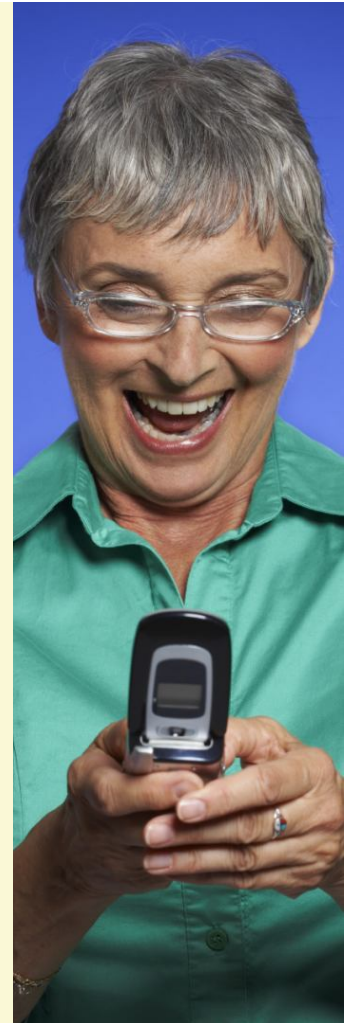


Mobile phone
assessment of
cognition:
Development of a
validation model.

Brian Tiplady

ICAP: 12th July 2010



- Cognitive/performance testing has generally been carried out in the laboratory
- The skills and abilities assessed are important for everyday life



- Reaction Time
- Accuracy of performance
- Memory
- Attention



Approaches to Portable Testing

- Take the laboratory (and investigator) out to the subjects
 - Hospital wards and recovery rooms, places of work
 - Field studies on alcohol and illicit drugs, in pubs, clubs, festivals
 - Driver impairment
- “Free-range” Studies with unsupervised assessments
 - Tests used over substantial period in everyday life
 - Investigator not directly involved in testing
 - Support via reminders, alarms and feedback

Mobile Phone



- Many people already have one and are comfortable using it
- Economical if wireless transmission required
- Easy to download applications from PC or via WWW
- Small screen can be a limitation, but a wide variety of tests can be implemented
- Not all phones are Java-enabled

Validation questions with mobile phones

- Is the device capable of accurate timing?
- Is the software working as intended?
- Are tests with a small screen equivalent to other methods?
- Can unsupervised users cope with the tests?
- Are they using the system properly
- Are the tests capable of detecting the effects of interest?

Validation Model

| | |
|--------------------------------|---|
| Device Level Validation | Includes correct operation of phone and software, e.g. timing of responses, randomisation algorithms |
| Intrinsic Validation | Aspects of test data such as differences between responses to stimuli of differing difficulty |
| Extrinsic Validation | Ability of test to detect changes within individuals or between individuals due to well-established influences on cognition |

Memory Scanning

A set of five digits is shown on the phone screen



Memory Scanning

A set of five digits is shown on the phone screen

Single digits appear. The user presses YES or NO as quickly as possible

Speed and accuracy of responses are recorded



Memory Scanning: Device Level Issues

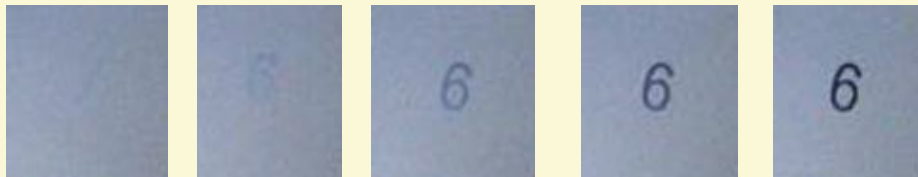
- Randomisation of target sets
- Randomisation of stimuli in blocks
- Correct recording and classification of responses
- Response timing

Device Level Validation: Timing

- Video recording of screen display allows measurement of time taken for image to be fully displayed
- Transducer to give external record of response timing

