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Title: Tactile Vibrating Toolkit and Driving Simulation Platform for Driving-Related Research

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NOTE to Video Editor: Please keep the affiliation numbers for Jibo He as 4,1 (as opposed to the expected 1,4). Authors insisted that we list the affiliations in this order.

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Author Questionnaire

1. Microscopy: Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or similar? **N**

2. Software: Does the part of your protocol being filmed demonstrate software usage? **Y**

If **Yes**, we will need you to record using screen recording software to capture the steps. If you use a Mac, QuickTime X also has the ability to record the steps. Please upload all screen captured video files to your project page as soon as reasonably possible.

Videographer: Please capture only 3.3.1. for reference, all other screen capture files provided

3. Interview statements: Considering the Covid-19-imposed mask-wearing and social distancing recommendations, which interview statement filming option is the most appropriate for your group? **Please select one**.

☒ Interviewees wear masks until the videographer steps away (≥6 ft/2 m) and begins filming. The interviewee then removes the mask for line delivery only. When the shot is acquired, the interviewee puts the mask back on. Statements can be filmed outside if weather permits.

4. Filming location: Will the filming need to take place in multiple locations (greater than walking distance)? **N**

Protocol Length

Number of Shots: **19**

Introduction

1. Introductory Interview Statements

REQUIRED:

1.1. **Jibo He**: Our protocol provides researchers a very adaptable platform and tools for investigating the benefits and effectiveness of the application of tactile devices, especially for in-vehicle warning systems **[1]**.

1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

REQUIRED:

1.2. **Ao Zhu**: This vibrating toolkit provides a safe, inexpensive, and effective technique for investigating various kinds of driving-related research. The method can also be used to conduct other human behavior studies **[1]**.

1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

OPTIONAL:

1.3. **Annebella Tsz Ho Choi**: This protocol has provided insight into the potential application of smart wearable devices in promoting driving safety **[1]**.

1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

Ethics Title Card

1.4. Procedures involving human subjects have been approved by the Institutional Review Board (IRB).

Protocol

2. Driving Simulation Software Configuration and Driving Simulator Preparation

2.1. To configure the driving simulation software for an experiment, open the folder of the driving simulation software, the **Runtime** folder, and the **Config** folder **[1]**.

2.1.1. WIDE: Talent opening folders, with monitor visible in frame

2.2. Open the **expconfig.txt** file and make any adjustments to the default settings of the driving simulation as necessary according to the experimental design **[1]**.

2.2.1. SCREEN: screenshot_1: 00:13-00:19

2.3. Configure the UDP (U-D-P) settings if a UDP data transfer is required for the experiment and use **True** or **False** to allow the time stamp data synchronization to a specific local network IP address via the **enableUDPSendData equals** option to determine whether to enable the UDP for data transfer **[1-TXT]**.

2.3.1. SCREEN: screenshot_1: 01:43-02:04 *Video Editor: please speed up* **TEXT: UDP: User Datagram Protocol**

2.4. Then specify each section of the IP address using the commands as indicated to define the IP address for the UDP transfer **[1]**.

2.4.1. SCREEN: screenshot_1: 02:13-02:34 *Video Editor: please speed up*

2.5. To set up the driving simulator, connect the steering wheel, three mounted projectors, and three projector screens to the computer **[1-TXT]**. Place the projector screens 60 centimeters above the ground and 22 centimeters away from the front of the instrumented vehicle **[2-TXT]**.

2.5.1. Talent connecting steering wheel and/or projector to computer *Videographer: difficult step* **TEXT: Screen dimensions: 223 cm x 126 cm**

2.5.2. Talent checking out screen/mock-adjusting screen position **TEXT: Only two screens used in demonstrated experiment**

2.6. Select **Options** and **Display** to set the screen resolution to match the screen size upon starting the driving simulation software **[1]**.

2.6.1. SCREEN: screenshot_2: 00:06-01:16

2.7. Then, on the **Configure** page, select a player and follow the instructions provided by the software to calibrate the steering wheel, accelerator, and brake pedal **[1]**.

2.7.1. SCREEN: screenshot_3: 00:10-00:52 *Video Editor: please speed up*

3. Vibrating Toolkit Configuration and Preparation

3.1. To configure the vibrating toolkit, connect the toolkit to the power supply **[1]** and switch on the toolkit **[2]**.

3.1.1. WIDE: Talent connecting toolkit to power supply
3.1.2. Talent switching toolkit on

3.2. Connect the toolkit to the computer via Bluetooth and complete a pilot skin sensitivity test to define the vibrating frequency to be used for the experiment **[1]**.

3.2.1. SCREEN: screenshot_4: 00:25-00:29

3.3. Then use the codes as indicated to set the vibrating frequency to 70 hertz and to synchronize the brake events from the driving simulation software and vibrating toolkit **[1]**.

3.3.1. SCREEN: To be provided by Authors: Code being entered to set vibrating frequency, then brake events being synchronized NOTE: Not uploaded at postshoot time, authors were reminded. If it's still missing, please try to add the VO to the previous shot.

4. Driving Simulation Experiment

4.1. To conduct a driving simulation experiment, after obtaining informed consent **[1]**, help the Participant adjust the seat distance to the pedal **[2]** and to set the backrest to a comfortable position **[3]**.

4.1.1. WIDE: Participant giving consent form back to Talent
4.1.2. Talent helping Participant adjust seat distance
4.1.3. Talent helping Participant adjust backrest

4.2. Inform the Participant how to operate the simulator, including the steering wheel, brake pedal, and accelerator pedal **[1]**, and show the Participant the road map that will be used for the driving simulation **[2]**.

