & Barcroft, 2011, pp. 431-2).

The study required participants to complete a pre-test and demographics information sheet during a two-week test period, play the game during a two-week intervention period, and complete the post-test and survey response during a four-week period. These timeframes needed to be wide in order to accommodate outside demands of the school on students' time: students undertake shift work on clinical placement, attend university lectures, tutorials, workshops, and practicums, and they need to complete assignments, among other demands, so forcing their attendance into a narrow timeframe was unfeasible. Students were asked to play the game as much as they wanted during a two-week period, resulting in an average of 688 word exposures, about 100 minutes, per participant.

A dependent t-test was conducted on the pre-test and post-test scores. Further dependent t-tests were run on inter-test groups of word parts which were not used in the game, in order to check if exposure or memorisation affected word part recognition results in the pre-test and post-test. A correlation was run on 'time in Australia' and 'age' as a check for extraneous factors influencing the study. As previously mentioned, the average time participants had spent in Australia was 2 years, and this is much longer than the 3 months to 1 year period when most phonological awareness is developed in a L2. Thus, the length of time taken to complete the study probably had little effect on the results. Furthermore, the average age of the learner was 30, well beyond the period in childhood where phonological awareness is most active. Nonetheless, as a fail-safe measure, a correlation was used to search for a relationship between improvement, age, and time in the country.

Finally, the semi-structured survey answers were collated and a thematic analysis was conducted. This paper will report only the relevant themes related to the hypotheses. As such, participant comments will be used in the discussion section to support or negate the hypotheses.

RESULTS

Overall, participants experienced a significant increase in phonological awareness $t(24) = -5.18$, $p < .0001$, $r = .73$), as evident in the scores found in the pre-test ($M = 36$, $SE = .87$) as compared to the post-test ($M = 40$, $SE = .55$) administered after the intervention. The effect size indicates that this is a substantive finding, but it must be kept in mind that the sample size was small.

The results were similar for the test of word parts which appeared both in the test and the *Medicina* game: participants demonstrated an increase in phonological awareness after the intervention, $t(24) = -4.88$, $p < .0001$, $r = .71$), with an increase in post-test scores ($M = 20$, $SE = .36$) as compared to pre-test scores ($M = 18$, $SE = .50$). While this result may be due to familiarity with the words used in the game, significant results were also found for word parts which were not used in the game: participants demonstrated an increase in phonological awareness after the intervention, $t(24) = -3.34$, $p < .005$, $r = .56$), with an increase in post-test scores ($M = 20$, $SE = .36$) as compared to pre-test scores ($M = 18$, $SE = .50$). It should be noted that the relationship was stronger for familiar word parts from medication names used in the game, in comparison to word parts not used in the game, but both results remain significant and have strong effect sizes that represent substantive findings for phonological awareness gained through the game. Once again, it must be kept in mind that the sample size was small.

No significant correlation was found between pre-test/post-test scores and other factors such as time spent in Australia or age. Since all the participants were over the age of 15, it was unlikely that age would be a significant factor in improvement

(Flege, 1993). Similarly, length of time spent in the country was possibly a factor (Flege et al., 1997), but this study found no relationship to the rate of improvement found for test scores. However, improvement on the test scores was correlated: the pre-test score had a significant relationship to the post-test score (n = 21, r =.52, p <.01) (note that four participants' scores were excluded from the correlations because they reported no IELTS score). This implies that the participants' final score related to how well they scored in the pre-test, which suggests a linear rate of improvement over time.

All participants gave qualitative feedback on the semi-structured survey. There were no comments that contradicted or negated the hypothesis among the responses. Rather, many useful comments were gathered that enriched and supported the evidence gained from the quantitative data.

DISCUSSION

The purpose of this study was to ascertain if *Medicina* increases phonological awareness. The statistical tests and effect sizes confirm that phonological awareness was indeed improved substantially after the participants played the *Medicina* game during a two-week period. Furthermore, since the participants' IELTS scores for listening and reading were excellent (they are eligible for professional registration), it makes the results more promising. One might not expect that a significant improvement in phonological awareness is possible among such advanced learners, yet they demonstrated a greater ability to distinguish between similar phonemes in the post-test. It points to the need for phonological awareness training even at an advanced level.

As discussed earlier, the game was designed to evoke rephonologization by presenting the necessary competing items, misunderstandings, and communicative breakdowns theorised to trigger the process of phonological perceptual change. The Perceptual Assimilation Model of speech perception suggests that rephonologization occurs throughout the lifespan, but not as dramatically as is seen during childhood and the initial year spent in an immersive environment. Indeed, in terms of theoretical importance, the findings of this study not only support the PAM-L2 notion, that perceptual learning is possible at all ages, but also that "forceful linguistic pressure" can drive this process (Best & Tyler, 2007, p. 32). In this case, the pressure was placed upon participants to learn similar-sounding novel words for their professional needs, and the phonemes of this new vocabulary were difficult to distinguish, because their parts occupied a densely populated phonological space. According to PAM-L2, these are prime conditions for reconceptualising existing phonological categories and creating new phonological categories as needed (Best & Tyler, 2007, p. 30), thus improving speech perception. This study supports the possibility that linguistic pressure on the learner produces rephonologization, as posited in PAM-L2.

A major contributor to linguistic pressure, according to the participants, was the time limit, which they felt was an important feature of the game. One participant commented that "the speed of game was really good. It was faster than I could do it could enhance my skill for catching the word. If it was slow I would never improve." Another participant said that a good feature of the game was its "time limit, if you are not quick then it's gone. You should be quick, like in placement and daily life." The time pressure compelled them to respond quickly and they felt the skills they were developing would help them deal better with the clinical setting. This is indicated in the following participant's comment that "this game helps to act quickly like in wards during our placement, we need to get medicines very quickly. So it helps to practice that."

A possible confounding factor in the study is that raised awareness about mishearing medication names contributed to participant improvement.

The result would be that participants paid more attention to learning medication names and they may have been stimulated to develop their language skills. To some extent, the latter is an effect of playing the game, and could legitimately be considered a contributing feature to the effectiveness of *Medicina*. However, to control for these factors, students were asked in the semi-structured survey if they had undertaken extra study of medical terminology or used the click-and-play word website associated with *Medicina* (which they were informed was available for them to practice). All students replied no. This implies that any gains in medication name knowledge were from either *Medicina* or possibly general knowledge gained from the nursing curriculum (which has no focused teaching of either linguistic skills or medical terminology). The results must be interpreted keeping these factors in mind.

Another possible confounding factor was that participants could rote-learn the materials rather than make real gains in phonological awareness. While the pre-test and post-test was designed to avoid this issue, by using only half of a real word and placing it with another half to form a non-word, the possibility still remains that memorization of word parts would occur. Taking this into consideration, word parts were gathered both from medications names used in *Medicina* and other medications names not used in *Medicina*. It was evident from the effect sizes, $r = .71$ as compared to $r = .56$, that repeated exposure to the word parts found in the game resulted in better recognition than word parts that were not found in the game. Nonetheless, significant gains were made in word parts which were not used in the game, and this indicates only some degree of rote-learning had influenced the results. It must also be remembered that the game was created with the dual purpose of familiarising students with low-frequency medication names, and the kinds of sound configurations found among this group, so it was expected that there would be some confounding effect.

Another area of concern in the interpretation of the results is the possibility that improvement in ability to distinguish between phonemic contrasts is solely due to faster processing of what is already known, rather than an increase in phonological awareness. It needs to be remembered that both the pre- and post-tests, and the game, used timed conditions designed to put the participant under duress. As a result, through statistical analysis alone, there is some doubt that the participants improved in their ability to distinguish between phonemes rather than improving their ability to speedily process already categorised phonemes. However, this problem can be resolved by analysing the feedback of the participants, noting which of these effects they perceived from the game.

