PatRec: A Mobile Game for Learning Social Haptic Communication

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ABSTRACT

Social Haptic Communication (SHC) is one of the many tactile modes of communication used by persons with deafblindness to access information about their surroundings. SHC usually involves an interpreter executing finger and hand signs on the back of a person with multi-sensory disabilities. Learning SHC, however, can become challenging and time-consuming, particularly to those who experience deafblindness later in life. In this work, we present PatRec: a mobile game for learning SHC concepts. PatRec is a multiple-choice quiz game connected to a chair interface that contains a 3x3 array of vibration motors emulating different SHC signs. Players collect scores and badges whenever they guess the right SHC vibration pattern, leading to continuous engagement and a better position on a leaderboard. The game is also meant for family members to learn SHC. We report the technical implementation of PatRec and the findings from a user evaluation.

CCS CONCEPTS

• **Human-centered computing**; • **Accessibility technologies**;

KEYWORDS

Deafblindness, Haptics, Game-Based Learning, Vibrotactile feedback, Visual Impairments, Assistive Technology, Tactile Sign Language, Accessible Games

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1 INTRODUCTION

Social Haptic Communication (SHC) is one of the many modes of communication used by persons living with deafblindness [6, 8]. SHC is broadly defined as the interaction of two or more people in a social context where information is conveyed using the sense of touch. Social Haptic Communication can be applied across the spectrum of language users, from those with highly complex signed or spoken language to those with limited communication [19]. SHC signs, also known as haptices, are performed on neutral zones on the body of a person with deafblindness. Most SHC signs are executed on the upper back using fingers or hand movements, but other parts of the body such as arm, wrist, palm and upper knee can be used. In other words, SHC allows for discreet near real-time information transfer, where a person with deafblindness can passively receive information while sitting or standing [18, 20]. For instance, SHC signs may be used to inform persons with deafblindness about emotions and facial expressions or to provide spatial information about locations, including descriptions of rooms or the number of people around them. Learning Social Haptic Communication, however, can become challenging and time-consuming, particularly to those who experience deafblindness later in life. There is a growing body of accessibility literature exploring the potential benefits of using digital games for educational purposes [12, 13, 21]. Game-based learning can be an engaging and motivating tool for improving literacy and communication skills [5, 7, 12, 13]. Therefore, we introduce PatRec: a mobile game for learning Social Haptic Communication concepts. The game interface connects to a chair cover that contains a 3x3 array of vibration motors emulating different haptices (i.e. touch signs) that would otherwise be executed using fingers or hands on the back of the user. Our goal was to develop a haptic game for supporting SHC learning in a fun and engaging way to both users with and without sensory disabilities.

2 THE MOBILE GAME

PatRec was developed with the aim to introduce SHC concepts to persons with and without deafblindness in a gamified learning context. As shown in Figure 1, a vibration pattern is activated onto the backrest of a chair and players need to select the on-screen graphical representation of the SHC sign that best matches the pattern they felt on the back. This is done using a four choices quiz-game mechanic that increases difficulty as the player progresses

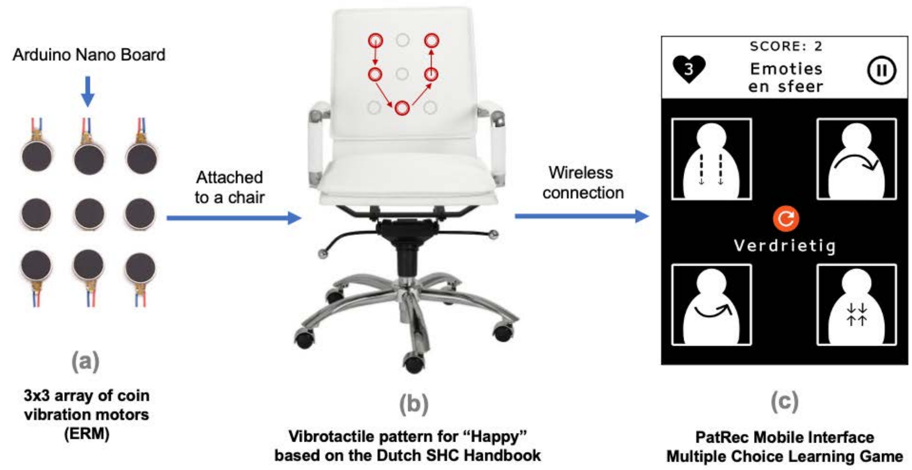

Figure 1: (a) PatRec uses a 3x3 array of vibration motors attached to a chair. (b) Vibration patterns emulating SHC signs are displayed onto the back of the user. (c) Using a mobile interface, the user needs to guess the right SHC sign based on the vibration pattern perceived on the back.