4.2.1. Talent instructing/demonstrating how to use simulator
4.2.2. LAB MEDIA: Figure 4

4.3. Inform that Participant that they should drive as they would in the real world while following the car in front of them and keeping a two-second headway behind it **[1]** and instruct the Participant to brake as soon as possible whenever the front vehicle brakes, even if the scenario does not require a brake response **[2-TXT]**.

4.3.1. Talent gesturing about driving in real world, while Participant listens/nods to indicate paying attention
4.3.2. Talent gesturing to pedal/Participant depressing brake/nodding **TEXT: Front vehicle rear lights will turn on when braking as per real-world driving**

4.4. Have the Participant complete a 5-minute practice trial that includes a set of 5 random brakes to learn how to maintain a two-second headway distance behind the front vehicle **[1]**.

4.4.1. Participant practicing driving/braking *Videographer: Important step*

4.5. During the practice trial, if the participant is between 2.25 to 2.5 seconds behind the front vehicle, the driving simulation software will play a prompt with a female voice saying "too far, please speed up" **[1]**.

4.5.1. SCREEN: screenshot_5: 00:22-00:32 *Video Editor: please include prompt message audio*

4.6. If the participant is less than 1.5 seconds behind the front vehicle, the driving simulation software will play a prompt with a female voice saying "too close, please slow down" **[1]**.

4.6.1. SCREEN: screenshot_5: 00:33-00:37 *Video Editor: please include prompt message audio*

4.7. When the Participant has completed the practice session and can maintain a stable following distance, let the Participant know that the study can be stopped without any penalty by notifying the experimenters at any time as necessary **[1]**

4.7.1. Talent indicating ok to stop *Videographer: Important step*

4.8. Inform the Participant of the location that the vibrating toolkit will be placed before each block begins **[1-TXT]** and use medical tape to assist the Participant in putting on

the toolkit **[2]**.

4.8.1. Talent explain while Participant listen/ nods to indicate paying attention *Videographer: Important step* **TEXT: *e.g.*, finger, wrist, or temple placement**
4.8.2. Talent taping toolkit *Videographer: Important step*

4.9. Inform the Participant that the toolkit will vibrate to warn the Participant to brake when the front vehicle is braking **[1]** and have the Participant begin the first trial **[2]**.

4.9.1. Shot of toolkit, then toolkit vibrating *Videographer: Important step*
4.9.2. Participant wearing toolkit and driving simulation *Videographer: Important step*

4.10. Give the Participant a 2-minute rest upon the completion of each block to reduce any carryover effects **[1-TXT]**.

4.10.1. Participant taking hands off wheel/relaxing **TEXT: 4 blocks/experiment; 13 random braking events/block**

4.11. When all of the trials have been completed, have the Participant indicate their preference for and the vibration intensity at each location of the toolkit on a scale of 1-7 **[1]** and record the usage rate of each of the Participant's daily wearable accessories **[2]**.

4.11.1. Shot of preference sheet location preference and vibration intensity indicated OR Participant filling out questionnaire
4.11.2. Talent recording Participant ring, watch, glasses, other accessories

Protocol Script Questions

A. Which steps from the protocol are the most important for viewers to see? Please list 4 to 6 individual steps.
4.4., 4.7.-4.9.

B. What is the single most difficult aspect of this procedure and what do you do to ensure success? Please list 1 or 2 individual steps from the script above.
2.5.

Results

5. Results: Representative Brake Rate and Time Responses to Vibrotactile Warning Notification

5.1. In this representative analysis, the driving simulation experiment took place in a bright environment, with the simulated scene designed to appear similar to driving on the highway on a clear day **[1]**.

5.1.1. LAB MEDIA: Figure 5

5.2. Post hoc analyses using pairwise Bonferroni-corrected *t*-tests **[1]** indicated no significant pair-wise comparison differences in the brake response rates between task conditions **[2]**.

5.2.1. LAB MEDIA: Figure 6
5.2.2. LAB MEDIA: Figure 6 *Video Editor: please add bracket and n.s. text over data bars*

5.3. As illustrated, the application of tactile warnings could facilitate drivers' reactions toward upcoming hazards while driving **[1]**, especially when the warning device was located on the drivers' finger or wrist **[2]**.

5.3.1. LAB MEDIA: Figure 7
5.3.2. LAB MEDIA: Figure 7 *Video Editor: please emphasize Finger and Wrist data bars*

5.4. Interestingly **[1]**, while participants perceived the highest level of vibration in the temple area **[2]**, the preference for the vibrating toolkit to be located at the temple area was the lowest **[3]**.

5.4.1. LAB MEDIA: Figure 8
5.4.2. LAB MEDIA: Figure 8 *Video Editor: please emphasize red data point in relation to x-axis*
5.4.3. LAB MEDIA: Figure 8 *Video Editor: please emphasize red data point in relation to y-axis*

5.5. In addition, the fact that over 50% of the participants wore a watch in their everyday life **[1]** suggests the feasibility of adopting wearable vibrotactile devices as a warning system in real life **[2]**.

5.5.1. LAB MEDIA: Figure 9 *Video Editor: please emphasize Watch data bar*

5.5.2. LAB MEDIA: Figure 9

Conclusion

6. Conclusion Interview Statements

6.1. **Guanglin Liu**: Instead of performing the car-following task, researchers can perform an N-back task to investigate the cognitive effects of tactile warnings simply by activating the option in the same protocol **[1]**.

6.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera