Motivational Techniques for Blind Exercise

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ABSTRACT
To be updated by 9/18 at the latest, of about 150 words

Author Keywords
Accessibility; video games; exergames; visual impairments; Kinect; motivation; deployment; eyes-free; audio feedback; yoga; health.

ACM Classification Keywords
K.4.2 [Computers and Security]: Social Issues – Assistive technologies for persons with disabilities, H.5.2 [Information Interfaces and Presentation]: User Interfaces.

INTRODUCTION
To be filled in by 9/18 at the latest

BACKGROUND AND RELATED WORK
Here we discuss background and related research about persuasive technologies explored generally within HCI, and accessible exercise technologies.

Persuasive Technologies
One aspect of exercise technologies well studied in the HCI community is how to persuade people to continue toward their exercise goals. According to Fogg's book, Persuasive Technology, there are three different functional roles that a persuasive technology can take: 1) ~~being~~ a tool ~~and to increasing~~ increase capability, 2) ~~being~~ a medium that provides an experience, ~~and~~ or 3) ~~being~~ a social actor that creates a relationship [8]. Some existing tools to promote exercise include Fitbit [7], Jawbone's UP [27~~25~~], and Houston [1]. Fitness tools can make a user's target behavior easier to achieve by presenting relevant measurements using~~by~~ numbers or other visual stimuli. It was recently found that positive framing of numerical information can impact one's self-efficacy to complete their goal [1]. A ~~couple~~ few examples ~~which~~ that provide a medium are UbiFit [4] and Fish'n'Steps [13]. ~~Both of these fitness media~~These both provide an experience of growing a garden or fish, with the growth reflecting their fitness level. Persuasive technologies that act as social actors include UbiFit [4], larklife [12], relational agent interface (named Laura) [1], and the mobile lifestyle coach [9]. Each of these systems provides coaching support and rewards for positive feedback, such as a happy face for completing activities. Eyes-Free Yoga was designed to be a persuasive technology that ~~strives to be an eyes-free persuasive technology,~~uses non-visual techniques to serve as ~~as~~ a tool ~~by lowering~~to lower the barrier to practice yoga through sound-based posture guidance ~~and leading them through each posture through sound,~~ and as a social actor ~~by providing~~that provides positive feedback through words of encouragement and musical awards.

Workout 1 1. Cat/Cow Pose 2. Child's Pose 3. Downward Dog Pose 4. Downward Dog Flow 5. Standing Forward Fold 6. Standing Forward Flow 7. Mountain Pose	**Workout 2** 1. Lower Back Release 2. Thread the Needle Pose 3. Bridge Pose 4. Bridge Flow 5. Happy Baby 6. Bound Angle Pose 7. Reclined Twist 8. Corpse Pose
Workout 3 1. Mountain Pose 2. Warrior I Pose 3. Warrior II Pose 4. Reverse Warrior Pose 5. Tree Pose 6. Chair Pose 7. Standing Forward Fold 8. Downward Dog Pose 9. Plank Pose 10. Cobra Pose 11. Reclined Twist 12. Corpse Pose	**Workout 4** 1. Cat/Cow Pose 2. Child's Pose 3. Downward Dog Pose 4. Downward Dog Flow 5. Plank Pose 6. Chair Pose 7. Standing Forward Fold 8. Tree Pose 9. Warrior I Pose 10. Warrior II Pose 11. Reverse Warrior Pose 12. Bridge Pose 13. Happy Baby 14. Bound Angle Pose 15. Reclined Twist 16. Corpse Pose

Table 1. Pose sequence of the four different workouts.

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Accessible Exercise Technologies

The space of accessible games or exergames is still a young field in both research and practice. There are three possible phases during gameplay in which a disability be negative: 1) receiving stimuli, 2) determining a response, and 3) providing input to the game [2725]. For people with visual impairments, the problem occurs with ~~phase 1~~the first phase~~, because~~ since most stimuli in video games are visual [1715]. Blind Hero is one accessible game ~~which~~ that uses a glove to transmit haptic feedback to a player [2826]. While there are efforts in research on video game accessibility, this problem is not solved when generalizing to mainstream video games [2220].