Device Level Validation: Timing

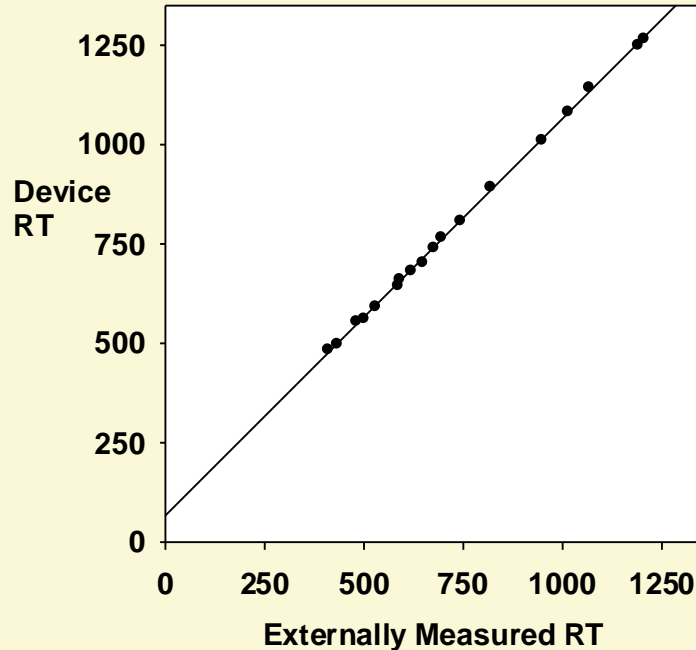
Successive screen shots from mobile phone display at 210 fps:



← 9.5 msec →

Is this compatible with adequate timing accuracy for summary measures (usually means of 20+ responses in a given category)?

Device Level Validation: Timing (msec)



Device Level Validation: Timing

- Correlations in all cases ≥ 0.9995
 - Less than 0.1% of error variance due to timing inaccuracy in device
- Device RT consistently greater than external recording
 - Probably due to delay in appearance of stimulus.
 - Not relevant when differences in scores are used, so long as delay is consistent
 - Would need to be allowed for in norm generation

Memory Scanning: Intrinsic Issues

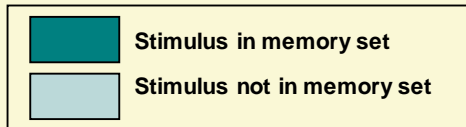
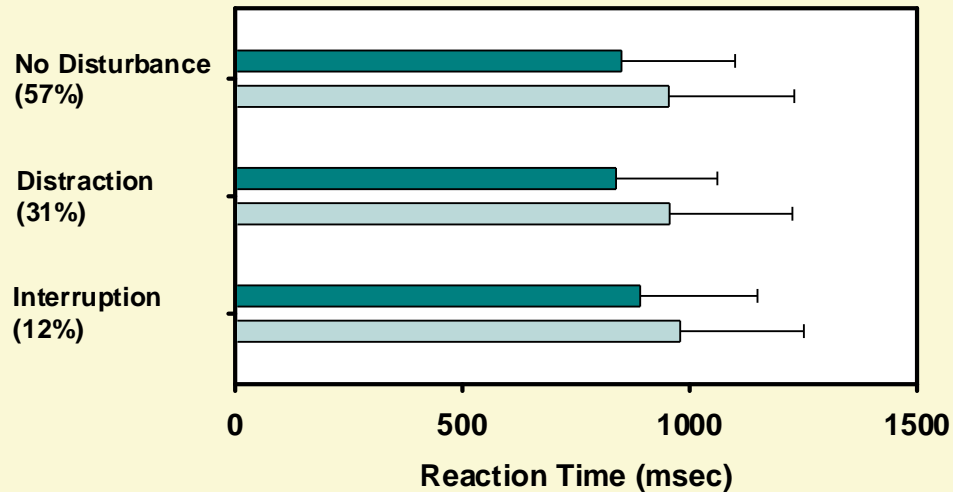
- Responses to digits in the memory set are shorter, typically about 100 msec less, than for digits not in the set.
- Establishment of these differences allows comparison of mobile phones to other test systems, e.g. PC
- Differences also provide an indication of test integrity in an unsupervised setting

