Annotations from the literature for the project

How to improve balance using X type of feedback. The articles regarding haptic feedback are related to vibration – sometimes referred to as vibrotactile - (as there are other types of haptic feedback like stretching skin which help, but we don’t have the sensors to attempt this)

Notation:

* H = haptic feedback article
* A = auditory feedback article
* AH = auditory and haptic feedback

Theoretical things that we need to search for:

* Theoretical background of how balance works
* Combination of feedback. I am pretty sure that there was an effect for this in the earlier slides, and it is worth checking
* Where to put the vibration motors (and why). E.g. left and right, around the waist. Also, how to codify the vibration
* Same as before with sound; which type of sound is best and how to (theoretically wise) use it to help users
* Studies with people actually balancing left-right

H1

**Notes:**

Study on participants which suffer from bilateral vestibular loss (hence worse balance)

They use an interesting metric called MBS (mobility balance score). Initially, worse than 4.2/10. After a month of using it, increased to 7.9/10.

They use vibrotactile feedback via the waist

In a pilot study they carry out, they observe that feedback over the waist proved to be superior to feedback to the head.

They say that effects are not durable once the belt is not used (belt is meant to be used all the time in everyday life of participants)

H2 (SUPER RELATED TO OURS, even used similar materials. Very good for understanding IMU)

**Notes:**

Uses 2 vibration motors, one in the frontal part of the body other at the back, around the L5 level. The vibration was synchronized with an accelerometric measurement encoding a combination of position and acceleration of the body of mass in the anterior-posterior direction.

Uses vibration always on an vibration with a dead zone (after effects)

They had to stand still with eyes closed and with different types of feedback

Results: with vibrotactile feedback, sway is reduced proportionally to the frequency in anterior/posterior and medial-lateral directions and there was no difference between dead-zone and always on

They use an IMU, teensy and vibration actuators

The AP acceleration of the CoM modulated the amplitude and frequency of the vibration

“*for choosing this kind of coupled vibration motors was 2-fold: they are inexpensive and the vibration feedback is more effective when frequency and amplitude are coupled*”

A1:

42 persons, 21 with balance problems 21 without. Try different types of audio, mainly:

* Spatial audio
* Static rest frame audio
* Rhythmic audio
* CoP

Main task was to stand straight and look to certain things. Spatial and CoP were the most successful

Spatial: user turns head and noise played at different volumes in each ear to stimulate the real stationary audio source

Static: just white noise played in headphones

Rhythmic: white noise beat at 1 sec intervals

CoP: similar to static, but pitch and stereo pan changed based on the center of pressure path from the balance board

AH1:

Basically, a review of different types of feedback for motor learning (not just balance)

Auditory learning:

* Auditory alarm: sound without any kind of modulation is played as soon as, and as long as, the related movement variable exceeds a predefined threshold
* **Movement variables (could be useful)**: movement variables are represented by sonification; that is, their magnitudes and changes over time are represented by nonspeech audio
* **Movement error (could be useful)**: auditory feedback about the deviation between the actual performance and the target performance—is sonified

A systematic approach is required when designing auditory interfaces/feedback given the multiple parameters (e.g. pitch, amplitude, loudness …). Gives **a starting point to know how to build them. E.g:**

* Key events should be presented by volume changes
* separate continuous data streams should be mapped to different timbres, rather than to different rhythms
* Pitch good for vertical movement
* velocity and acceleration have also been successfully mapped to pitch height

Haptic feedback:

First, it argues that making errors drives motor learning, and we should not prevent users from failing a task.

* Position control
* **Haptic guidance (will be useful)**: guiding human to ideal motion. The control of most haptic guidance feedback strategies is based upon reference trajectories. The few existing studies on complex motor tasks revealed that haptic guidance reduces the perceived workload, improves the current performance, and enhances motor learning
* **Vibrotactile** (ours)displays have mainly been developed to improve navigation and orientation in order to reduce workload of the visual and auditory system (SO, DOES THIS MEAN THAT THEY ARE REDUNDANT?). The signal should be clear but not irritating or harming. And, as has already been discussed for auditory feedback design, the polarity of the signal must be considered

In general, haptic feedback has not been tested to be better or worse than other feedback types

Multimodal feedback:

They address that audiohaptic feedback has not been tested so far, and provide more information about audiovisual and visuohaptic. So, we need to find a bit more about this. Bare in mind we are also using visual feedback, although it is not what interests us to check.