into the game. The game levels consisted of 16 Dutch SHC signs [18] grouped by topics and their difficulty increases with the user's experience. The design of the vibration patterns was informed by co-creation sessions with individuals with deafblindness [16, 17]. The mobile game incorporates the principles of game-based learning by rewarding players with a collection of badges and experience points (XP) as they achieve new game levels. To improve the competitive element, players lose game lives and points on the leaderboard whenever they choose the wrong SHC sign option. PatRec was designed to foster social play between mixed-ability players that can compete for a better spot on the leaderboard. For this, we ensured that the game interface was accessible for players with different sensory characteristics. These elements have been included as research suggests that gamified learning brings many advantages, among which improved learning outcomes, increased learner's engagement and the offer of enjoyable experiences [2, 7, 10, 14]. This could help minimizing the problem that more than half of the adults with deafblindness reported being unsatisfied with their current recreational and social activities [11]. The mobile game implementation is described below.

2.1 Hardware Implementation

A textile cover (i.e. also referred to as "chairable") was used to attach a 3x3 array of vibration motors to the backrest of a chair. The hardware setup communicates with the mobile game interface using 9 Eccentric Rotating Mass (ERM) coin-shaped vibration motors (Adafruit 10x2.7mm) connected to an Arduino Nano board. To adhere with the psychophysics principle that perception on the back is vertically denser [15], the vibration motors on the vertical axis are arranged using 1.5 times the distance used for the motors on the horizontal axis.

2.2 Software Implementation

The mobile game application was developed in Unity and its prototype is compatible with Android devices. The vibration patterns that emulate SHC concepts are encoded as JSON files. Vibration pattern duration varied between 0.5 and 4 seconds depending on the pattern. Vibration motor activation (i.e. frame) also varied between patterns but the shortest frame duration was 200 milliseconds. Frame interpolation (i.e. overlap) was only used for patterns emulating a line being traced. The mobile interface sends these vibration patterns to the chair using a MQTT message bus [3].

2.3 Accessibility Implementation

The game interface uses high contrast pictorial representations of SHC concepts with proper sizing and extra spacing for text [4]. The GUI works across devices with different screen sizes. An audio-description mode was implemented for blind and low vision users in which the definition of each SHC sign is described in audio through a "tap to hear, tap twice to confirm" system. Currently, the game is accessible to players with residual sight and/or hearing.

3 USER EVALUATION

As a proof-of-concept, a usability test was conducted with 10 participants with no reported sensory disabilities (age range 18-63 years old; mean age = 33 years old; 3 male; 7 female). Participants were first given an introduction to the game and how it works. Participants were then asked to complete four interaction tasks using a think-out-loud protocol: (1) create an account and adjust the accessibility sessions to their wishes, (2) explore the game options, (3) complete at least 3 game levels, and (4) check their achievements. Upon completion, participants were asked to evaluate the game using a SUS questionnaire [1, 9] and shared their views about the mobile game in semi-structured interviews. Our findings include

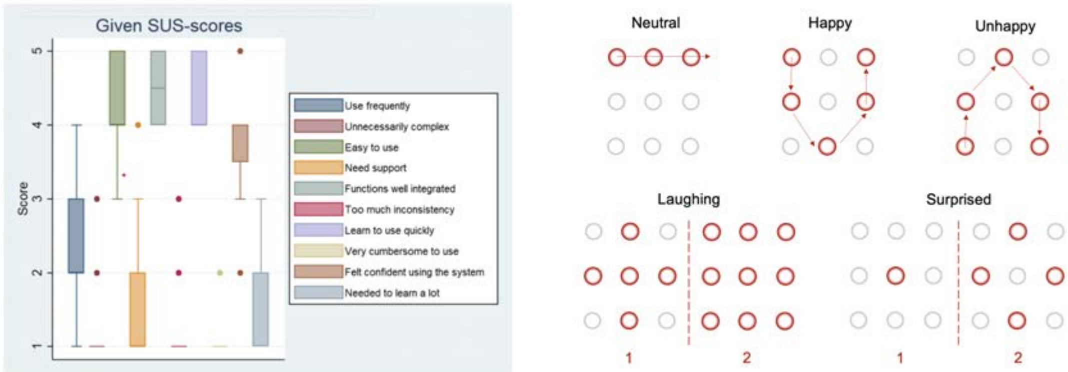

Figure 2: Left: Mean SUS scores per question. 1 = Strongly Disagree; 5 = Strongly Agree. Error bars represent S.D. Right: Examples of in-game vibrotactile patterns emulating Dutch SHC signs.

an average SUS score of 80.1/100, which indicates a usability score between "good" and "excellent" (Figure 2). Furthermore, most participants were able to complete all game levels without major issues. Some participants, however, noticed that some on-screen representations of SHC signs are easier to be linked to vibrotactile patterns than others. This finding indicates that designing intuitive graphical representations of haptices should be prioritized as patterns become more complex to be perceived. All sessions were recorded, and the study received ethical approval by the Ethics Committee of the Eindhoven University of Technology's HTI Group.

