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## Telephone assessment of cognitive function in adulthood: the Brief Test of Adult Cognition by Telephone

SIR—Increased understanding of cognitive function in normal ageing is of major importance for both theoretical advancement and practical public health reasons. Cognitive function plays a critical role in an individual's ability to function independently across the lifespan, with substantial documented links to quality of life, morbidity [1], mortality [2] and dementia [3]. The Brief Test of Adult Cognition by Telephone (BTACT) addresses the need for a brief test that is sensitive to cognitive differences in normal ageing, including episodic verbal memory, working memory span and executive function [4], reasoning and speed of processing [5]. It includes tasks based on laboratory research as well as modified versions of well-documented psychometric tests that have been adapted for telephone administration with non-demented adults.

Although in-person testing is often the preferred mode, it is not always feasible; telephone testing offers advantages such as convenience, low expense and the opportunity to test a greater number of individuals, including those who cannot be tested in person. This method can reach a wide range of respondents who vary in physical mobility, health status and educational level.

Previous telephone testing has focused primarily on screening for dementia using instruments that are not sensitive to cognitive performance in normal healthy adults [6–8]. Nevertheless, the validity of telephone testing in normal ageing has been supported by other studies [9, 10], such as the HRS/AHEAD study [11], which reported no significant difference in performance between telephone and in-person tests [12, 13].

The BTACT extends the range of these previous studies in two important ways. First, the range of cognitive domains tested is extended beyond orientation and memory to include key abilities that are paramount in current theories of cognitive ageing. Second, the BTACT is appropriate for testing a wider population including well-functioning younger and middle-aged adults as well as older adults. This allows for sensitivity to individual differences in cognition that may be associated with a large array of biological, social, health and psychological factors [14].

## Methods

The Basic BTACT battery requires <20 min to administer in person or by telephone, using paper-and-pencil scoring methods. The only equipment recommended for the Basic BTACT is a recording device (e.g. a tape recorder or computer) with a phone jack to record the interview. We also have developed an alternative form of the BTACT for repeated testing, available on our website (<http://www.brandeis.edu/projects/lifespan>). In addition, an optional task-switching test can assess attention and task-switching ability; this requires a computer for recording a digitised sound file.

The interviewer first screens to ensure that the participant can hear the materials clearly. To minimise cheating, we specifically ask participants not to write down anything during the test and to close their eyes to facilitate concentration.

The test includes these subtests (see Appendix A in supplementary data at <http://www.ageing.oxfordjournals.org>):

- *Episodic verbal memory*: immediate recall and delayed recall of a 15-word list [15, 16].
- *Working memory span* reflecting a system that stores and manipulates information: measured with backward digit span [4, 17, 18].
- *Verbal fluency*: assessed by category fluency, an index of executive function [16] that is linked with frontal lobe function [19].
- *Inductive reasoning*: a measure of fluid intelligence assessed with number series completion [20].
- *Speed of processing*: measured with a backward counting task requiring rapid generation of a non-automatic sequence [5, 11, 21].
- An optional *task-switching* test yields baseline measures of reaction time and task-switching costs [22].

Participants

We administered the BTACT to a probability sample of 84 healthy, community-dwelling volunteers from the Greater Boston area ranging from 23 to 80 years old, who were divided by age into younger (<40 years), middle-aged (40–59) and older (>60) groups. Table 1 summarises descriptive characteristics of the groups, which did not differ significantly by analyses of variance (ANOVA) in education,  $F(2,81) = 1.19, P = 0.310$ . Participants reported a mean of 1.05 (SD = 1.29) chronic health problems from a checklist of 12 common conditions, indicating that they were a relatively healthy sample, although the older group reported more problems than the other groups ( $P < 0.05$  by Tukey post hoc tests). All participants were able to understand verbal instructions and performed within normal age limits on the verbal fluency and working memory tests, indicating that they were not cognitively impaired. Research was funded by the US National Institute on Aging, complied with ethical standards, and was approved by the University Institutional Review Board.

Results

Effects of age and education

Table 1 summarises scores for the three age groups on the six basic BTACT subtests. Test scores were excluded for outliers that were >2.5 SD from the age-group mean or failure to follow instructions. Kolmogorov–Smirnov tests showed normal distributions for immediate (1.13) and delayed verbal memory (1.20), verbal fluency (0.66), reasoning (1.21) and speed (0.58); only working memory span showed some departure from normality (1.79,  $P < 0.003$ ).

