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Psychomotor Vigilance Task Evaluation for Touchscreen Devices

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Problem

The Psychomotor Vigilance Task (PVT) is considered the gold standard fatigue detection device and is used frequently in fatigue research. With the rapid development of new technologies it is essential to develop PVT available on different platforms such as touchscreen devices. The big advantage of such PVT is that it can be implemented on small devices and can be easily used in field studies.

The purpose of this study was to compare a psychomotor vigilance task developed for use on touchscreen devices with the original PVT-192 in conditions of acute sleep loss and circadian desynchronization.

Method

The study was approved by NASA Institutional Review Board. Participants signed a consent form prior to participating in the study. They were asked to complete a series of background questionnaire describing their sleep/fatigue history and habits. On the day of the experiment, participants arrived in the lab approximately two hours after their habitual time. Participants were asked to stay awake for up to 24 hrs and take 5-minute reaction time tests every 2 hours on two different devices: the original PVT-192 and NASA-PVT on an iPod.

The original PVT-192 was designed as a hand-held test that delivers a three-mm visual stimulus (a reaction-time counter), which requires the participant to make a pushbutton response within 1.5 seconds with interstimulus interval varying from 2 to 10 seconds (Dinges and Kribbs, 1991). Participants were instructed to press the response button as rapidly as possible once the visual stimulus appears. If participants press the button too soon a “false start” appears on the display. The number of performance lapses (trials in which the participant failed to respond within 500 ms) and reaction times during each PVT trial are analyzed. The task has no significant learning

curve (Dinges and Kribbs, 1991), which makes it well-suited to measure behavioral alertness in pilots.
The NASA PVT was developed for a touchscreen PDA and was implemented on 5th generation, 32-GB Apple iPod (Apple Inc., Cupertino, CA), and running IOS5.1.1. The development of the NASA PVT followed all the features of the original PVT-192 described above.

Results

The final sample consisted of 10 participants (5 males, 5 females). The participants were between 19 and 38 years of age (M = 25.1, SD = 6.17) and in good health. The average start time of the testing was 12:28 hrs (SD = 1:44) and the average finish time was 6:57 hrs (SD = 0:59). Systematic changes of inverse reaction time (mean 1/RT) and lapses (reaction times > 500 ms) across time and the differences between the two PVTs were analyzed using separate repeated measures ANOVA with two within-subjects factors (test (PVT type) and time).
Analyses of mean 1/RT indicated a significant main effect of test ($F(1,2) = 88.08$, $p = .011$), a significant main effect of time ($F(10,20) = 4.012$, $p = .004$) and a test*time interaction ($F(10, 20) = 4.15$, $p = .003$) (See Figure 1). Post-hoc contrasts revealed a significant quadratic trend for time ($F(1,2) = 25.41$, $p = .037$) and significant linear ($F(1, 2) = 20.31$, $p = .046$) and quadratic ($F(1,2) = 24.61$, $p = .038$) trends for the test*time interaction.
Analyses of lapses revealed a main effect for time only ($F(10,20) = 3.69$, $p = .006$) (see Figure 2). The post-hoc contrasts revealed significant linear ($F(1, 2) = 20.24$, $p = .046$), quadratic ($F(1, 2) = 494.93$, $p = .002$) and cubic ($F(1, 2) = 39.92$, $p = .024$) trends for time.

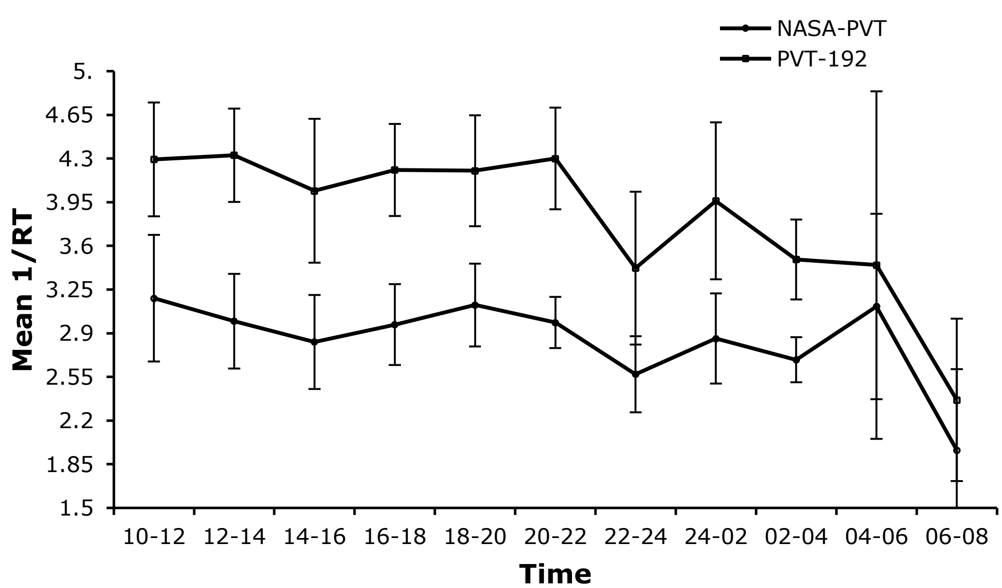

Figure 1. Means and standard deviations of the 1/RT for the NASA-PVT and PVT-192 during 24 hrs of sustained wakefulness.

