Deep Pressure Proprioceptive Feedback

Pre-Experiment Setup

1. Make sure forms are printed out.
2. Prepare white noise soundtrack Have headphones and headphone covers available.
3. **Sanitize:** Wipe down wearable device with 70%EtOH. Wipe upper armband, rigid portions of the actuator device, and sanitize the sleeve with UV wand. Wipe down keyboard and mouse. Change headphone covers.
4. Plug in monitor and make sure on.
5. Open Teenyduino and the firmwarePIEZO2LOF.ino on laptop.
6. Open iTerm on laptop. Cd to PIEZO2 directory
7. Turn on power supply and make sure set to 12 V.
8. Plug USB and power cable to device. Make sure the flex sensor and actuator cables are plugged in to the electronics.
9. In Teensyduino, reset/upload and open serial monitor to begin serial output and then close the window.
10. Thank the subject for their participation and tell them water to drink now or between breaks and hand sanitizer is available.

Thank you for participating in this experiment. Can I offer you any water to drink now or between the breaks?

11. Position device such that electronics box has usb/power to the left, actuator connections to the bottom, curved surface up.
12. Position actuator housing with sensor enclosure extension pointing down and actuator away from the subject, so the tactor can extend fully and retract with no interference.
13. In iTerm: python calibration.py. Input subject number
14. Turn on electronics 12V power switch on. When power switch is on, actuator should move and start at same level as soft device interface. Press button to go to actuator calibration stage.

Before we begin, I'll calibrate the device and we'll go over some forms.

15. Press button and actuator should start sweeping
16. Have the subject sign a consent form:

To participate in this experiment, I need your written consent. The first form is a consent form detailing <XYZ>. Please review and sign at the marked sections if you agree.

Note that there is a section in the form about video. You will not be recorded; there is no video for this experiment. This is a standard consent format used for these types of experiments. The experiment will take approximately 1 hour. Remember, you can choose to drop out at any time. To be compensated you will need to complete the study.

17. Provide Pre-Experiment Survey in Subject Record Document and ask the subject to fill out the 1st page only.

Please fill out the 1st page of this document.

18. In the Subject Record Document, write down the subject number and which protocol file number is being used.
19. Explain general setup:

Today, you and I will be working together to study proprioception. Proprioception is our awareness of the position and movement of our own body. For example, while I'm talking to you, I'm aware where my arms are – if it's in front of me, to my sides, even if my eyes are closed, I can feel if arms are above my head.

However, proprioception, this awareness of our body, isn't perfect. Let's do a quick activity to illustrate that.

First, please raise your arms above your head. Then bend your wrist and fingers so your fingers are horizontal, parallel to the ground. And then, bring your hands together so your fingertips touch at exactly the same height. It's not quite easy! One hand may be higher or lower than the other hand and your hands may slip past each other. Evidently, proprioception - our awareness of where our bodies are – isn't perfectly precise.

Today we'll be working together to study proprioception and evaluate the effect of deep pressure proprioceptive feedback.

I am going to explain the experiment setup. On the screen to your right, there will be two blue lines adjoined by a blue dot. This represents an elbow angle, where the blue segment to right of the dot represents the upper arm and remains horizontal. And the blue segment to the left of the dot represents the forearm, and its angle will change.

You will rest your right upper arm on this surface and curtain will prevent you from seeing your arm. Your goal is to move your elbow and match your arm to the angle you see on the screen.

During this experiment, you will be wearing this device on your right arm. And as you move your elbow, you will receive different types of pre-programmed pressure feedback, or possibly no feedback at all, on your arm. You'll also be wearing an elbow sleeve so we can measure your actual elbow angle.

I am going to set you up to run the experiment by putting on the arm-worn device and then running some calibrations. Are you ready? Is it ok if I touch the device and your arm to position it properly? As I touch the device and your arm, I will say exactly what I'm doing while I'm doing it so you know what is going on.

20. Attach the arm-worn device to Subject's listed dominant hand:
   - Adjust subject's seat so their arm is level with rest surface.

First, let's adjust your seat so your upper arm is level with the surface. On the right hand side of the chair and in front of a round knob, you'll see a pink piece. Press up on the pink piece to move the chair's height. Remain seated and press the pink piece to reduce the height. And stand up and press the pink piece to increase the height.

Please extend your right arm forward with your palm facing up and see if the rest surface feels comfortable for you.

- Place sleeve on elbow, yellow pieces facing out and gap positioned at the elbow. After they wear the sleeve, ask them to bend their elbow and reposition if need be so gap is at elbow

  Next, please wear this sleeve at your elbow with the yellow plastic pieces facing away from your body.

  I'm going to be twisting the sleeve, sliding the sleeve up or down, etc.

  Could you please bend your elbow for me? Great.

- Place actuator enclosure and electronics on their arm. Enclosure should be on outer, hairy side of arm and electronics on the inner arm side. Make sure sensor enclosure if pointing up towards their hands. When their palm is down and actuator is on hairy side, make sure electronics box has usb/power to the left side (will be flipped to right side when their arm is the right direction). Ask them to face palm up, bend elbow and see how it feels. Ask if it feels stable.

  Next, we'll be attaching this to your arm. Could you please face your palm down towards the table? I'm going to slide this device onto your arm and then tighten it. As I tighten it, could you let me know how it feels – if it's too tight or loose?

  Now could you face your palm up, rest your upper arm on the rest surface, and bend your elbow? How does the device feel? Does it feel stable?

- Insert the flex sensor with yellow wire up? Adjust sleeve and sensor accordingly

  Now I'm placing the a sensor in the sleeve so I'll be touching the sleeve. Could you bend your elbow for me? I'm going to adjust the sleeve and sensor

21. Calibrate the device for the user.
    - Calibrate the angles
      Now we'll calibrate the device to you. First, we want to make sure your elbow angle is measured properly by the sleeve. Please extend your arm, palm facing up. And then slowly bend your elbow and then slowly extend it again. Repeat this a few times. Are you ready?

- Repeat a few times until green line makes sense

  Now we'll see if it calibrated correctly. A green line segment will appear that represents your measured elbow angle in real-time and this green line should match with your actual arm movements. Let's try and if it doesn't look right, we'll calibrate again

- Next, set max pressure

  Next, we're going to set the max amount of pressure that will be applied to your arm. The device will apply some pressure to your arm and progressively increase the pressure. When it starts to feel uncomfortable, let me know. We'll repeat this process a few times

- Have user put on noise cancelling headphones – Play white noise

  Throughout the study, we ask that you wear these headphones. They will play white noise to cancel external noise, but you should still be able to hear me if I talk to you. Please let me know if these get uncomfortable at any time.

- See if max pressure and elbow bending lines up.

  Bend your elbow back and forth. How does the pressure feedback feel? Is it too uncomfortable or painful at any point? We'll adjust accordingly

- Set up curtain

Run Experiment

22. Explain task and learning phase

Your goal is to move your elbow and match your elbow angle to the angle you see on the screen. When you think your arm matches the angle on the screen, click the screen with the mouse to move on and you'll be shown another angle.

We will begin with a learning phase where you can get acclimated to the environment. During this learning phase, a green line segment will appear overlayed on the blue elbow angle that shows you what your elbow angle is now measured by the sleeve. In the learning phase, please pay attention to the pressure feedback you receive on your arm and how that corresponds to where your arm actually is, which is shown with the green arm. Really think about how the feelings on your arm correspond to the green line segment that shows you where your arm is. The learning phase consists of 20 angles and then you'll have an optional 1 minute break.

23. In iTerm: python pilotStudy.py. After learning, pause and ask if they'd like a break
24. Use timer for 1 minute break
25. Explain testing phase

Now we will begin the testing phase with the same activity as before: match your elbow angle with the blue elbow angle on the screen.

During this testing phase, you may (or may not) receive pressure feedback and there may (or may not) be a green line segment showing you where your arm actually is. Please note that in testing phase, we are testing the device and the effect of haptic feedback, not you! So do your best and that will be more than enough. The testing phase consists of 40 angles with an optional break at the halfway point.

Do you have any questions for me? Once you're ready, click on the screen to proceed.

26. Once they click on screen and begin testing phase, every 10 trial angles, click the button and make sure haptic feedback is turning on and off
27. Monitor data on iTerm to make sure nothing is off.
28. After 20 trial angles, ask if they'd like a 1 minute break. Use timer to monitor and then have then click screen to proceed
29. Repeat steps 25 and 26

Post Experiment

30. Ask the Subject to fill out the post-experiment survey (on 2nd page of the doc they were given earlier) and the compensation form

Please fill out the 2nd page of this document and this compensation form for the gift card!

31. Thank the subject for their participation.