ANOVA showed significant differences between the age groups for each of the measures: immediate memory,  $F(2,81) = 8.40, P < 0.001$ ; delayed memory,  $F(2,81) = 14.87, P < 0.001$ ; working memory,  $F(2,79) = 3.37, P = 0.039$ ; verbal fluency,  $F(2,78) = 5.23, P = 0.007$ ; speed,  $F(2,81) = 13.84, P < 0.001$  and reasoning,  $F(2,80) = 4.12, P = 0.020$ .

Table 1. Descriptive data (means and standard deviations) for younger age, middle-aged and older age groups on Brief Test of Adult Cognition by Telephone (BTACT) subtests

	#	Age M (SD)	Years of Education M (SD)	Gender	Episodic Verbal Memory: Immediate (proportion correct) M (SD) <sup>a</sup>		Episodic Verbal Memory: Delayed (proportion correct) M (SD) <sup>a</sup>		Working Memory (longest span correct) M (SD) <sup>b,c</sup>	Reasoning (proportion correct) M (SD) <sup>a</sup>	Speed of Processing (number of items produced) <sup>c</sup>	Verbal Fluency (number of items produced) <sup>d</sup>
					M (SD) <sup>a</sup>	M (SD) <sup>a</sup>						
Younger	25	34.04 (4.80)	16.12 (2.28)	9 males, 16 females	0.51 (0.13)	0.39 (0.14)	5.88 (1.42)	0.69 (0.25)	49.24 (10.78)	24.00 (7.10)		
Middle	27	49.96 (4.84)	15.44 (1.93)	13 males, 14 females	0.49 (0.12)	0.29 (0.12)	5.31 (1.46)	0.60 (0.33)	45.37 (8.88)	20.26 (4.72)		
Older	32	71.09 (5.36)	15.16 (2.75)	14 males, 18 females	0.39 (0.13)	0.19 (0.14)	4.91 (1.28)	0.46 (0.30)	35.25 (11.43)	18.63 (6.44)		
Total	84	53.27 (16.19)	15.54 (2.38)	36 males, 48 females	0.46 (0.14)	0.28 (0.16)	5.32 (1.42)	0.57 (0.31)	42.67 (11.99)	20.77 (6.46)		

<sup>a</sup>Normal range 0–100%.

<sup>b</sup>Normal range 2–8 items correct.

<sup>c</sup>Normal range 10–80 items correct.

<sup>d</sup>Normal range 5–50 items correct.

<sup>e</sup>Differs significantly by age group,  $P < 0.05$ .

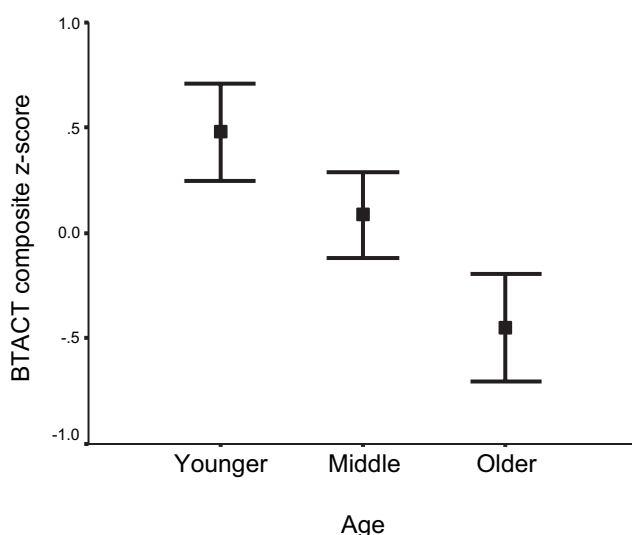
Tukey tests showed that older adults recalled fewer words than the younger and middle-aged groups on both immediate and delayed tests; at delayed testing, the middle-aged group recalled less than the younger ( $P < 0.05$ ). Older adults also performed significantly worse on the working memory, verbal fluency, speed and reasoning; the younger and middle-aged groups did not differ significantly on these tests.

