Are Touch Screen Devices Appropriate for Neurocognitive Testing?

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ABSTRACT

OBJECTIVE: The primary study objective is to evaluate in computerized neurocognitive testing the accuracy and sensitivity of touch screen devices on response capture and timing compared to keyboard devices .

METHOD: Healthy volunteers were selected to take the CNS Vital Signs (CNSVS) neurocognitive test battery either on the Ipad 2 (Apple, Inc) using web browser interface and compared to the matched subject data take from the CNSVS normative database.

RESULTS: The touch screen tablet interface resulted in significant difference in timing as compared to keyboard interface. Response accuracy was impacted as well.

CONCLUSIONS: There are significant differences in device reaction time when comparing touch screen to keyboard. Tablets and other touch screen devices should be used with caution in computer based neurocognitive tests. Researchers and clinicians should understand that they do not provide reliable reaction time when compared to devices with native keyboard.

INTRODUCTION AND BACKGROUND

INTRODUCTION: CNSVS is a computerized neurocognitive test battery that was developed as a routine instrument[1]. Several tests record reaction time with millisecond precision. CNSVS is originally designed for subjects using conventional computer keyboard. With popularity of tablets and other touch screen devices, question arises whether the touch screen interfaces affect test result compared to keyboard interface. Valid neurocognitive tests of reaction time require millisecond precision.

BACKGROUND: Currently the iPad is the most popular touch screen tablet on the market. Clinicians and researchers are using iPads to access clinical and other information. It is well known that different touch screen devices suffer from inconsistent input lags[2]. A review of the technical literature has revealed that the iPad 2 has an input lag of approximate 235 milliseconds, which is an improvement from iPad 1's input lag of approximately 290 milliseconds[3]. It is also known that input lag does not always improve in newer generations of touch screen devices[4]. Furthermore the performance of these flash memory based touch screen devices tends to erode over time which can potentially affect input lag and recorded reaction time[5].

METHODS and STUDY DESIGN

Using the CNS VS web battery, we tested the iPad 2 against a traditional keyboard laptop to determine if iPad's touch screen input affect test result. Three tests from the CNS VS test battery were used for this study:

•Verbal Memory Test (VBM): Fifteen words are presented, one by one, on the screen every two seconds. For immediate recognition, the participant has to identify those words nested among fifteen new words. There is a delayed recognition trial as well.

- Visual Memory Test (VIM): Fifteen geometric figures are presented, one by one, on the screen. For immediate recognition, the participant has to identify those figures nested among fifteen new figures. There is a delayed recognition challenge as well.
- Continuous Performance Test (CPT): Participant is asked to respond to the target stimulus "B" but not to any other letter. CPT has a ceiling effect. Normal subjects are expected to have near perfect scores. The 200 stimuli are presented at random for 5 minutes.

DESIGN: Group A subjects took the tests on the iPad. The tests will be administered with a proctor in the room where the participants will remain seated during the time of test administration without interruptions.
PARTICIPANTS: 15 participants were selected for Group A, 15 control subjects for Group B were selected from normative database age matched to Group A.
DEMOGRAPHICS: Group A age range from 29 to 54 with mean of 42.5 years old, Group B age range from 29 and 59 with mean of 42.6 years old.

Group B subjects were drawn from a normative database of VBM, VIM and CPT test result using laptop and web browser test interface, matched to Group A's age.

SAMPLE SIZE: This study enrolled 15 subjects for Group A, and draw 15 control subjects from a normative database.
INCLUSION CRITERIA: age 12-60, English speaking male and females, with "everyday" familiarity and ability to use tablets and computers.

EXCLUSION CRITERIA: current or past psychological disorders, currently treated for psychological disorders, inability to user laptop or tablet, inability to complete the test.