The evidence supporting a growth of phonological awareness and phonemic knowledge, rather than the game merely providing an opportunity to develop a faster processing of what is already known, comes from the participants themselves. When asked in a semi-structured questionnaire about what they thought was good about the game, the invariable answer was the opportunity to gain familiarity with the spoken forms of medication names and to relate pronunciation to written form. For example, one participant wrote that the game *"helped in differentiating different word sounds... understanding the difference between how certain words are pronounced"*. This clearly points to an improvement of phonological awareness rather than merely a faster processing of what is already known. An understanding of small points of difference in pronunciation was gained. Another participant realised that their phonological awareness was improving, but that they still needed time before they could automatically process speech: *"I just listened. I cannot quickly response to random words but next time I hear that word I am familiar with that one"*. Some students reported that the game consolidated the links between spoken and written forms. The students learned how to relate pronunciation to spelling, which aided word

recognition and reading speed. One participant recognised this benefit, discussing how the game lead to automatization: *"I was able to familiarize the pronunciation... better than before"* and the result was that "*it improves my reaction in finding the right medication each time I play the game"*. This supports the notion that speed only comes after familiarisation, and that the game does both.

Other evidence of the improvement of phonological awareness is evident in the participants' attention to the different Australian accents used in the game. Participants pointed out that it helped prepare them for local speech in clinical placement. They stated that the strength of the game was *"the use of the Australian accent"* and another wrote that *"When I checked medications online I got American accents, and it definitely confuses me. Medicina is more accurate, it is better than doing it online* [in online dictionaries]*"*. When asked about how the game prepares students for Australian clinical practice, one participant wrote that it helps *"understanding different accents and volume (loud or not) of the voice"*, whereas others felt they learned *"how slight differences in the way a word is pronounced can make it so different"* and *"to realize there are slight accent difference between different people"*. Overall, it was common to receive feedback such as: *"When I heard the names before, I was guessing, but now I am listening and thinking"*. The students realized that they were not rote-learning names – rather, they were improving their listening skills. One participant wrote that through the game, *"You will come to know your tendency/weak point in your listening skill"*.

Another point to be made about gains in phonological awareness can be found by examining the recommendations given by participants on how others should play the game. Participants often suggested that players need to repeat the words, in their minds or out loud, while the game was running. They advised that prospective players *"should follow the pronunciation, speak after it is heard"*, *"practice by mimicking the pronunciation"*, and to *"read it out loud... or repeat it in your mind. This helps you to pick out small differences between similar named medications"*. This indicates a fine-tuning of phonological awareness, which is then practiced repeatedly each time an opportunity arises in the game. Indeed, one participant inadvertently referred to a design feature of the game, the use of minimal pairs, writing that *"Sometimes you can repeat the word when you hear it to help you remember what was pronounced, for example 'pam' or 'bam'"*. All of the comments in the preceding paragraphs support the suggestion that the distinction between words and sounds comes before an improvement in processing speed. They point to phonological awareness being improved, and then consolidated, as automatisation was gained. Considering the qualitative data, it seems safe to conclude that the quantitative results describe an increase in phonological awareness arising from the game, rather than just a faster processing of what is already known.

More support for phonological awareness being improved by *Medicina* emerged when participants commented on the impact the game had on their educational experience. One wrote *"I found it quite helpful to become familiar with the "sound" of each drug name, because it help me to pick up the sounds in my class"*. Similar comments were made by another student *"after the game I heard medication names in tutorial, and normally I wouldn't have known them"* and "*I hear more names in lectures and study. I now know more words in class and books. I catch up on what they mean"*. There was only a limited amount of medication names covered by the game in comparison to the vast number used in practice, but the students were able to begin to learn the general forms and anticipate the kinds of names that sounded like medicines: *"I know it is a medication by what it sounds like"* and *"I can recognise the medication word immediately, at least I know it's a medicine and not a disease or other thing"*. Another aspect of *Medicina*'s

impact in the educational setting is identified in another comment noting that *"I'm not sure I comprehend words and how much I've always been tested. This game is very helpful for me. In class, the teacher uses the words and it quickly reflects in my mind and I know it is a medication – it ease my fear of new words"*. These impacts on the educational setting indicate the wider relevance of the learning from the game, since it improved student performance in the classroom.

