Learning Piano Songs with Passive Haptic Training: an Interactive Lesson

Asha Bhandarkar
abhandarkar6@gatech.edu
Georgia Institute of Technology
Atlanta, GA, USA

Tan Gemicioglu
tgemici@gatech.edu
Georgia Institute of Technology
Atlanta, GA, USA

Brahmi Dwivedi
bdwivedi6@gatech.edu
Georgia Institute of Technology
Atlanta, GA, USA

Caitlyn Seim
cseim@stanford.edu
Stanford University
Stanford, California, USA

Thad Starner
thad@gatech.edu
Georgia Institute of Technology
Atlanta, GA, USA

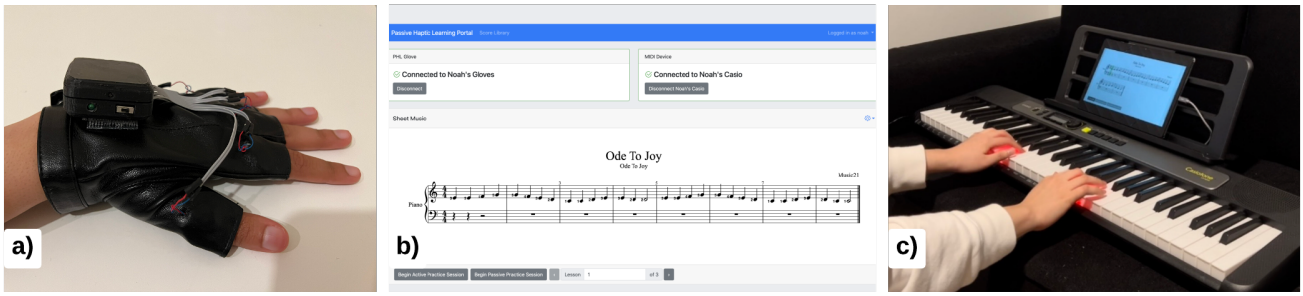

Figure 1: (a) Passive haptic learning gloves. (b) Web app for active and passive practice. (c) Active practice on light-up keyboard.

ABSTRACT

Passive haptic learning (PHL) is a method for learning piano pieces through repetition of haptic stimuli while a user is focused on other daily tasks. In combination with active practice techniques, this method is a powerful tool for users to learn piano pieces with less time spent in active practice while also reducing cognitive effort and increasing retention. We propose a demo combining these two learning methods, in which attendees will engage in a short active practice session followed by a passive practice session using vibrotactile haptic gloves. Attendees will be able to experience the effects of passive haptic learning for themselves as well as gauge their mastery of the piece with a final performance at the end of the demo.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Haptic devices**.

KEYWORDS

Haptic; Tactile; Wearable; Passive Training; PHL; Piano

UbiComp/ISWC '22 Adjunct, September 11–15, 2022, Cambridge, United Kingdom

ACM ISBN 978-1-4503-9423-9/22/09.
https://doi.org/10.1145/3544793.3560321

ACM Reference Format:
Asha Bhandarkar, Tan Gemicioglu, Brahmi Dwivedi, Caitlyn Seim, and Thad Starner. 2022. Learning Piano Songs with Passive Haptic Training: an Interactive Lesson. In *Proceedings of the 2022 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp/ISWC '22 Adjunct), September 11–15, 2022, Cambridge, United Kingdom.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3544793.3560321

1 INTRODUCTION

Traditional piano learning methods often focus on learning theory and techniques, practicing new pieces, and rehearsing previously learned ones. Passive haptic learning (PHL) offers an alternative method for practice and rehearsal, accelerating the learning process and improving retention [2]. We focus on a self-paced piano learning method that combines passive haptic learning with active practice to accelerate learning and reduce cognitive load required from practice.

As opposed to active learning, passive learning is "caught, rather than taught" [7] and can result in learning even without motivation and effort [11]. PHL utilizes vibrotactile stimulation to passively teach piano by applying an intensive repetition of instructional cues directly to the fingers [4]. Prior research has shown that learning occurs whether or not audio accompanies the tactile cues [8] and that PHL does not occupy user attention during learning [5] [6]. In more recent research, piece selection has expanded from single hand melodies to two-handed chorded pieces [10].