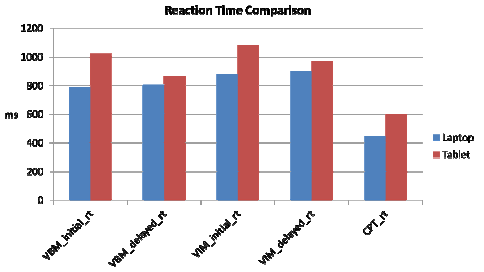
PRIMARY ENDPOINT: Difference in recorded reaction time in VBM, VIM and CPT using iPad 2 web browser interface compared to laptop web browser interface.

SECONDARY ENDPOINT: Difference in recorded correct/incorrect results in VBM, VIM and CPT using iPad 2 web browser interface compared to laptop web browser interface.

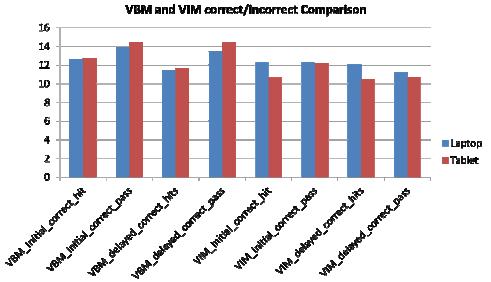
DATA ANALYSIS: Difference in recorded reaction time and correct/incorrect results was evaluated using independent sampled T-test. `

RESULTS

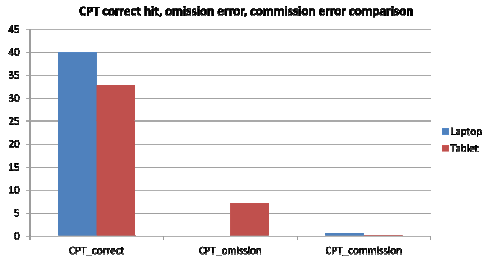
REACTION TIME COMPARISON: Reaction time between tablet and laptop revealed significant differences in the VBM's initial reaction time, VIM's initial reaction time, and CPT's correct hits reaction time with $p < 0.0003$ for all three reaction times. Although VBM's and VIM's delayed reaction time did not reach significant difference, they were all trending toward significant differences with tablet's mean reaction time greater than laptop's mean reaction time.



CORRECT/INCORRECT COMPARISON: Majority of the VBM and VIM's correct and incorrect scores did not show significant differences. Only VBM's delayed correct pass score showed a significant difference, p=0.031. Given VBM is a test of memory performance and this difference could be due to memory performance differences between subjects.



Normal subjects are expected to have near perfect scores in CPT. The mean difference for CPT corrected response is 6.6 with $p = 0.0249$. A subset of Group A participants had extremely low CPT correct response, even though the proctor visually confirmed these participants tapped the touch screen during the correct stimulus This suggest the response capture time on the tablet distorts performance.



CONCLUSIONS and DISCUSSION

- Reaction time differences are significant between laptops and touch screen Ipad tablets.
- It is also interesting to note that out of 15 subjects in Group A that took the CPT on the tablet, a subset of 6 participants experienced extremely low score on the tablet, most likely indicating the tablet did not register their response even though the study was performed in a proctored environment. The CPT test is designed such that healthy volunteers should not miss more than 1 or 2 out of 40 correct stimuli. These 6 subjects on average missed more than 17 correct stimulus, ranging from 3 to 30 missed correct stimulus. The same 6 participants performed normally on VBM and VIM tests on the tablet. These 6 participants all have extensively used touch screen smartphones and tablets so lack of user experiences should not be a factor. The long input lag of the iPad 2's touch screen could potentially contribute to this high error rate[5].
- As the result of this study, caution should be exercised in assessing neurocognitive status on touch screen devices. As different touch screen devices have different latencies depending on screen type, processor and age of device, if a touch screen device must be used, it should be the same device for each serial testing event.

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Disclosure: Mr. Alan Boyd is the CEO of VNS Vital Signs and a developer of the CNS VS test battery