Cognitive assessments on portable devices: A comparison between phones and tablets

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Portable Neuropsychological Testing

Assessments of cognitive function are important endpoints in clinical research, both as measures of efficacy, and as indicators of unwanted effects. The use of portable devices to implement such tests allows a much broader range of settings for such testing, including

- Everyday assessment, where testing is carried out in the context of an individual's normal life, e.g. at home and at work. Testing is unsupervised – the experimenter may be involved in initial instruction and practice, but does not administer the tests.
- Field testing, including assessment in clubs and pubs, or workplaces. This is generally experimenter administered.
- Clinical settings, where portability allows ready assessment in hospital wards and waiting rooms. Again, experimenter administered.

The smaller the device the greater the portability and flexibility. Mobile phones are a very useful size particularly for everyday testing, but screen size may be a limitation. In order to evaluate the possible impact of screen size on test results, we compared a set of six tests given on both a mobile phone (6cm diagonal screen) and a tablet (18cm).

Arrow Reaction Time

Arrows appear one at a time pointing left or right, and the subject presses a button to indicate the direction

Number Pair Test

A set of seven digits appears on the screen. The task is to check if the **second** and **fourth** digits are the same.

If they are the same (above, left), the subject presses the **Yes** (4) button as quickly as possible, if not (above, right), the **No** (6) button.

Arrow Flankers

Five symbols appear in a row. The middle one is always an arrow, pointing to left or right, and the subject presses a left or right button to indicate the direction. The other flankers (distractors) may be arrows, pointing in the same or opposite direction or neutral squares

Memory Scanning

A set of five digit is first shown, and memorised. Then a series of single digits is presented, and subjects press a **Yes** or **No** button to indicate if the digit is in the memory set

Shape Pairs

Two shapes are shown side by side. A series of shapes is then shown, and the subject presses a left or right button to indicate on which side each shape first appeared. After a while, subjects see an additional pair of shapes, and again respond to single shapes, but now with a set of four shapes. This is repeated until subjects are responding to eight shapes.

Serial Sevens

A starter number in the range 800-899 is displayed, and then a series of reducing 3-digit numbers. Subjects respond **Yes** if the number is 7 less than the preceding number, **No** otherwise

Implementation of the Test Battery

The test battery was set up on a Tesco Hudl 7-inch Android tablet (18cm screen), and on a Nokia 301 Java-enabled mobile phone (6cm screen). The battery took about 18-20 minutes to complete.

For all tests instructions were given to "work as fast and as accurately as you can". Mean reaction times were recorded for all correct responses, as well as the proportion of of errors (%).

Study Outline

39 healthy volunteers, aged 18 – 30 years, 20 female, took part. The study used a two-period crossover design, with tests on the two platforms given in randomised order in a single half-day session. Within each period, volunteers completed five practise assessments, then a final assessment that was used for the present analysis. After completing the battery on each device, subjects completed the mental effort scale to evaluate perceived cognitive load.

Subjects were instructed not to consume alcohol for 24 h before testing, and not to consume caffeine on the day of testing.

Results

Mean scores for test measures were very similar for both devices. No difference was statistically significant ($p > 0.05$, paired t-test) and effect sizes (difference/pooled SD) were all small (< 0.25)

Correlations between the scores on the two platforms are shown in Table 1. With one exception, (Shape Pairs errors) correlations are > 0.5, and most are > 0.7, indicating good agreement.

The mental effort scale gave very similar results for the two platforms, with mean (SD) being 5.7 (2.6) for the phone and 5.6 (2.7) for the tablet (max score 15). Thus there was no difference in perceived cognitive load in using the two platforms.

Test	Correlation	
	RT	PE
Arrow RT	0.536	0.756
Number Pairs	0.748	0.726
Arrow Flankers	0.824	0.530
Memory Scanning	0.814	0.640
Shape Pairs	0.605	0.144
Serial Sevens	0.716	0.751

Table 1: Correlation between test scores obtained on phone (6cm screen) and tablet (18cm screen).

RT = Reaction Time;
PE = Percentage errors

All values are statistically significant at $p < 0.001$ except Shape Pairs PE, which is not significant ($p>0.05$)

Discussion

The tests included in our battery evaluate a range of cognitive/performance domains, including attention, psychomotor performance, memory and executive function. These tests have been previously successfully implemented on both tablets and mobile phones (see, e.g. Tiplady et al. 2004, 2005a,b; 2009; Thomson et al. 2009; Kennedy et al. 2011; Keenan et al. 2014). The present comparison of tests on the two platforms suggests that there is little effect of screen size on test performance, either in terms of the outcome measures or on perceived cognitive load in carrying out the tests.

Clearly not all tests can be implemented on a 6cm screen. Tasks involving visual search or maze following are two examples that have been implemented on tablets but would not be suitable for a small phone. Nonetheless a wide variety of aspects of performance can be assessed.

Mobile phones are particularly suitable for assessment of cognition using the approach of ecological momentary assessment, where assessments are scheduled at random or irregular times, and require the subject to carry the device at all times. This approach has been used in a number of studies of alcohol and addiction both with phones and small personal digital assistants (see, e.g. Tiplady et al. 2009; Jones et al. 2014; Waters et al. 2014

Summary and Conclusions

1. We compared a portable test battery set up on a mobile phone (6cm diagonal screen) and a tablet (18cm screen), evaluating reaction times and error scores.
2. Differences between the two platforms were small and not statistically significant. Correlations between measures on the two platforms were generally high. There was no difference in perceived mental effort between the two platforms.
3. These results suggest that screen size has little or no effect on test performance, and support the use of mobile phones in portable cognitive assessment.

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