Exergames for the Blind

The accessibility community has recognized accessible exergaming for the visually impaired as a research problem [1614]. Two strong efforts from the research community are the creation of accessible alternatives to Wii Sports games, VI-Bowling [1816] and VI-Tennis [1715]. Morelli et al. completed a careful analysis of primary (or necessary) visual cues used in Wii Sports Bowling and Tennis, and converted them to audio feedback from the speakers or tactile feedback from the Wii Remote. VI-Tennis was evaluated with children. The researchers measured the difference in energy expenditure, scores, and enjoyment from the original Wii Sports game. They found that people scored better and enjoyed the game more with the accessible version and produced health benefits due to physical activity. VI-Bowling, evaluated with adults, was found to be enjoyable and a sufficient challenge. Morelli et al. developed a solution using sensory substitution to make Kinect games accessible to for eyes-free interactions [2018].

Instead of adapting a current exergame, there has been work in developing original exergames, including Pet-N-Punch [1917]. This game, which uses the Wii remote and nunchuck, encourages exercise in the upper body with auditory and tactile feedback to engage the player. The player has to hit rodents and pet cats at a farm. The researchers measured energy expenditure and scores. The participants were able to achieve light to moderate exercise. In addition, they found participants comparing scores to one another after the completion of the study.

Eyes-Free Yoga is also an original game~~s~~, as opposed to a game modification. In contrast, while energy expenditure is useful for assessing the effectiveness, our measure of success is minutes of exercise per day, self-efficacy, mindfulness, and physical activity enjoyment. Finally, to the author's knowledge, this is the first deployment study of an accessible exergame for the blind.

EYES-FREE YOGA DESIGN

We designed Eyes-Free Yoga as ~~a~~is ~~a~~ yoga exergame accessible to people who are blind or low-vision by providing auditory-only instructions and feedback. Eyes-Free Yoga uses the Kinect platform to guide players through different yoga poses, and provides feedback on how to correct their position if they are in a standing posture. We created an engaging experience with yoga music, and confirmation tones as a player would fix their yoga pose. These characteristics of our program are strategies for systems that direct human action [10]. We determined and followed six principles in designing Eyes-Free Yoga: accessible, yogic, encourages confidence, targeted to novices, accessibility features do not compromise learning, and encourages a challenging workout. The full details of the initial implementation are described in [2321]. ~~The remainder of this section will focus on what is new about this technology.~~We have since expanded on this design significantly to make it into a fully functional game and workout system that can be deployed long term outside of a lab setting and without assistance from researchers. The remainder of this section describes the newest version with the additional features.

Eyes-Free Yoga

~~Eyes-Free Yoga is a yoga workout system that~~ contains four workouts (in approximate minutes): 26, 40, 67, and 80. These are labeled Workouts 1-4 respectively throughout this paper. The four sequences (see Table 1), in addition to the verbal scripts, were developed with one yoga instructor. All of the standing postures have custom feedback as described in [2321].

Eyes-Free Yoga Hardware and Software

TODO: Add photo figure of the system.

Eyes-Free Yoga consists of a suite of hardware: 1) Windows laptop, 2) Microsoft Kinect for Windows, 3) External speakers. In addition to default programs, the Windows laptops had Windows 8.1, Kinect for Windows Toolkit, Python, NonVisual Desktop Access (NVDA), ~~Chrome Remote Desktop,~~ and Eyes-Free Yoga installed. We saved ~~Five~~ five Rich Text Format (rtf) files ~~were saved~~ to the Desktop containing directions for Workouts 1-4, and basic computer instructions (including keyboard shortcuts) to use NVDA and Eyes-Free Yoga. Eyes-Free Yoga ~~was also saved as~~also appeared as a shortcut ~~to the Desktop~~on the desktop so users could quickly access the program and ~~.~~

~~Various settings were changed about the laptop computers to make use of the system as seamless as possible: 1) The~~we configured the laptops ~~laptops were configured so upon~~to automatically login and start the screen reader booting or restarting~~,~~ so blind ~~participants~~ users ~~were~~ are able to work without assistance. ~~the computer without login credentials and with a screen reader.~~

~~Participants interacted~~Users interact with the system using NVDA screen reader. To simplify use, they only had to navigate the d~~D~~esktop~~,~~ and within RTF files if they were open.

To ensure that Eyes-Free Yoga was running reliably, and data collection was robust, we wrote a python script which sent an email containing Eyes-Free Yoga usage logs to the

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first author. The script ran daily using Window's Task Scheduler. In the event a problem arose with Eyes-Free Yoga, the first author had access to the laptops via Chrome Remote Desktop. Finally, after each workout completion, Eyes-Free Yoga sent an email to the participant to fill out a survey about their experience.