Our current research efforts are focused on studying the idea of passive haptic rehearsal - where active practice sessions are accompanied by separate passive learning sessions - to further increase retention and mastery of piano skills [3]. We hope that our

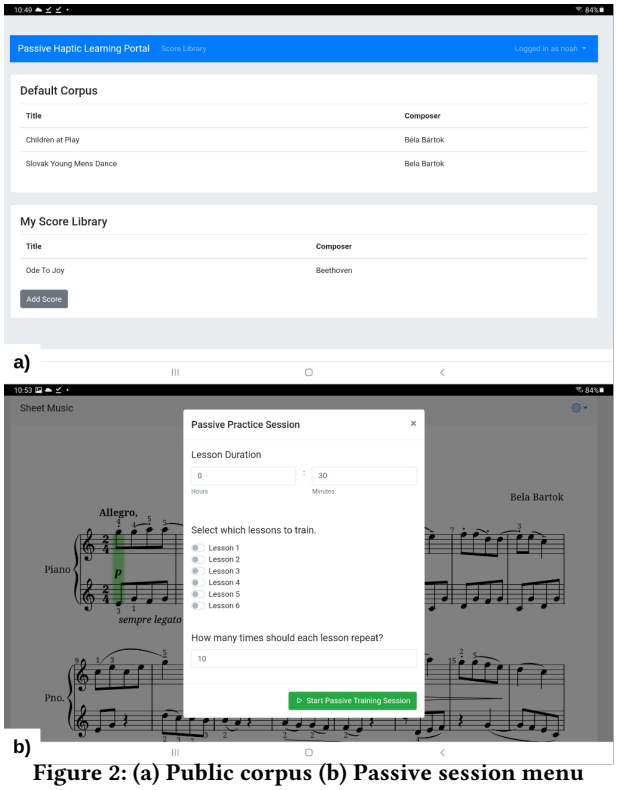

Figure 2: (a) Public corpus (b) Passive session menu

demo will serve as a way to further understand the benefits of PHL as well as raise awareness of alternative piano learning methods.

2 PASSIVE HAPTIC LEARNING SYSTEM

The PHL learning system includes a pair of haptic gloves, a Bluetooth-capable tablet (a Samsung Galaxy Tab A8) and a Casio LK-S250 keyboard with light-up keys functionality. The gloves contain five vibration motors (Precision Microdrives 310-103) at the base of the fingers and the electronics contained in a 3D-printed case at the back of the palm to protect from sweat, dust, and other damage. Using the vibration motors, the gloves repeatedly stimulate the user's fingers in the order in which the piano keys are played. The gloves, being fingerless, do not interfere with the user's daily tasks. The gloves are self-contained, and do not need a continuous connection to an external device to operate. The right glove controls the left through Bluetooth LE. The battery life of the gloves is around three hours.

The tablet is used to gain access to our web app, which allows the user to create an account and interact with a song in multiple ways. The user can view sheet music, play the song with audio and visual cues, and record their own performance of the song. All users have access to songs in a public corpus that they can learn, and they can also upload their own songs as MusicXML files, which are processed and stored in their account. Our web app software uses the computational musicology library *music21* for processing and interacting with digital scores [1]. When a new song is uploaded to the web app, the song is processed in two ways: first, to automatically produce fingering data for each note in the song (for tactile vibrations) and second, to chunk the song into smaller "lessons", since passive training optimally works on short segments of 10-17 stimuli [9]. These "lessons" are repeated multiple times during passive training. The web app allows the users to connect the tablet to their PHL gloves over Bluetooth LE and to the keyboard over USB. Once connected, the user can initiate passive training sessions, with various adjustable parameters such as duration of a practice session, which lesson to learn, and the number of times it is repeated.

The above passive training is meant to be used in coordination with active training using a technique of the user's preference. These techniques could include using sheet music, or using light-up keys on the Casio keyboard. The Casio keyboard can demonstrate the song by playing the audio and lighting up the keys in synchrony, after which the user tries to repeat the song, and this process can be repeated multiple times.

