Measurement of Visual Reaction Times using Hand-held Mobile Devices

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BACKGROUND

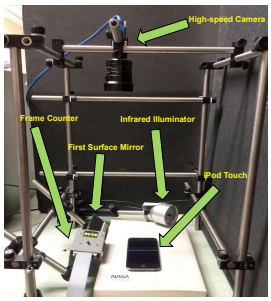
The Psychomotor Vigilance Test (PVT) is a widely used tool for the assessment of fatigue (Dinges & Powell, 1985). It consists of a series of measurements of simple reaction time to a visual stimulus; fatigue is associated with "lapses," typically defined as reaction times in excess of 500 milliseconds. Although the original PVT consisted of a 10 minute data collection period, shorter intervals have been show to be adequate (Loh *et al*., 2004).

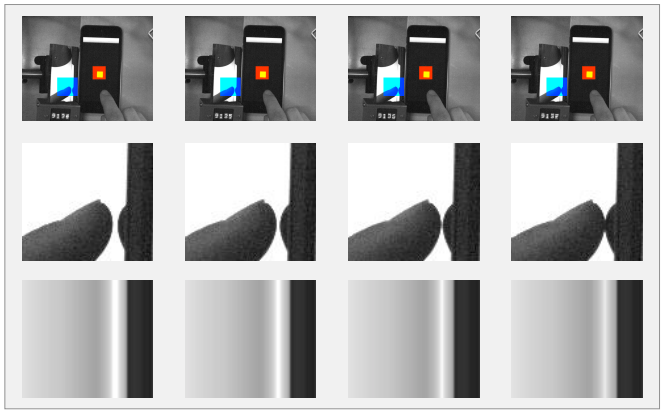
We have developed a version of the PVT that runs on Apple Computer iOS devices such as the iPad, iPhone, and iPod Touch. Here we present the results of a study done to validate the reaction times reported by the software.

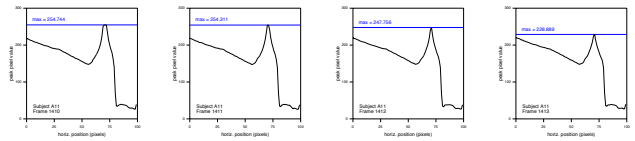
METHODS

A high-speed video camera (Point Grey Research FL3-U3-13Y3M) captured images of the iPad display at 500 fps. A mirror placed to the side provided a profile view of the subject's finger.

A trial commenced with the appearance of the stimulus (a white square). The square was replaced by the program's estimate of the reaction time after detection of a touch event.



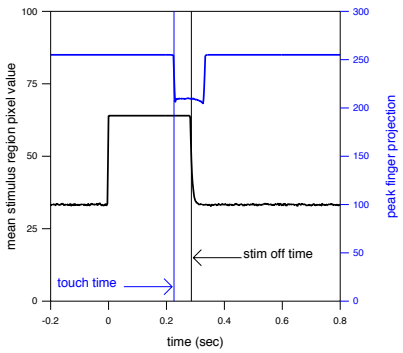




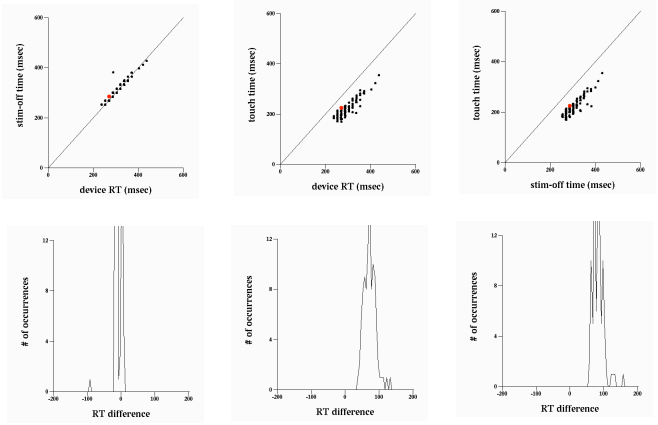
Stimulus onset and offset times were determined by computing the average pixel value in a region containing the stimulus (red square in top row of images, above).

Touch times were determined by computing the column averages of subimages containing the fingertip, and then finding the maximum value. These steps are illustrated in the lower three rows of images above.

At right is shown stimulus and finger traces for a single trial. The difference between the touch time and the stimulus off time provides a measure of system latency.



RESULTS



In addition to the stimulus-off and touch times estimated from the video recordings, the iPod software estimates the reaction time by sampling the master clock at stimulus-on and touch-down times ("device RT" in the plots above). On the left we see that this estimate is highly correlated with the stimulus-off time, with the disappearance of the stimulus sometimes delayed by one display refresh (16.7 milliseconds). (The one outlier point corresponds to the last trial when the operating system animates a transition to the next screen.) The red point in the scatterplots corresponds to the sample trial shown to the left.

The center and right panels show the touch times plotted against the device RT and the stimulus-off time. Here we see that the touch is not registered by the software until an average of 70 milliseconds after the finger first makes contact with the screen. More troubling that the absolute latency (which can be calibrated away) is the variability, which limits the ultimate precision of reaction time measurements made with this technology. The data from all subjects is summarized below.

CONCLUSIONS

Hand-held mobile devices like the iPod Touch provide convenient and portable platforms for behavioral testing. However, reaction times reported by the device are 80+-20 milliseconds longer than our best estimate of the actual touch time. Calibration of each device family is needed when absolute reaction times are needed, and the variability limits the ultimate precision.

REFERENCES

Dinges, D. F., and Powell, J. W. (1985). Microcomputer analyses of performance on a portable, simple visual RT task during sustained operations. *Behavior Research Methods, Instruments & Computers,* **17**(6), 652-655.

Loh, S, Lamond, L., Dorrian, J., Roach, G., and Dawson D. (1985). The validity of psychomotor vigilance tasks of less than 10 minute duration. *Behavior Research Methods, Instruments & Computers,* **36**(2), 339-346.

Supported by the Technologies for Airplane State Awareness (TASA) project of NASA's Airspace Operations and Safety Program (AOSP), and the NASA Engineering and Safety Center (NESC).