# TouchBand: A Pressure-Sensitive Wristband as Input for Smartwatch Scrolling and Selection

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## Proposed Experimental Design

**PART 1: Research question and hypothesis**

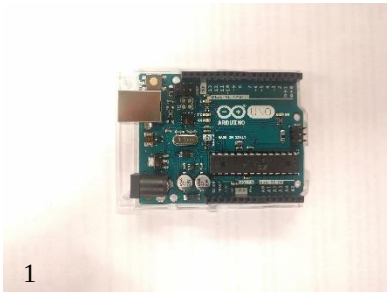
Due to the limited screen size of smartwatches and restricted number of applications offered on smartwatches, there are fewer touchscreen gestures available for smartwatches than for smartphones. For example, pinching and stretching fingers to zoom in and out is difficult on a smartwatch touchscreen. We will focus on developing an alternative input method for the two most common touchscreen gestures on smartwatches: tapping for selection and sliding for scrolling.

Research question: Is using the whole smartwatch wristband as touch input, including the back of the band, more convenient to users and will it make selection and scrolling function faster and more accurate compared to the conventional touchscreen interaction?

We hypothesize that our input method can deliver higher selection accuracy and faster selection (of targets on screen) and scrolling speed (for lists) compared to conventional input method for smartwatches (i.e. display touchscreen) because in our design the finger will be moving along bigger interaction area. Moreover, moving the touch interaction off the screen will allow the user to not block the display screen while interacting with the device.

**PART 2: Apparatus**

For the sensitive wristband we are fabricating, we will use analog capacitive sensors attached to an Arduino on one end and to the wristband on the other. We will use aluminum foil as the capacitor. We will have a smartwatch to test our input method and for the experiment. The Arduino will send the touch signals wirelessly to the smartwatch.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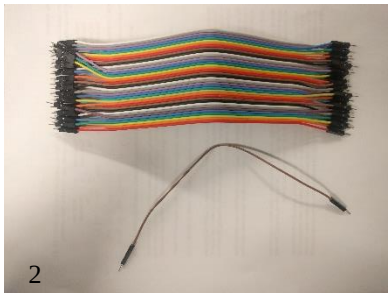
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3


4

5

1: Arduino
2: Wires
3: Aluminum foil
4: Wristband
5: smartwatch

**PART 3: Participants**

We will recruit 12 volunteers as participants. There will be 6 males and 6 females in the age range of 20 to 30. The participants will be a mixture of graduate and undergraduate students. All of them will be our colleagues the Computer Science Department. While all participants will likely be experts in using smartphones and laptops, some will have previous experience with smartwatches while the rest will have not used a smartwatch before.

**PART 4: Experimental design**

We have two *independent variables*:

- Input Method/Tool
- Task

The Input Method/Tool factor has two *levels*:

- Smartwatch display touchscreen
- Smartwatch with touch-sensitive wristband

The Task factor has two *levels*:

- Scrolling
- Selection

We have two *dependent variables*:

- Speed
- Accuracy

In every *trial*, a participant will use one of the devices (touchscreen or wristband) and attempt to finish one of the functions (scrolling or selecting). In each *trial*, we will measure the speed and accuracy of a participant selecting a target on the screen.

Our experiment will have a *within-subjects design*, i.e. all participant will experience all levels in all factors. This design will make the process much more streamlined and less resource heavy, since we have a limited number of participants and we want to collect as much data as we can for all factors and all levels. Moreover, by trying all input methods and tasks, participants can compare the input methods and express their preference which is as important to this experiment as the participants' performance with each input method. Finally, a *within-subjects design* will allow us to reduce the amount of error arising from natural variance between individuals.

Each participant will have to do 4 trials in the following orders to offset order effects (i.e. counterbalancing) if applicable (Table 1).

| Participant number | First trial | Second trial | Third trial | Fourth trial |
|---|---|---|---|---|
| 1-3 | Tool: touchscreen<br>Task: selection | Tool: touchscreen<br>Task: scrolling | Tool: wristband<br>Task: selection | Tool: wristband<br>Task: scrolling |
| 4-6 | Tool: touchscreen<br>Task: scrolling | Tool: touchscreen<br>Task: selection | Tool: wristband<br>Task: scrolling | Tool: wristband<br>Task: selection |
| 7-9 | Tool: wristband<br>Task: selection | Tool: wristband<br>Task: scrolling | Tool: touchscreen<br>Task: selection | Tool: touchscreen<br>Task: scrolling |
| 10-12 | Tool: wristband<br>Task: scrolling | Tool: wristband<br>Task: selection | Tool: touchscreen<br>Task: scrolling | Tool: touchscreen<br>Task: selection |

Table 1: Order of trials

**PART 5: Tasks and Procedures**

**Note:** Each participant will do the experiment separately and no parallel testing will be taking place.

**Step 1: Introduction**

We will introduce to the participant verbally the experiment and how it will be conducted. Afterwards, we will give them written instructions about what will happen in the experiment, the different stages, and all the tasks they will be required to do at each stage. Finally, if a participant consents to doing the experiment, he/she will be asked to answer these questions (for data collection and results analysis):

- Age:
- Use of smartwatch: None Average (check time/music) Frequently (emails/directions)

**Step 2: Training**

Each participant will be trained on how to use our touch-wristband prototype (and the smartwatch display touchscreen if they don't know already). They will have 3 minutes on their own to explore the tools and adapt to them. Participants will be given a practice round to accommodate for learning curve by doing one round of scrolling task and one round of the selection task (the definition of a round is explained in the next step).