3 DEMO OVERVIEW

Our demo will provide a unique experience for attendees to interact with the entire PHL hardware stack and experience PHL during the conference. The demo will begin with a short active practice session (to provide a baseline) and an introduction to the system lasting around five minutes in total. Attendees will be given an introduction to the web app - notably its active and passive practice functionality. Then attendees will attempt to play a short pre-selected two-hand piano piece on a keyboard after they have seen the song "played to them" through the web app, the keyboard's step-through sheet music, audio, and the keyboard's light-up keys. This piece will be carefully selected for it to be accessible to people with little to no musical background. The attendees will then be given an introduction to the PHL glove interface and will wear the gloves for the next hour as they attend the next conference session and complete their daily tasks. The demo will conclude with a performance where attendees will complete the same exercise done at the beginning and listen to a recording of their performance to gauge their mastery of the piece. The estimated total time of the demo will be around seventy minutes. By demonstrating the system and having attendees experience PHL firsthand, we hope to bring awareness to the idea of passive training through haptic feedback technology as well as receive general feedback from the wearable computing community on our system and research efforts.

ACKNOWLEDGMENTS

This research was supported by the National Science Foundation, Partnerships for Innovation grant #2122797, and the Georgia Research Alliance, Inc. based in Atlanta, Georgia.

REFERENCES

[1] Michael Scott Cuthbert and Christopher Ariza. 2010. music21: A toolkit for computer-aided musicology and symbolic music data. (2010).
[2] Rumen Donchev, Erik Pescara, and Michael Beigl. 2021. Investigating Retention in Passive Haptic Learning of Piano Songs. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 5, 2 (June 2021), 60:1–60:14. https://doi.org/10.1145/3463513
[3] Tan Gemicioglu, Noah Teuscher, Brahmi Dwivedi, Soobin Park, Emerson Miller, Celeste Mason, Caitlyn Seim, and Thad Starner. 2022. Passive Haptic Rehearsal for Accelerated Piano Skill Acquisition. https://doi.org/10.48550/ARXIV.2203.12749
[4] Kevin Huang, Ellen Yi-Luen Do, and Thad Starner. 2008. PianoTouch: A wearable haptic piano instruction system for passive learning of piano skills. In *2008 12th*

IEEE International Symposium on Wearable Computers. 41–44. https://doi.org/10.1109/ISWC.2008.4911582 ISSN: 2376-8541.

[5] Kevin Huang, Thad Starner, Ellen Do, Gil Weiberg, Daniel Kohlsdorf, Claas Ahlrichs, and Ruediger Leibrandt. 2010. Mobile music touch: mobile tactile stimulation for passive learning. In *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10*. ACM Press, Atlanta, Georgia, USA, 791. https://doi.org/10.1145/1753326.1753443

[6] Daniel Kohlsdorf and Thad Starner. 2010. Mobile Music Touch: The effect of primary tasks on passively learning piano sequences. In *International Symposium on Wearable Computers (ISWC) 2010*. 1–8. https://doi.org/10.1109/ISWC.2010.5665877 ISSN: 2376-8541.

[7] Herbert E. Krugman and Eugene L. Hartley. 1970. Passive Learning from Television. *Public Opinion Quarterly* 34, 2 (Jan. 1970), 184–190. https://doi.org/10.1086/267788

[8] Tanya Thais Markow. 2012. *Mobile music touch: using haptic stimulation for passive rehabilitation and learning*. Ph. D. Dissertation. Georgia Institute of Technology.

[9] Caitlyn Seim. 2019. *Wearable vibrotactile stimulation: How passive stimulation can train and rehabilitate*. Ph. D. Dissertation. https://smartech.gatech.edu/handle/1853/61253 Accepted: 2019-05-29T14:03:08Z Publisher: Georgia Institute of Technology.

[10] Caitlyn Seim, Tanya Estes, and Thad Starner. 2015. Towards Passive Haptic Learning of piano songs. In *2015 IEEE World Haptics Conference (WHC)*. 445–450. https://doi.org/10.1109/WHC.2015.7177752

[11] Cliff Zukin and Robin Snyder. 1984. Passive Learning: When the Media Environment Is the Message. *Public Opinion Quarterly* 48, 3 (Jan. 1984), 629–638. https://doi.org/10.1086/268864