

# Eyes-Free Exercise with Auditory and Tactile Feedback

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## ABSTRACT

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Video games; exergames; eyes-free; audio feedback; tactile feedback; exercise.

## ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces.

## INTRODUCTION

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## RELATED WORK

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## STUDY DESIGN

Participants completed three exercises: 4 x 10 jumping jacks, 4 x 10 bicep curls with 11b weights in front of a Microsoft Kinect. The program, implemented in C#, recorded the highest and lowest point of their wrist, and corresponding timestamp for each jumping jack and bicep curl. The feedback received for each exercise is described below:

Jumping Jacks. Feedback is given once per second, with the intention to pace the exercise at one jumping jack per second.

1. *Voice* – Participants heard “start”, followed by “one” through “ten”.
2. *Pitch* – Participants heard piano notes in sequence: A, B, middle C, D, E, F, G, A, B, high C. Pitch A cued the participants to begin.
3. *Volume* – Participants heard middle C played progressively louder in volume. The first note cued the participant to begin.
4. *Tactile* – Participants wore an arm strap with a Samsung Galaxy S4. The phone would vibrate 500ms on,

500ms off eleven times. The first vibration cued the participant to begin.

Bicep Curls. Feedback is given once per second, to cue the raising and lowering of the arms. The goal was to complete one full bicep curl every 2 seconds.

1. *Voice* – Participants heard “up” ... “one” ... “up” ... “two”, through “up” ... “ten”.
2. *Pitch* – Participants heard piano notes in sequence: E, F, G, A, B, low C, D, E, F, G, A, B, middle C, D, E, F, G, A, B, high C.
3. *Volume* – Participants heard middle C played progressively louder in volume. The note repeated 20 times. The first note cued the participant to begin.
4. *Tactile* – Participants wore an armband with a Samsung Galaxy S4, and felt vibrations 1 second on to cue raising the arms, followed by 1 second off to cue lowering the arms. This repeated 10 times.

## Study procedure

Participants were asked interview questions about their background with exercise and exergames, in addition what they notice with their sight, hearing, or touch during these activities. Participants completed 4 x 10 jumping jacks and 4 x 10 bicep curls with 11b weights. After each exercise, participants gave their preference of feedback, and their thoughts about not receiving visual feedback during the exercise. The session lasted one hour in total, and they were compensated with a \$10 Amazon gift card.

The order of feedback was randomized for each participant

p1 p9	p5 p13	<i>Voice</i>	<i>Pitch</i>	<i>Volume</i>	<i>Tactile</i>
p2 p10	p6 p14	<i>Pitch</i>	<i>Volume</i>	<i>Tactile</i>	<i>Voice</i>
p3 p11	p7 p15	<i>Volume</i>	<i>Tactile</i>	<i>Voice</i>	<i>Pitch</i>
p4 p12	p8 p16	<i>Tactile</i>	<i>Voice</i>	<i>Pitch</i>	<i>Volume</i>

Table 1. Order of feedback presented for jumping jacks and bicep curls.

using a 4x4 Latin Square. For each participant, the order of feedback given for jumping jacks and bicep curls was consistent. See Table 1 for the order of feedback given.

### Participants

We recruited 16 participants who were able to complete the lab study. There were 7 females and 9 males. Their average age was 25.5 with a range between 22 and 32 years (median = 28). All but one of the participants had current exercise experience including weight lifting at the gym (8), biking (6), running (6), swimming (3), rock climbing (3), kayak (2), squash, yoga, ultimate frisbee, soccer, treadmill, elliptical, boarding, spinning, TRX training, and roller derby. The majority of participants (11) had experience playing exergames including Wii Sports (6), Kinect dancing games (3), Dance Dance Revolution (3), Kinect Adventures! (3), Kinect yoga game, Wii volleyball game, and Wii zumba game. Five participants had no experience because they did not like video games (2), were too busy, would rather be active outside, or no reason.

### RESULTS

Below we present the results for participants' ability to pace, and their preference of feedback for jumping jacks and bicep curls.

#### Jumping Jacks – Pacing at 1 per second

All 16 participants were able to pace themselves while completing jumping jacks during the *Voice*, *Pitch*, and *Volume* conditions. When taking an average of the median jumping jack interval time for each participant, the times were reported as .953 seconds, .967 seconds, and .964 seconds respectively. Pairwise comparison using the Wilcoxon Rank Sum report differences that are not statistically significant, meaning these three techniques were effective at pacing the participants (see Table 2).

The feedback type that was least effective was *Tactile*, with 3 of the 16 participants only completing 6 of the 10 jumping jacks in the 10 second timeframe. These participants were unable to feel the vibrations while moving: *I couldn't really feel this and it might be because I was moving* (p11), and: *The vibration was kind of hard to feel, I thought I only felt 6* (p16). These participants would therefore wait be-

<i>Voice vs. Pitch</i>	W = 104, p = 0.38
<i>Voice vs. Volume</i>	W = 102, p = 0.33
<i>Voice vs. Tactile</i>	<b>W = 72.5, p = 0.04</b>
<i>Pitch vs. Volume</i>	W = 125.5, p = 0.94
<i>Pitch vs. Tactile</i>	W = 86, p = 0.12
<i>Volume vs. Tactile</i>	W = 85.5, p = 0.11

**Table 2. Pairwise comparisons of median jumping jack revolution time using Wilcoxon Rank Sum.**

Feedback Type	Average Rank	Borda Count
<i>Voice</i>	1.5625	55
<i>Pitch</i>	1.9375	46
<i>Volume</i>	2.375	42
<i>Tactile</i>	2.9375	33

**Table 3. The average rank and Borda Count for each type of feedback during jumping jacks. Note that the participants could call ties.**

tween jumping jacks to feel a vibration before continuing to the next one. The average of median times for each participant was 1.17 seconds, and there was a difference between *Voice* that was statistically significant (see Table 2). The average median time for participants able to feel the vibrations was 0.98 seconds, while the three participants had an average median of 2.00 seconds.