EYES-FREE MOTIVATIONAL TECHNIQUES

In addition to providing an accessible alternative to yoga that is suitable for the home, we were interested in having users begin to practice yoga~~,~~ and sustain their practice over a longer period of time. This corresponds to Fogg's Behavior Grid~~,~~ as a "Green Path" behavior [26~~24~~]. This path suggests to: 1) couple the trigger with an existing habit, 2) increase one's self-efficacy by making the behavior easier to do, and 3) reduce demotivation by making the behavior more familiar. To fulfill the Green Path, we developed auditory reminders (fulfills #1) and musical levels and badges (fulfills #2 and #3) that were specifically designed to be suitable for people who were blind or low vision:

1. Musical reminders: ~~—~~Ten minutes before a person pref~~er~~s~~red~~ to exercise, the first background music track ~~was~~ is played on the~~ir person's~~ computer as a reminder to exercise. ~~The time was selected by asking people~~The system asks the user to ~~when~~ choose a time they would prefer to exercise, similar to creating a habit as in [25~~23~~].
2. Musical levels: ~~—~~As a person ~~advanced~~ advances to the next level, they hear~~d~~ water sounds with increasing power in addition to the background music. This conveys a sense of progress. Table 2 shows ~~The~~ the level progression and corresponding music ~~is shown in Table 2~~.
3. Musical achievements: ~~—~~We developed three different types of musical achievements, or badges, that one could receive while exercising:
   a. Performance Badge: ~~—A~~A person ~~needed~~ needs to address all custom feedback for at least 50% of the standing postures and complete the full workout. If the workout had no standing postures, ~~then~~ they still needed to complete the workout.
   b. Endurance Badge: ~~—~~For each workout, the person need~~s~~ed to exercise for a minimum required amount of time[1].
   c. Consistency Badge: A ~~—A~~ person need~~s~~ed to earn three endurance badges within one calendar week.

   These three badges all ha~~v~~ed a distinct musical sound. ~~In addition, p~~Players can~~ould~~ visit their badges by visiting the "Trophy Case." The trophy case ~~would~~ announce~~s~~ the number of badges earned~~,~~ and play~~s~~ the respective sounds. ~~In order t~~To keep people motivated and knowledgeable during the workout, the system ~~would~~ announces when they had ~~under~~less than five minutes to receive an endurance or consistency badge.

[1] Workout 1: 20 minutes, Workout 2: 30 minutes, Workout 3: 45 minutes, Workout 4: 60 minutes.

Technical Development

We developed ~~The~~ the musical levels and achievements ~~were developed~~ in conjunction with Eyes-Free Yoga in Microsoft Visual Studio with C#. They were implemented behind a flag, so ~~a participant~~users would only hear them if ~~the they were using the system with~~ motivational techniques option was enabled. We implemented ~~The~~ musical reminders ~~were implemented~~ with Microsoft's Task Scheduler~~,~~ by running Windows Media Player with background music at specified dates and times.

EYES-FREE YOGA DEPLOYMENT STUDY DESIGN

We conducted an 8-week deployment study of ~~We deployed~~ Eyes-Free Yoga in the homes of four~~six~~ people with visual impairments~~, two of which we had to withdraw because they had to drop out of the study after 1-2 weeks of participation and had never experienced the motivational techniques.~~. ~~From this point~~In this section, we ~~will~~ discuss the study procedure and ~~the four~~ participants.

Procedure

We designed the deployment study to be 8 weeks in duration where participants used it under two conditions:

1. *Baseline* – Participants used the system as described in "Eyes-Free Yoga Design."
2. *Treatment* – Participants used the *Baseline* system and also had the ~~, in addition to the~~ motivational techniques described in "Eyes-Free Motivational Techniques~~.~~" enabled.

We conducted a sequential single case experimental study, using randomization tests [11]. We chose this study design because it provides internal validity even for a small number of participants [6], and it is an agile methodology that has been recommended to evaluate technologies for behavior change [11,24~~22~~]. ~~In order t~~To provide sufficient statistical power, we conducted an ABAB study design, where A is *Baseline*, and B is *Treatment*. Each A and B phase had a minimum phase length of 7 days, but consistent with requirements of randomization tests, the phase lengths were determined at random prior to the beginning of each single case experiment [11]. The total number of measurements for each single case experiment was 56, which allowed a total of 4495 random arrangements and hence a minimum p value of 2.22 × 10e-4. ~~We will~~ now discuss the study procedure in chronological order.