3.1 Demonstration session with an expert in SHC

A high-fidelity prototype was presented to a teacher and expert in Dutch Social Haptic Communication who evaluated the mobile game positively as it is suitable for family-use and encourages social play for both users with and without sensory disabilities. The expert also appreciated the different accessibility features present in the game and suggested including in-app haptic feedback when selecting a pattern (in)correctly. Additionally, the participant recommended braille-reader compatibility in future versions of the game.

3.2 Follow-up session with a user with deafblindness

A follow-up session was conducted with a participant with deafblindness (47 years old, female; Usher Type 2A, i.e. hearing loss from birth and progressive vision loss) who tested the game with a family member. The participant did not have prior knowledge in SHC. As the participant had low vision and hearing aids, she interacted with the mobile interface using audio-descriptions of on-screen SHC concepts. We found that the participant was able to learn how to match vibration patterns to SHC signs quickly and accurately. The participant also mentioned that if the set of vibration patterns would be expanded, it would definitely be practical for future use. However, the participant mentioned that the intensity of the vibration was too strong at times. In her own words, she "felt like the vibrations were flowing through to her upper legs and neck". From experience, she shared that persons with deafblindness sometimes feel fatigued by tactile communication, and having such strong vibrations could become overwhelming. The participant suggested the possibility to adapt the intensity of the vibrations as well as the location and grid size of the vibration motors. Furthermore, the participant's family member also demonstrated great interest in the game, confirming the thoughts of the expert in SHC.

4 DISCUSSION AND CONCLUSION

Our findings show that there is a compelling opportunity to using haptic games for users with a diverse set of sensory characteristics. Overall, users described PatRec as "fun", "interesting", "useful", "practical", and "adaptable to user needs". The ability to foster social play between mixed-ability players was also welcomed by different users. Additionally, most users were able to complete all SHC levels in relatively easy manner. Although most participants initially reported that they enjoyed playing the game, we were not able to observe how PatRec engages users in learning Social Haptic Communication over a longer period of time. Therefore, a longitudinal study is still needed for investigating the long-term effects of gamified learning on SHC literacy.

For future work, we plan to include an expansion of Social Haptic Communication concepts available in the game. We used Dutch SHC signs for our proof-of-concept, however future iterations of the game could include local SHC concepts used by persons with deafblindness in other countries. Furthermore, based on user feedback, a number of iterations can be made to the user interface. The ability to adapt the intensity of the vibrations was deemed as useful for users with sensitive tactile perception. We also plan to expand the vibration grid from 3x3 to 4x4, as well as including more participants with deafblindness in the co-design process.

Finally, PatRec allows users to learn new Social Haptic Communication concepts at their own pace using vibrotactile patterns that emulate meaningful touch messages. Users are introduced to haptices while challenging themselves to score points, earn badges and compete against other players for a better spot on the leaderboard. In this way, PatRec uses gamified learning and social play to engage different individuals with SHC, allowing for better situational awareness and social integration of persons with deafblindness at the same time that it decreases dependency on others. We conclude that haptic games like PatRec are promising tools for players regardless of their sensory characteristics.

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REFERENCES

[1] Aaron Bangor, Philip T. Kortum, and James T. Miller. 2008. An Empirical Evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction* 24, 6 (2008), 574–594. DOI:http://dx.doi.org/10.1080/10447310802205776

[2] Andreas Lieberoth. 2015. Shallow gamification: Testing psychological effects of framing an activity as a game. *Games and Culture* 10, 3 (2015), 229–248. DOI:http://dx.doi.org/10.1177/1555412014559978

[3] Arthur Theil, Lea Buchweitz, James Gay, Eva Lindell, Li Guo, Nils-Krister Persson, and Oliver Korn. 2020. Tactile Board: A Multimodal Augmentative and Alternative Communication Device for Individuals with Deafblindness. In *19th International Conference on Mobile and Ubiquitous Multimedia* (*MUM 2020*). Association for Computing Machinery, New York, NY, USA, 223–228. DOI:https://doi.org/10.1145/3428361.3428465

[4] Carmen Willings. Font Legibility for Students who are Blind or Visually Impaired. Retrieved March 31, 2021 from https://www.teachingvisuallyimpaired.com/font-legibility.html