To examine the effects of age after controlling for education effects, we included educational level as a covariate. Education effects were not significant for immediate,  $F(1,80) = 2.65$ ,  $P = 0.107$ , or delayed memory,  $F(1,80) = 1.89$ ,  $P = 0.173$ , or for speed,  $F(1,80) = 2.62$ ,  $P = 0.109$ . Education was significant for verbal fluency,  $F(1,77) = 6.93$ ,  $P = 0.010$ ; reasoning,  $F(1,79) = 9.04$ ,  $P = 0.004$ ; and working memory,  $F(1,78) = 7.35$ ,  $P = 0.008$ . Overall, the findings suggest that although education is related to several of the tests, they remain generally sensitive to adult age differences.

### BTACT composite score

It is often useful for researchers and clinicians to work with a single composite score that represents performance across several domains. A principal axis factor analysis on the Basic BTACT measures suggested a one-factor solution (one eigen value  $>1$ ); the factor matrix showed moderate to strong loadings for all six tests, ranging from 0.54 to 0.81. The composite score (the average of standardised  $z$ -scores for six measures) showed good internal consistency of  $\alpha = 0.82$ .

Figure 1 shows age differences in the mean composite score for the three age groups,  $F(2,83) = 16.79$ ,  $P < 0.001$ . Tukey comparisons showed that young and middle-aged subjects differed marginally,  $P = 0.057$ , but older adults performed significantly worse than the other groups. Analysis of co-variance (ANCOVA) showed that although education had significant effects,  $F(1,80) = 8.93$ ,  $P < 0.01$ , age differences remained highly significant,  $F(2,80) = 15.05$ ,  $P < 0.001$ .



**Figure 1.** Mean standardised Brief Test of Adult Cognition by Telephone (BTACT) composite scores for younger, middle-aged and older age groups (95% confidence intervals).

### Validation of the instrument

The BTACT tests have been used previously in neuropsychological and laboratory applications. To confirm that our telephone measures yield results similar to the more standard in-person tests, we carried out a validation study that demonstrated the expected significant correlations between BTACT measures and standardised in-person assessments of vocabulary, episodic memory and speed of processing.

We also tested additional samples of adults on the BTACT both in person and by telephone and found no significant effect of mode of testing for any of the subtests, confirming previous reports [9–11, 13, 23] (see Appendix B at <http://www.ageing.oxfordjournals.org>).

### Discussion

The BTACT provides a brief battery for telephone assessment of key domains of cognitive function, using tests that are sensitive to performance in community-dwelling adults ranging from young to middle-aged and older. The basic BTACT is administered in  $<20$  min, is easily scored, requires no special equipment and provides a composite measure of cognitive function; an optional computerised task-switching test can yield further information on reaction time and executive function.

The primary contribution of the BTACT is to extend the range of cognitive telephone testing in terms of both the target population and the cognitive domains sampled. To demonstrate the instrument's appropriateness for testing a wide range of adult ages and educational levels in normal-functioning participants, we tested not only two extreme age groups but also middle-aged adults, and thus add to research on midlife cognition [14]. Overall, our findings show poorer performance by older adults and smaller differences between younger and middle-aged adults.

The BTACT extends previous telephone instruments by assessing not only memory but other important cognitive domains including speed of processing, a key measure for detecting subtle age and health-related differences in large community samples.

One possible limitation of telephone testing is hearing difficulty for those with hearing loss [24], and therefore we include a brief screening at the beginning of the interview. However, hearing has not presented a significant problem in previous research [11, 13]; one phone survey reported hearing difficulties with  $<4\%$  of the sample [8].

Cognitive abilities are critical to the well-being and independent function of individuals across the lifespan [25, 26]; the BTACT offers researchers and clinicians the convenience of telephone assessment of cognitive function as an alternative to in-person testing.

### Key points

- The Brief Test of Adult Cognition by Telephone (BTACT) was shown to be an efficient and effective method of testing cognitive ability in normal-functioning adults ranging in age from young to older adults.

## Research letters

- The BTACT subtests were sensitive to age-related differences in episodic verbal memory, working memory span and executive function, reasoning, and speed of processing.
- The BTACT provides a composite score of cognitive function that is sensitive to age-related differences in middle age and later life.
- The BTACT is useful for testing normal-functioning adults from a range of educational background.

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## Conflict of interest

None declared.

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