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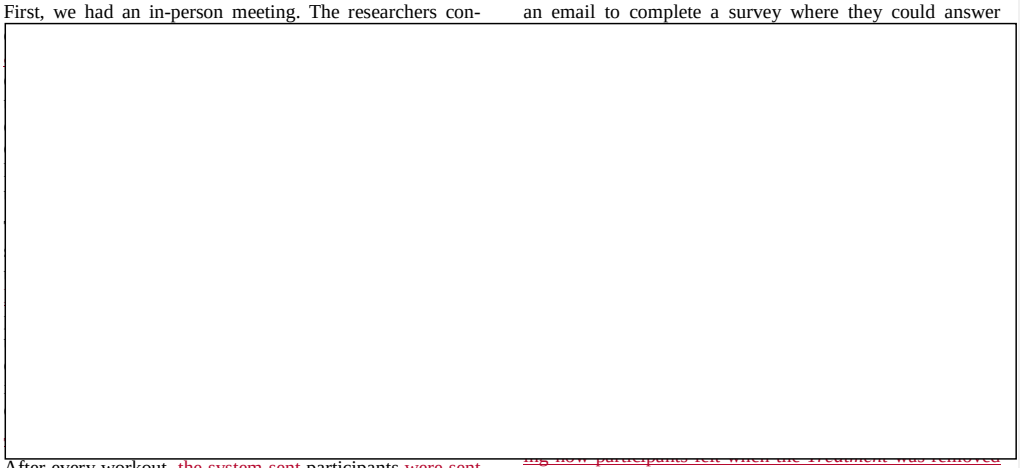
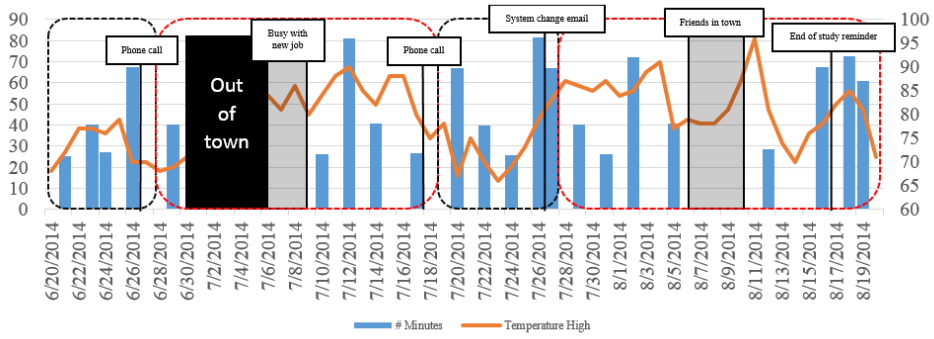
First, we had an in-person meeting. The researchers con-



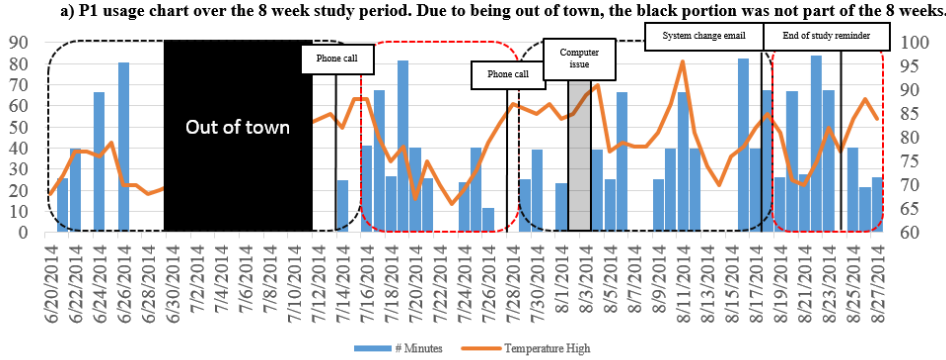
After every workout, the system sent participants ~~were sent~~ an email to complete a survey where they could answer ~~ing how participants felt when the treatment was removed~~ and added back in again.