**Step 3: Trials**

There will be four trials for each participant. The order of trials is different between participants as illustrated in Table 1. We will use one smartwatch that is equipped with a touch-sensitive wristband for all trials and all participants. As Table 1 shows, trials 1 & 2 and trials 3 & 4 are paired up in terms of input method used. Depending on which trial it is, the participant will strictly use that input method. We will watch the participants closely to make sure they don't use the other input method.

We built an app that participants will use on the smartwatch to test the different input methods and tasks. Once the app is running, there is only one option: new session. Each session has two tasks: scrolling and selecting so the testing of an input device for two tasks is done in one session. Hence, each new session in the app will cover two consecutive trials: trials 1 & 2 is a session and trials 3 & 4 is another session. Diagram 1 summarizes how the testing app works and the following will explain in detail how the tasks are run and how data will be collected. When the participant has the smartwatch on them, we run the app and click '**new session**' which will generate an ID. All data collected from this session will be saved under this ID. Afterwards, the screen will go to the **main menu** which has three options: scrolling, selection, and finish. We will click on the task that should be done in this trial.

If **scrolling** task is selected, the participant will see a screen asking them to select a particular item. Once the participant is ready, they click start. A long list of items will appear and the participant has to navigate up and down to find the desired item. We will place the desired item randomly in the second half of the list. The first item on the list is highlighted (which means it can be selected) and as the user scrolls up and down the highlighting moves to the different items on the list. If the participant taps on the wristband on the wrong item, the app will record it as wrong attempt (and we count how many times they click on wrong items before selecting the right one for accuracy analysis later) but nothing will happen to [the] screen until the participant selects the right item. The app records the time from when the participant presses the start button until they click the desired item. Once the right item is selected, that round is finished and the app goes back to the start screen, which asks to click on a different item. Each participant has to do 10 rounds. Once the participant finishes the required number of rounds, the screen goes back to the **main menu** and we select the next task or the finish option if this was the second task.

For the **selection** task, the participant has to select (by tapping) the black square in a color grid of 2X2, 3X3, and 4X4 respectively (this is called a round with three stages) and this will be repeated 5 times. If a participant makes a wrong choice at one stage, the app moves on to the next grid layout and this will be recorded as a wrong selection and will be used later for the accuracy calculation. The app will record the time from when the grid shows up on the screen until a user makes a selection in each stage. Once all 15 stages are done, the screen goes back to the **main menu**.

Once a participant finishes the two tasks, we will click '**Finish'** and the screen will show the ID of the session and we keep record of this ID in association with the participant for data analysis. There will be a 2-minute break time until the next session which will cover two trials of the other input method. We estimate that the entire experiment will take 30 minutes per participant.