#### Jumping Jacks – Preferred Feedback

Participants sentiments toward each type of feedback had variety, but there was still a clear ranking of preference using average ranking and Borda Count: 1<sup>st</sup> – *Voice*, 2<sup>nd</sup> – *Pitch*, 3<sup>rd</sup> – *Volume*, and 4<sup>th</sup> – *Tactile* (see Table 3). To avoid biasing a participant's preference, the researcher explained the four types of feedback in the same order in which the participant experienced them.

*Voice* feedback ranked the highest among participants because it felt natural: *I am used to that. It is how I would normally do it, and so I kind of expected - I know how long it would be between them* (p2), and: *It automatically tracks that [counting] for you and reminds me of when I was doing martial arts so it has that element* (p3). In addition, *Voice* provided an extra piece of information the others could not provide – counting: *It was easy. It counts and you can just follow along without any problems* (p13), and: *It just made me feel easier to keep track of* (p15).

*Pitch* feedback had more mixed results. Participants favored *Pitch* because it pertained to music: *I'm a musician; it's meaningful* (p1), and: *In general I like the idea of communicating in pitch* (p6). *Pitch*, with its increasing notes, was able to convey a sense or progress: *They changed the note it was higher so I know it was going to the end* (p13). On the other hand, participants were not always keen on the increasing notes: *The notes were super annoying because it's getting higher and higher and higher* (p12). In addition, *Pitch* sometimes did not communicate enough information: *I didn't have a sense of how far along I was at each point in time* (p3), and sometimes communicated extraneous information: *When they [notes] went up I don't know why I guess maybe are you supposed to be increasing intensity?* (p9).

*Volume* also had a mix of positive and negative sentiment. The change in *Volume* was not immediately perceivable by participants: *I couldn't tell the difference in volume for the*

first several (p4), so this may have affected their sentiment. Participants favorite this technique due to its consistency: *I think what worked best was increasing in volume note because it was very regular* (p7), and: *I felt like it was more of a constant beat* (p10). However, *Volume* was not always viewed as useful: *It doesn't sound like a useful thing, it's the same note over and over* (p6), possibly because it doesn't convey a sense or progress: *I would hear a note and I wouldn't be counting in my head already* (p16).

Finally, *Tactile* was ranked as the least useful of the four techniques. Participants had a difficult time keeping the pace as they were moving: *I liked the vibration the least because it was actually pretty hard to detect when I was moving* (p2), and: *I don't think it was a strong enough feeling so for that reason I didn't like it too much* (p3). Interestingly enough, three participants ranked *Tactile* as their first choice, notably because they felt it was tied to their body: *It was tied to my body, I could feel it* (p5), and: *Tactile feedback was directly tied to the activity I was doing, so as I was moving my arm I could feel the vibration so I knew whether I was on track* (p14). Finally, p4 liked the fact that *Tactile* was more discrete: *It was the least distracting*.

#### **Bicep Curls – Pacing at 1 per 2 seconds**

This will follow the same recipe as jumping jacks

#### **Bicep Curls – Preferred Feedback**

This will follow the same recipe as jumping jacks

#### **DISCUSSION**

Below we discuss takeaways derived from the participants' ability to pace, and learning their preferences.

##### ***Tactile* Feedback not as effective while moving quickly**

While a majority of participants were able to follow the *Tactile* feedback while performing jumping jacks, three experienced difficulty, only completing 6 or the 10 in the same time. In addition, two of the participants mentioned mechanisms that enabled them to pace differently than intended: *I didn't feel anything afterwards so I was doing random things at whatever pace* (p10), and: *The vibration I could barely feel. I initially felt it because I was standing still. I couldn't feel it, but I could hear it. Hearing it was confirmation that I was feeling it* (p9). This suggests that *Tactile* feedback should be used with caution while completing faster paced physical activity. With a slower paced activity, there is potential: *Tactile could be good for exercises where you are holding something stationary* (p6).

#### **Information is Key**

The more relevant information encoded in the feedback type, the better. Participants provided positive and negative sentiments for feedback based on the amount of information it provided. During jumping jacks, *Voice* was preferred due to the extra information it provided with the count. Regardless of the feedback presented for exercises with pace, providing progress will improve the experience. Designers may be able to utilize musical feedback, by providing the finish tone initially or providing chords. *Tactile* feedback could change in intensity or rhythm to convey progress. In addition, conveying multiple types of feedback simultaneously is beneficial, as people perceive the feedback faster [cite paper].

#### **CONCLUSION**

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