Level #	# Minutes spent in level	Background Water
1	30	None
2	45	Water drops
3	67.5	Creek
4	101.25	Stream
5	151.875	Lake
6	227.8125	Rapids
7	341.71875	Sea
8	Until end of study	Ocean

Table 2. Level progression of Eyes-Free Yoga.



a) P1 usage chart over the 8 week study period. Due to being out of town, the black portion was not part of the 8 weeks.



b) P2 usage chart over the 8 week study period. Due to being out of town, the black portion was not part of the 8 weeks.

Figure 1. Usage of P1 and P2 over the 8--week deployment.

~~The participants then completed another phase A and B before completing the study.~~

~~At the end of the study, we picked up the equipment, and conducted another interview. We included questions asked in both phone interviews, in addition to asking how participants felt when the *Treatment* was removed, and added back in again.~~

Participants

We initially recruited 6 participants for our study, two of which we had to withdraw because they had to drop out of the study after 1-2 weeks of participation and had never experienced the motivational techniques. This left us with ~~We recruited~~ four total participants who were able to complete the Eyes-Free Yoga deployment study. There were 3 females and 1 male, 2 were totally blind since birth, 1 can see some light and bright colors up close, and 1 is blind in one eye and low-vision in the other. Their average age was 43.5 with a range between 29 and 54 years. Their professions consisted of postdoctoral fellow, unemployed, collections representative, and retired. The participants varied in yoga experience, from no experience, one class, a few classes, and several classes in the past. Three participants had never tried exergames, and one had tried Wii Sports in the past.

We recruited participants through email lists for people who are blind or low vision. The study was conducted at each person's residence. ~~The participants spent~~Study sessions were 1-2 hours for the initial visit, 15-30 minutes per phone call, and 30 minutes to 1 hour for the final visit. We com-

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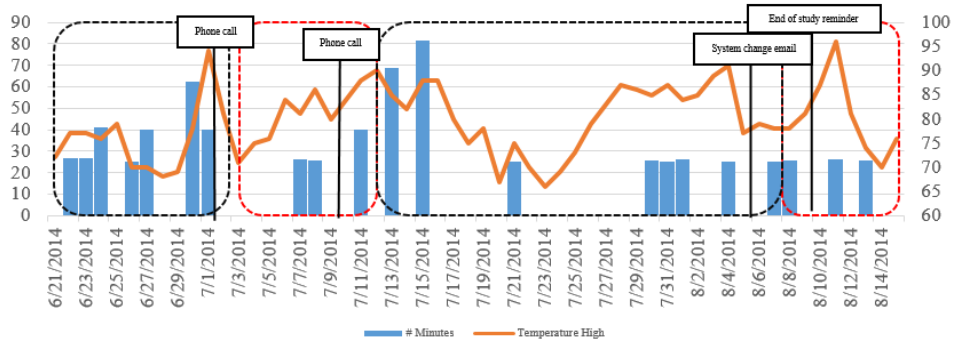
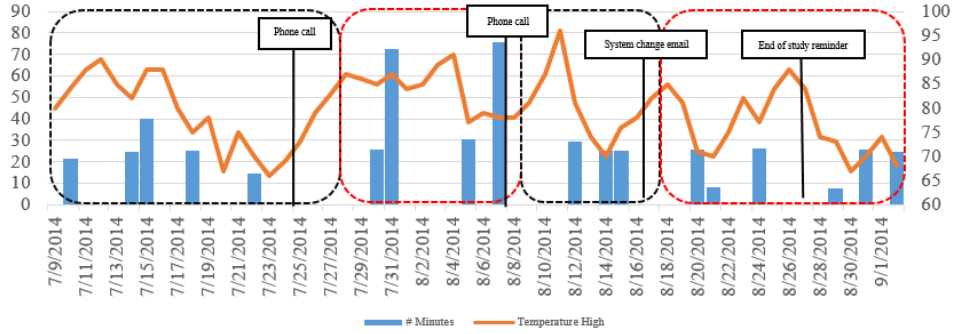


c) P3 usage chart over the 8 week study period.



d) P4 usage chart over the 8 week study period.

Figure 2. Usage of P3 and P4 over the 8 week deployment.