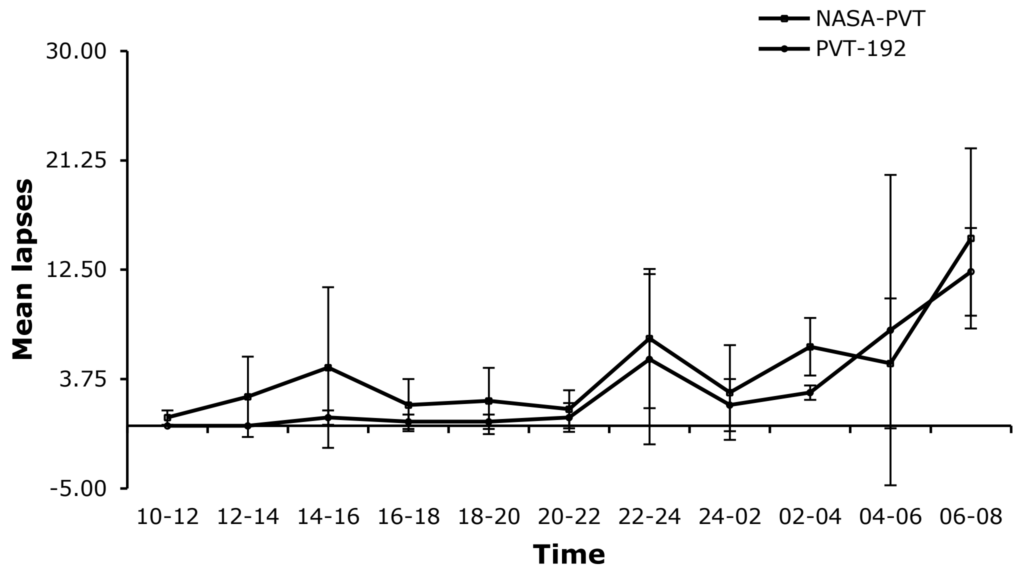

Figure 1. Means and standard deviations of lapses (reaction times > 500ms) for the NASA-PVT and PVT-192 during 24 hrs of sustained wakefulness.

Discussion

We found that the NASA-PVT and PVT-192 were sensitive to the 24 hrs of extended wakefulness in the same manner. The reaction times were slower and the lapses were higher as time progressed on both NASA-PVT and PVT-192. Overall, there was a decline in performance around 22:00-24:00 hrs which concur with the time the participants were usually going to bed and the worse performance occurred after 24 hrs of wakefulness (between 6:00-8:00 am) for both PVTs. The lapses followed the same pattern, with an increase around 22:00-24:00 hrs and with the highest number of lapses occurring in the morning hours (6:00-8:00 am).

We found a significant difference of mean 1/RT, but not lapses between the two PVTs with the reaction times for NASA-PVT being slower than those of PVT-192. Our previous research (manuscript under review) found that touchscreen devices expose latency between the actual time of an individual's touch response and the time recorded by the device. Factors that could contribute to the latency include the device, the operating system, and the application itself. We did not subtract the device latency of the device from our PVT results which could explain the higher reaction times for the NASA-PVT. Future investigations will examine the device latency for the app and adjust the reaction times accordingly.

Overall, this data suggest that the NASA-PVT could be a valid tool for assessing fatigue in field studies.

Summary

We developed a PVT app containing the same features as the original PVT-192 to use on touchscreen devices. We conducted a laboratory experiment in which the participants were awake for approximately 24 hrs and asked to take both NASA-PVT and PVT-192 every two hrs. Our results indicated that both PVTs showed reaction times decreasing and lapses increasing with the increased number of hours awake. We also found a difference in reaction times between the two PVTs with slower reaction times displayed by the NASA-PVT. This could be due to device latency that was not corrected for this particular study. Overall, the results suggest that the NASA-PVT developed for touchscreen devices could be a reliable tool to measure performance decrements due to fatigue and sleep loss. In particular, the app could be easily used in field studies (e.g., aviation, astronauts during space missions) due to its easy implementation on touchscreen devices.