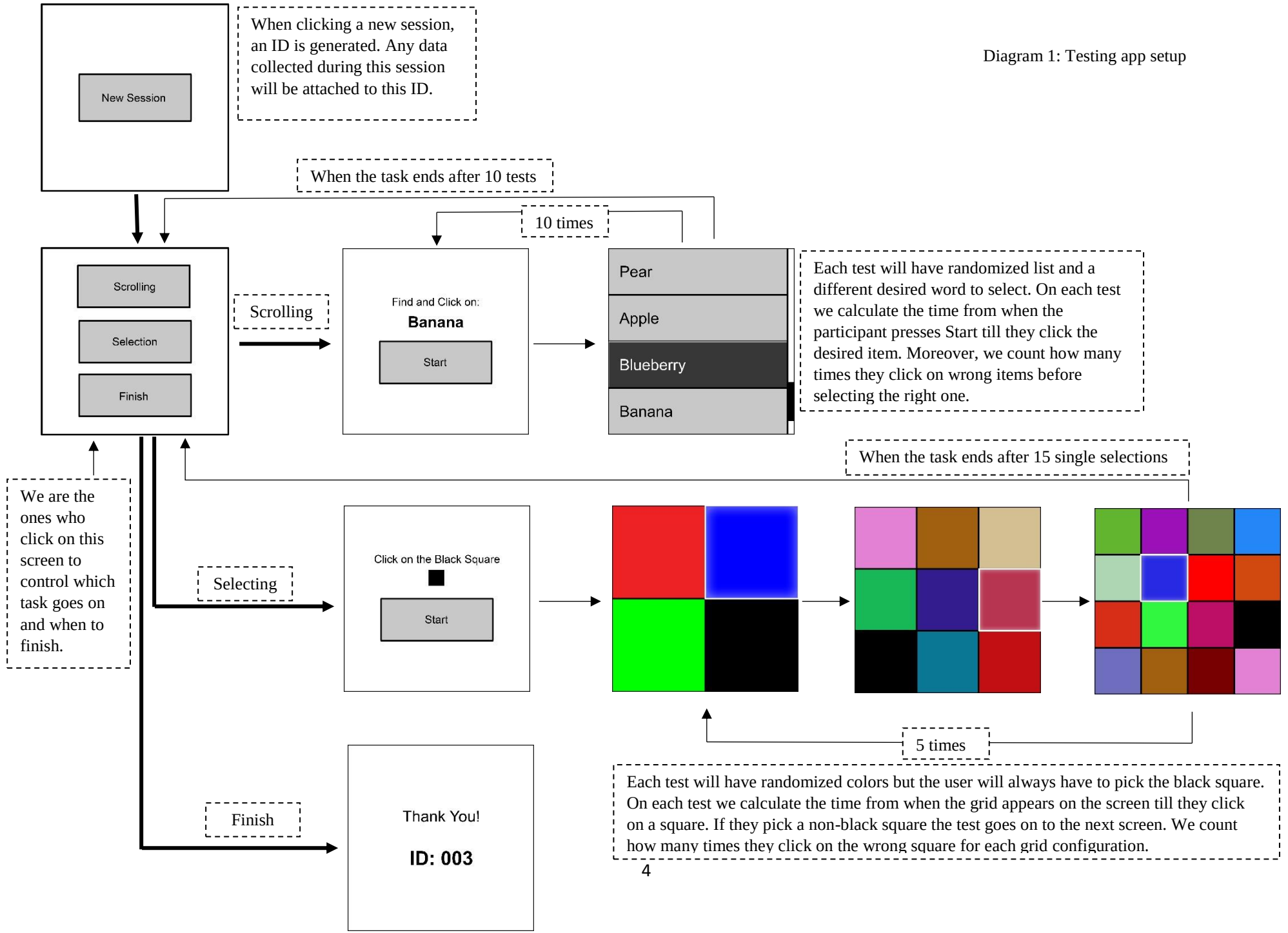


Diagram 1: Testing app setup

**Step 4: Survey**

Once a participant finishes all four trials, we will thank them for their corporation and they will be asked to fill out a survey regarding their experience with the two input methods. The questionnaire will include these questions:

- On a scale from 1 to 5 (with 1 being very easy and 5 being extremely difficult), how **difficult** was it to **learn** how to use the **wristband** as input method? 1 2 3 4 5
- On a scale from 1 to 5 (with 1 being very easy and 5 being extremely difficult), how **difficult** was it to **use** the **touchscreen** as input method for the **scrolling** task? 1 2 3 4 5
- On a scale 1 from to 5 (with 1 being very easy and 5 being extremely difficult), how **difficult** was it to **use** the **touchscreen** as input method for the **selection** task? 1 2 3 4 5
- On a scale from 1 to 5 (with 1 being very easy and 5 being extremely difficult), how **difficult** was it to **use** the **wristband** as input method for the **scrolling** task? 1 2 3 4 5
- On a scale from 1 to 5 (with 1 being very easy and 5 being extremely difficult), how **difficult** was it to **use** the **wristband** as input method for the **selection** task? 1 2 3 4 5
- Which method for **scrolling** do you **prefer** to use: Touchscreen or Wristband
- Which method for **selection** do you **prefer** to use: Touchscreen or Wristband
- Did using the **touchscreen** as input cause **fatigue**? Yes or No
- Did using the **wristband** as input cause **fatigue**? Yes or No
- Comments:

**PART 6: Measures**

We have two *dependent variables*:

- Speed
    - For scrolling task: the time it takes from when the list appears on the screen until the participant selects the desired object.
    - For selection task: the time it takes from when the color grid appears on the screen until the participant selects a square. If a participant selects the black square, the time recorded will be used as indication of speed. If a participant selects a non-black square, the time is recorded but will be used in accuracy analysis.
- Accuracy:
    - For scrolling task: (1) / (the number of times a participant clicks on an item - target and not target - in the list per round)
    - For selection task: per grid configuration, (the number of times black square is clicked) / (total number of rounds).

The above measures are crucial for determining whether our proposed input method is more suitable for scrolling through lists and selection of targets on smartwatches than the conventional one. By recording the time a user takes to select an item on the screen or to navigate a list, we can compare the performance of both input methods. Moreover, we are calculating the accuracy associated with each input method to assess the reliability of the input tool.

The survey at the end of the experiment is important to identify user experience with the different input methods. Even if the data from one input method show significant superiority over the other input method, users' personal experience with the device can show fatigue or hardship in learning or using a certain input method.

**PART 7: Data collection**

For each trial we will measure speed and accuracy. Our app will have built-in code to time stamp whenever new screen shows up and calculate the time from the start of the task until they click on the screen on the target. The code will also measure the accuracy by recording how many times an incorrect selection is made.

To collect data about user experience with the different input methods, we will personally observe each participant while they do the tasks and write notes about how they interact with the input tools. Moreover, each participant will fill out a questionnaire before the experiment indicating their skills with smartwatches and complete a paper survey at the end of their experiment to demonstrate their experience with the two input methods for the different tasks.