RESULTS

~~**To be filled in by 9/4 at the latest**~~**Quantitative results**

The four participants practiced yoga between the *Baseline* and *Treatment* conditions consistently throughout the study. More specifically, the Standardized Mean Difference (SMD) and p value was not significant (P1: SMD = 0.3248, p = 0.1737; P2: SMD = 0.4949, p = 0.1617; ~~-0.3041~~ P3: SMD = -0.3041, p = 0.236; P4: SMD = 0.3745, p = 0.3019). While the motivational techniques did not increase the number of minutes exercised per day, the participants used the system over the 8 week study period. Figure 1 and Figure 2 show the usage pattern for each participant, with possible external factors that may have affected usage.

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Qualitative results

Benefits of Eyes-Free Motivational Techniques

While the motivational techniques did not change the behavior of the participant's exercise habits, they enhanced the experience of Eyes-Free Yoga.

The auditory badges were by far the most noticed and well received feature from the point in which they were introduced: ~~*I noticed the earning badges is something new so that's really cool*~~ (P3). In particular, people enjoyed the anticipation of getting the badges during the workouts: *I'm curious when I'm going to get the next badge* (P2). Providing more information about when a participant would receive a badge provided enjoyment during the game: *I liked hearing that I was about to get an endurance badge* (P1), and *That was cool. I liked that. It tells you "you have five minutes before you earn a certain badge" so that was cool* (P3).

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The musical levels were added as extra background noise, and were not as noticeable by the majority of participants. P3, however, favored the levels during gameplay: *I noticed another sound was added to the music. So I thought it was a good addition.* As P3 progressed through the levels, they continued to report positive feedback about the background water: *I thought that was cool, it sounded like a mini lake or something. I like that. I thought it was a good addition.* Finally, P3 was interested in integrating different sounds into the game: *Possibly drums, Native American type of music, or they could choose the type of music.* Overall, this feature may be of benefit to players, and so it should be an option for gameplay.

The auditory reminders did not serve their intended purpose, but a couple of participants found this feature helpful. For instance: *Establishing certain times of day was more helpful* (P1). P3 would have the computer quiet until playing, and so the musical reminder *creates the mood for playing*. Overall, participants found that they did not need the musical reminders, because they *either made the decision that I'd done the routine for the day or I wouldn't for the day* (P2).

Overall, the motivational techniques enhanced the gameplay experience. When participants were asked how they felt when these features were removed, they took notice: *It was a little disappointing to not have the musical achievements* (P1), *I definitely noticed that they were gone. Once you get used to them being there they're part of your internal clock* (P2), and *Kind of bland. It was just more mechanical. Once they were added it added so much more to it and it seemed empty* (P3).

As the motivational techniques were added back to the system, P2 emphasized their impact: *They made the whole experience better. It just reminded me that I was in the process of the whole game, it also kind of reminded me to trigger in my head of what to do tomorrow and what I did today. It did serve a good purpose.* P3 added: *It was just a better experience.*

Increase in exercise

Two of the four participants used Eyes-Free Yoga as a stepping stone to exercise on a regular basis (P1, P4). Participants were asked before and during the study about their current exercise level using the exercise stages of change [15]. Two participants had been exercising regular for more than 6 months (maintenance phase), while one participant had intentions within the next 6 months (contemplation phase), and within the next 30 days (preparation phase). By the end of the study, the latter two participants had been maintaining a regular exercise regimen, and were in the action phase. P1 had moved from the preparation phase to the action phase, and said this at the end of the study: *I feel like I've gotten stronger.*

Yoga comprehension and enjoyment

Because the participants had the ability to use Eyes-Free Yoga over the 8 week study period, they were able to gain a better understanding of and appreciated for yoga. Yoga can provide a balance between relaxation and physical challenge. For instance: *I like the meditation times and quiet my brain and concentrate on breathing* (P2), while on the other hand: *Its good practice for balancing and a form of exercise and it's good that it's challenging* (P4). P1 expressed that they learned more about yoga as the study progressed: *By the last times I was getting better because I was getting different feedback. I felt like I must've learned something.* P3 found a benefit from using Eyes-Free Yoga throughout the study: *Now the more I do it, it's more natural. I would say more at ease, or more relaxed.*

Why were they motivated?