[5] Chandrika Jayant, Christine Acuario, William Johnson, Janet Hollier, and Richard Ladner. 2010. V-braille: haptic braille perception using a touch-screen and vibration on mobile phones. In *Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility* (ASSETS '10). Association for Computing Machinery, New York, NY, USA, 295–296. DOI:https://doi.org/10.1145/1878803.1878878

[6] Eli Raanes and Sigrid Slettebakk Berge. 2017. Sign language interpreters' use of haptic signs in interpreted meetings with deafblind persons. *Journal of Pragmatics* 107 (2017), 91–104. DOI:http://dx.doi.org/10.1016/j.pragma.2016.09.013

[7] James Gay, Moritz Umfahrer, Arthur Theil, Lea Buchweitz, Eva Lindell, Li Guo, Nils-Krister Persson, and Oliver Korn. 2020. Keep Your Distance: A Playful Haptic Navigation Wearable for Individuals with Deafblindness. In *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '20). Association for Computing Machinery, New York, NY, USA, Article 93, 1–4. DOI:https://doi.org/10.1145/3373625.3418048

[8] Jesper Dammeyer. 2014. Deafblindness: A review of the literature. *Scandinavian Journal of Public Health* 42, 7 (2014), 554–562. DOI:http://dx.doi.org/10.1177/1403494814544399

[9] John Brooke. 1996. SUS: A 'Quick and Dirty' Usability Scale. *Usability Evaluation In Industry* (1996), 207–212. DOI:http://dx.doi.org/10.1201/9781498710411-35

[10] Karen Robson, Kirk Plangger, Jan H. Kietzmann, Ian McCarthy, and Leyland Pitt. 2015. Is it all a game? Understanding the principles of gamification. *Business Horizons* 58, 4 (2015), 411–420. DOI:http://dx.doi.org/10.1016/j.bushor.2015.03.006

[11] Lauren Lieberman and Moira Stuart. 2002. Self-determined Recreational and Leisure Choices of Individuals with Deaf-Blindness. *Journal of Visual Impairment & Blindness* 96, 10 (2002), 724–735. DOI:http://dx.doi.org/10.1177/0145482x0209601004

[12] Lauren R. Milne, Cynthia L. Bennett, and Richard E. Ladner. 2013. VBGhost: a braille-based educational smartphone game for children. In *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '13). Association for Computing Machinery, New York, NY, USA, Article 75, 1–2. DOI:https://doi.org/10.1145/2513383.2513396

[13] Lauren R. Milne, Cynthia L. Bennett, Richard E. Ladner, and Shiri Azenkot. 2014. BraillePlay: educational smartphone games for blind children. In *Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility* (ASSETS '14). Association for Computing Machinery, New York, NY, USA, 137–144. DOI:https://doi.org/10.1145/2661334.2661377

[14] Michael Sailer and Lisa Homner. 2019. The Gamification of Learning: a Meta-analysis. *Educational Psychology Review* 32, 1 (2019), 77–112. DOI:http://dx.doi.org/10.1007/s10648-019-09498-w

[15] Myrthe A. Plaisier, Lotte I.N. Sap, and Astrid M.L. Kappers. 2020. Perception of vibrotactile distance on the back. *Scientific Reports* 10, 1 (2020). DOI:http://dx.doi.org/10.1038/s41598-020-74835-x

[16] Myrthe A. Plaisier and Astrid M. L. Kappers .2021. Emulating Social Haptic Communication with Vibration Patterns. In *IEEE World Haptics Conference* (WHC), Montreal, Canada.

[17] Myrthe A. Plaisier and Astrid M. L. Kappers. 2021. Social Haptic Communication mimicked with vibrotactile patterns - An evaluation by users with deafblindness. In *ASSETS '21: The 23rd International ACM SIGACCESS Conference on Computers and Accessibility Proceedings*. Association for Computing Machinery. https://doi.org/10.1145/3441852.3476528

[18] Projectgroep "Social Haptic Communication". 2017. Handboek Social Haptic Communication (SHC)

[19] R. Lahtinen and R. Palmer. 1996. Holistic Family Communication. Spoken Language by Touch is more than just Words. 4th European Deafblind Conference, Expoo, Finland

[20] Russ Palmer and Riitta Lahtinen. 2013. History of Social Haptic Communication, DBI Review, no. 50

[21] Vinitha Gadiraju. 2019. BrailleBlocks: Braille Toys for Cross-Ability Collaboration. In *The 21st International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '19). Association for Computing Machinery, New York, NY, USA, 688–690. DOI:https://doi.org/10.1145/3308561.3356104