An important matter needs to be raised in relation to the latter participant who felt 'untested' in class. The game was able to provide an educational situation which compelled them to interact and tested them in a way that other educational means had not. The qualitative feedback indicates that this is largely due to the personalised method of delivery and its referencing to reality, which improved motivation to learn. In a way, the game is a form of 'absent' teaching, one where educational content and feedback is delivered on a one-to-one basis for each player/student. Furthermore, the game allows students, as mentioned earlier, to consciously attend to novel phonetic forms enhancing learning (Pederson & Guion-Anderson, 2010). Participants reported that this educational format *"boosts me to learn more and more"* and *"it made me want to learn"*. One participant made the notable comment that "*When I read the textbook I feel really bored. When I play the game I feel really excited. Before the game I didn't try to read the drug books... Now I look up words in the drug books, because I do research and sometimes just because I am just interested."* This is an important educational advance for this participant.

An important aspect of the gaming teaching method is the simulation aspect of the game. Participants gave feedback commenting that they liked how *"it's a better simulation of a real work environment than just repeating drug names"* and that you could "*imagine yourself in a real situation*" which allowed them to *"immerse in the situation*". An intense focus on language is not possible in a real clinical situation because it is much more complex, requiring a student to sift through a multitude of sensory inputs, often producing cognitive overload, with mistakes being potentially life-threatening, and little time for self-contemplation. Language skills are difficult to improve in such a situation. Perhaps this is why more than one participant feared new words and felt relieved that the medication name now quickly reflects in their mind. It is easy to see how this would help students cope better in both the educational and the clinical environments.

To close, considering the overall results, participants significantly improved in their overall phonological awareness and could more rapidly relate spoken phonemes to their written form after playing *Medicina*. However, this result must be tempered by the study design which had no control group and a smaller-than-optimal number of participants. Undoubtedly, a more rigorous study is needed. Nonetheless, combined with the qualitative data, this study indicates the development of phonological improvement through *Medicina* to be wide-reaching, going beyond the game and into the classroom and clinical practice. The best part is that the aforementioned improvements were achieved while playing a fun game.

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KEY TERMS AND DEFINITIONS

Automaticity: Automaticity refers to a rapid and effortless processing of input which indicates a minimal allocation of cognitive resources. Automaticity of word form refers to an effortless processing of sounds, spellings, and features into whole words, thus enabling more attention to be given to meaning and use of those words.

Minimal Pair: The minimal pairs analytical technique is used in linguistics to identify the phonological elements of a language. One application of the minimal pair technique is to distinguish the phonemes that produce a change in word, such as the 'b' and 'p' in 'bat/pat'.

PAM-L2: The Perceptual Assimilation Model (PAM), as applied to a second language (L2) posits that phonological awareness most dramatically develops during vocabulary expansion which involves competing items in a densely occupied phonological space (i.e. similar-sounding words).

Phoneme: A phoneme is the basic smallest meaningful sound unit of a language. Each language has a phonemic inventory, or range of meaningful sounds that form the basis of that language.

Phonological Awareness: Phonological awareness refers to knowledge of the entire phonological system – knowing not only the range of sounds and phonemes used in a language, but also their articulation, permissible sequences and variations, assimilation rules, and more.

Rephonologization: Rephonologization is the process of building upon current phonological awareness and occurs throughout the lifespan. Rephonologization is most evident for second language learning during the initial year in an immersive second-language environment because it involves an intense assimilation of new sounds that expands the current phonological repertoire to include L2 input.

Word Form: Word form refers to a word's sound, pronunciation, appearance, spelling, general parts, and meaningful parts. Word form is the first of three stages theorised to be involved in knowing a word: knowledge of form, knowledge of meaning, knowledge of the word's use in context (as posited by Paul Nation).