We found that despite the motivational techniques, participants chose to use the system. There were several reasons for using Eyes-Free Yoga, including enjoying the four different routines: *I've been able to learn the routine and anticipate what's coming next and refine the poses a little bit so that's been positive* (P1). P2 also favored the use of routines: *Well I really enjoyed it. I enjoyed the fact that there were four different routines. Some at night when I wanted to relax or stretch and the other ones for more of a strenuous workout. I incorporated into my other workouts.*

Another reason for adhering to the system was the accessible feedback: *I like the feedback. I think it's really, I've never, and it's definitely something that I can participate in and use easily and feel like I can learn it and it's easy to comprehend* (P3), and *It does have good instruction about the poses. As a blind person it was very accessible in that way* (P4).

Factors that affect study data

While participants were enthusiastic to use the system, there were also factors that made using the system a challenge. For example, P1 started a new job and had to figure out their new schedule: *A little harder for me to stay motivated because I'm working full time. I have to really convince myself to do it.* Another reason was a warmer summer (see Figure 1 and Figure 2 to see the temperature highs during the deployment): *I feel fatigued so I try not to play when it's really hot* (P1), and: *It was also pretty hot* (P4).

Another factor pertained to the conundrum of yoga also being a game, as identified by P1 and P2. Despite this, they enjoyed the experience: *I don't usually think of yoga as being a video game. A different way of thinking about it, but I realized it can be kind of fun* (P1), and: *Don't get caught up, doing it just to acquire virtual accomplishment. Nonetheless, I liked when I got the accomplishments* (P1). In addition, P1 had one experience where they felt they did not deserve a badge: *Not sure I deserved a Performance badge today; I was shaking, wobbling, and grimacing all over the place.*

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Commented [RV21]: Ha! That's interesting. That's a typical yoga/spiritual stance, reinforcements are bad, contrived, we should do things because there's an internal voice or will that drives it, but not because something external triggers it… but everybody likes reinforcement no matter what mental rules you impose on yourself!
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Eyes-Free Yoga as a motivator for the blind

Eyes-Free Yoga as a system may have provided motivation due to the benefits particular to people who are blind or low-vision. P2 found that Eyes-Free Yoga provided a safe environment to learn yoga:

It's interesting and a good way for someone to demystify it in privacy with as little or as much as they want. Especially for someone like me that's blind. When you're in a room with other people you wonder if you're the short thumb, so there's a little sense of being awkward especially when you're doing something like this.

Another benefit to Eyes-Free Yoga are the detailed descriptions that are accessible to blind players:

I've always wondered what yoga was like and how to do the actual positions but I just never had the opportunity to me or learn the movements or have them described so if someone was interested in doing yoga on their own, I would recommend it.

While Eyes-Free Yoga may motivate more in home exercise for the blind, this may not translate to yoga classes. For instance, P1 felt that Eyes-Free Yoga made exercise more convenient: *I don't have that much free time. I haven't a found a place to go yet to exercise since we moved here.* P2 also expressed similar concern: *I feel like I know more of the poses, and that's less intimidating. But how willing am I to get to a place? The game is not solving other issues.* P4 mentioned money as a factor to use Eyes-Free Yoga over a yoga class: *For me the taking public classes are usually about having the money.* While attending yoga classes can be beneficial, we found that developing a system for in home exercise can be a viable solution, similar to developing exergames for older adults [14].

The participants of this study have expressed interest in using the system again: *It is definitely something I would want to invest in when it became available* (P1), *I made it a part of my day to day routine* (P2), and *If I had the opportunity again I would probably try it* (P4). One participant plans to purchase a yoga cd set, P4 has added new exercises: *The system got me to stretch more, and squats.*

~~**External factors affecting data collection**~~

~~TODO: Add 2 column figure of dates, whether used or not, starting new job, friends visiting, heat wave, travel, and any other factors volunteered via email, interviews, or survey responses.~~

DISCUSSION

To be filled in by 9/11 at the latest

Talk about opt-in features, discuss why people actually used the system

CONCLUSION

To be filled in by 9/18 at the latest

ACKNOWLEDGMENTS

To be filled in by 9/18 at the latest

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Commented [RV22]: That could be a third variable that both affected the A and B phases. Both phases were practiced in private and if practicing in private was a powerful contingency in and of itself, then the effect of B over A could have been mitigated. That's worth discussing.

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Commented [RV23]: My comment above applies here as well. Being instructed in both conditions (with our without motivational contingencies) could have been a factor affecting both conditions.

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