Everyday Life (“Free-Range”) Study

- 38 healthy volunteers (20 male) aged 18-54 years (mean 22.8) took part.
- Text (SMS) messages were sent twice a day at different times to the phones over 14 days.
- Volunteers completed assessments as soon as possible after receiving each text.
- Assessments included recording alcohol consumption, cognitive tests, and questions about disturbance during completion



Memory Scanning: Intrinsic Validation



Assessments included if no alcohol consumption reported in last 24h

Memory Scanning: Intrinsic Validation

Stability of differences in response times to different stimulus types indicates:

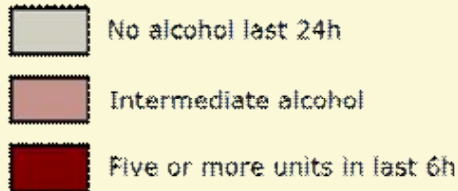
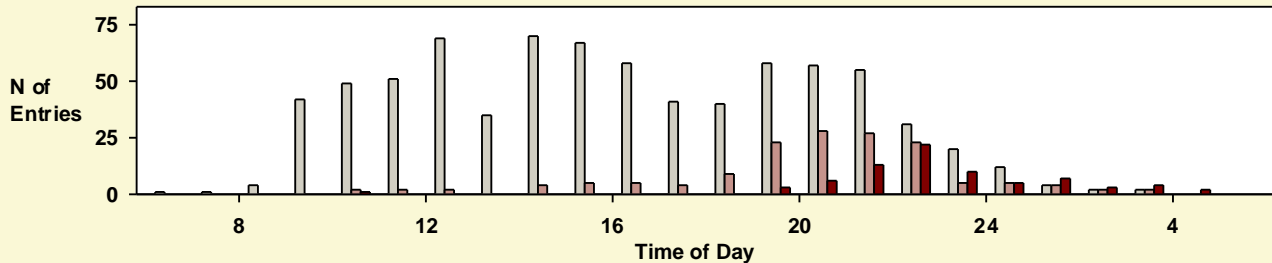
- Response time measurements are detecting differences as expected
- Task characteristics as expected on small-screen system.
- Volunteers are performing task as intended in unsupervised setting

Memory Scanning: Extrinsic Issues

Ability of the mobile phone system to detect effects of factors known to affect (usually impair) cognition

- Fatigue or sleep deprivation
- Drugs, e.g. alcohol, benzodiazepines
- Disease states

Distribution of Free-range Entries



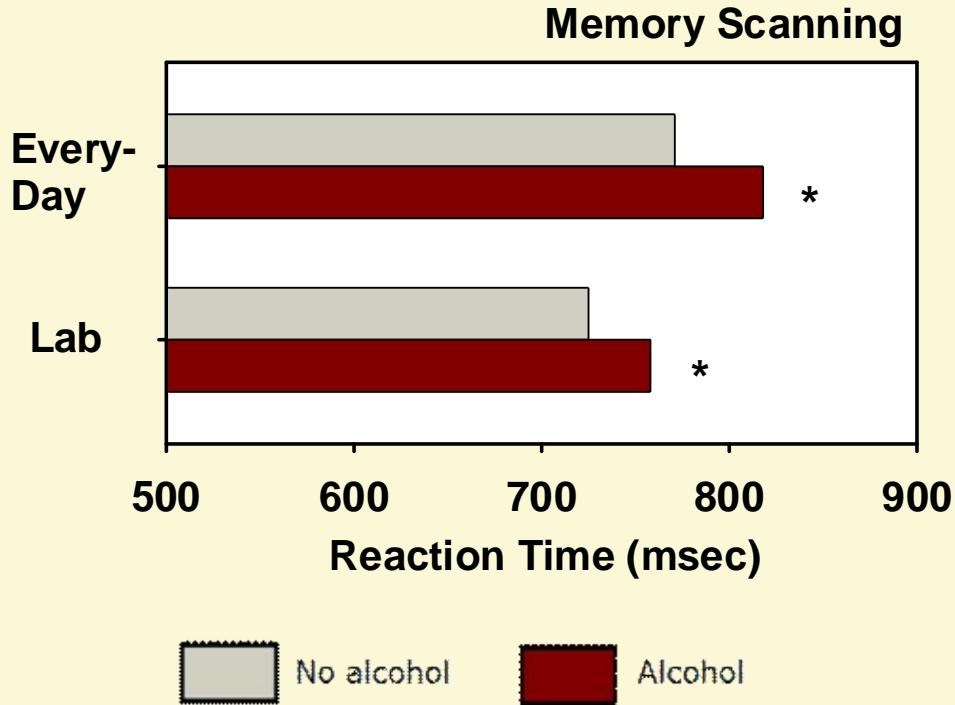
Entries with at least 5 units:

- 30/38 volunteers had at least one entry ≥ 5
- Maximum was 20 units (median 7)
- Previous work suggests that 7 units (reported) corresponds to a BAC of about 95 mg/100 ml.

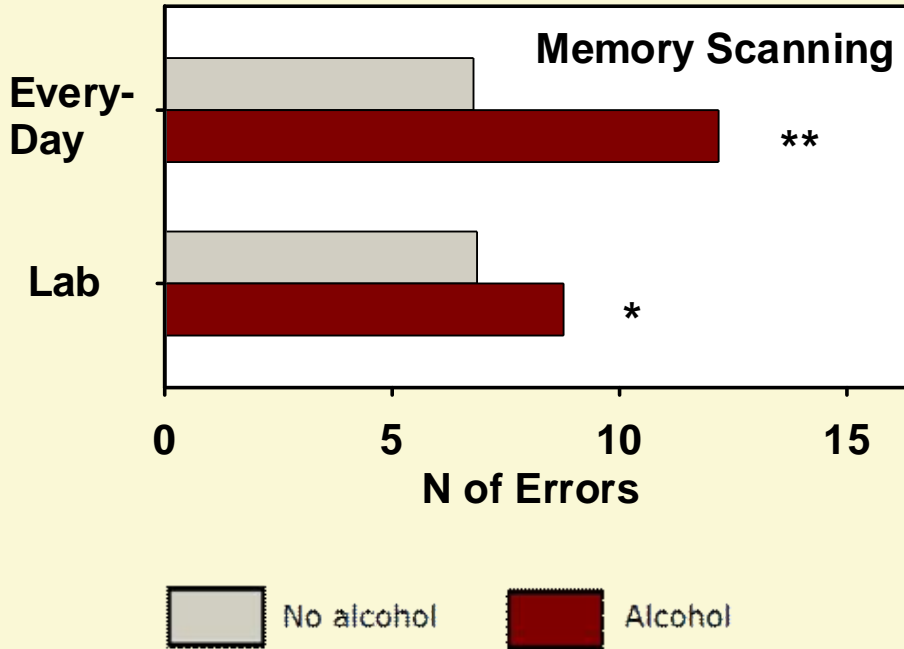
Laboratory (Battery)

- 26 of the volunteers took part in the lab study.
 - They received ethanol and placebo on separate days in random order
 - They completed the same assessments at intervals up to 2h after the drink.
- Mean blood alcohol concentrations were 124 mg/100 ml

Working Memory - Speed



Working Memory - Accuracy



Conclusions

- All three levels of the model give important information for assessing system validity.
 - Device level validation shows consistent bias in RT scores, but excellent agreement otherwise
 - Intrinsic validation shows expected patterns with stimuli of greater difficulty taking longer.
 - Test battery reliably shows effects of extrinsic factors such as alcohol impairment, both in everyday setting and laboratory
- These data support the validity of using mobile phones to collect cognitive performance data in both supervised and unsupervised settings

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