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Correlates of quitting the Paced Auditory Serial Addition Test in cognitively normal older adults participating in a study of normal cognitive aging

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Abstract

Our study of cognitive aging involves a comprehensive battery of neuropsychological measures. The Paced Auditory Serial Addition Test (PASAT) is the only test that some of our participants will refuse to complete. We explored variables related to quitting versus completing the PASAT in this sample of normal older adults. We hypothesized that quitting would be related to personality features, subclinical anxiety symptoms, demographics, and/or Wechsler Adult Intelligence Scale–Revised (WAIS–R) Arithmetic performance. A logistical regression model including NEO Personality Inventory–Revised (NEO-PI-R) depression and excitement seeking, age, and WAIS–R Arithmetic classified participants with moderate accuracy. We encourage investigators involved in longitudinal studies to consider causes for missing data, especially when secondary to participant refusal.

Keywords

Normal cognition; Aging; Personality; Paced Auditory Serial Addition Test; Neuropsychology

An important part of the early detection of cognitive decline in advance of the normal aging process in older adults is neuropsychological tests that are challenging enough to capture mild change. This results in sensitive neuropsychological measures, but also results in tests that are subjectively difficult for many individuals, including those who are judged to have normal cognitive functioning. The Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977) is an example of a test that is challenging for many individuals, even those with normal cognitive functioning. According to Strauss, Sherman, and Spreen (2006), the PASAT requires sustained attention as well as working memory, all at an increasingly challenging pace. They conclude, “recent thinking indicates that the PASAT is a demanding, multifactorial task” (p. 584).

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The Arizona APOE cohort is an ongoing study of normal cognitive aging initiated in 1994 with ongoing enrollment and follow-up. This sample is enriched for ApoE ϵ 4 (apolipoprotein E type 4), one of the strongest risk factors for Alzheimer's disease beyond age (e.g., Corder et al., 1993). The study involves comprehensive neuropsychological evaluation every 2 years, along with neurological evaluation and completion of other self-report and observer-report questionnaires. The PASAT was added to the neuropsychological battery in 1999 to expand evaluations of frontal lobe cognitive processes and is the only measure in our comprehensive battery that some subjects will refuse to complete or quit out of frustration with the perceived difficulty of the task.

Previous studies have examined whether personality traits are associated with study completion. Jerant, Chapman, Duberstein, and Franks (2009) reported that personality factors, specifically higher Openness, Agreeableness, and Conscientiousness were independently associated with *fewer* missing data in their randomized controlled trial of an illness self-management intervention in individuals over age 40 with a variety of chronic diseases. That study involved the participants completing a questionnaire on illness management self-efficacy; missing data resulted from drop-out, missed data collection appointments, or failure to complete the questionnaire at a data-collection appointment. Courneya, Friedenreich, Sela, Quinney, and Rhodes (2002) examined correlates of adherence in a randomized controlled trial of exercise in cancer survivors and found that Extraversion was an independent predictor of adherence to a home-based exercise program for the cancer survivors who were randomized to the exercise arm of the study.

Neither of the above studies involved neuropsychological test data, nor did they address participants actively refusing to complete a task with the investigator present. Furthermore, it is difficult to generalize the predictors of compliance with an exercise program at home to completion of a challenging cognitive task in the office. To our knowledge, there are no studies investigating refusal of the PASAT specifically or even active verbal refusal of a neuropsychological test. Perhaps the most similar literature is on passive refusal to complete just some items on self-report measures of personality and psychopathology and the impact of those missing data on results (e.g., Berry et al., 1997). However, such data are not directly applicable to quitting the PASAT or understanding the reasons for quitting behavior on neuropsychological tests for several reasons. First, item omission on measures of personality and psychopathology may not be generalized to test refusal on measures of cognition. Second, the PASAT is given by an examiner, to whom the participant must voice active refusal to complete the task, while measures of psychopathology are often self-report, and the participant can more passively omit answers to a few items while still completing the task. Finally, most studies examine how the omitted items affect resulting profiles, but do not consider what may have contributed to the participant omitting those items in the first place.

Thus, the goal of this study was to begin to understand the reasons for active refusal of a difficult cognitive task—in this case, the PASAT. We were especially interested in determining whether there are personality trait correlates of this behavior in otherwise cognitively normal participants.

Given the work of Jerant et al. (2007), we hypothesized that higher Openness, Agreeableness, and Conscientiousness would be positively related to completer status. Courneya et al.'s (2002) work suggests that higher Extraversion would also be related to completing the PASAT. We further hypothesized that higher Neuroticism—vulnerability to negative affect—would be positively related to quitting the PASAT. We also examined demographic characteristics, including age, gender, and years of education, to determine

their relationship to PASAT status. Specifically, we hypothesized that older age, female gender, and fewer years of education would be related to quitting the PASAT.

In this sample, participants were required to be free of current significant mood or anxiety symptoms to qualify for enrollment. Thus, we would be unlikely to have individuals in the study who would meet criteria for a formal mood or anxiety disorder. Nevertheless, we thought that subclinical levels of anxiety-related symptoms could be related to status on the PASAT. Specifically, we hypothesized that higher levels on Anxiety (ANX) and Anxiety Related Disorders (ARD) on the Personality Assessment Inventory (PAI; Morey; 1991) would be related to quitting the PASAT.

As part of the comprehensive neuropsychological battery, each participant completes the Arithmetic subtest of the Wechsler Adult Intelligence Scale–Revised (WAIS–R; Wechsler, 1981). As another measure of working memory based on mental calculation, we hypothesized that lower scores on Arithmetic would be seen in those quitting the PASAT.

METHOD

Participants

The Arizona APOE cohort began enrolling in 1994. Using local media advertisements, we recruited cognitively normal residents of Maricopa County who were 21 years of age or older to a study of normal aging. The majority of enrolled subjects are age 50 or older, and the project involves rolling enrollment. Through October of 2009, we enrolled 657 participants. Participants complete a comprehensive neurological and neuropsychological evaluation once every two years. Full details of enrollment as well as criteria for “normal” can be found in Caselli et al. (2009) as well as references utilizing earlier versions of the sample (e.g., Caselli et al., 2004). Briefly, to be considered normal, entry criteria included scores of at least 27 on the Mini-Mental State Examination (MMSE; with at least 1 of 3 on the recall subtest), 10 or less on the Hamilton Rating Scale for Depression (HAM-D) depression screen, and perfect scores on the Functional Activities Questionnaire (FAQ) and Instrumental Activities of Daily Living Questionnaire (IADL). We excluded anyone who reported a history (or who had evidence on physical examination) of a potentially confounding neurologic or psychiatric problem, or other medical problem including but not limited to stroke, epilepsy, multiple sclerosis, brain tumor, psychotic disorder or any history of antipsychotic medication use, current uncontrolled major depression or anxiety disorder, and any end-stage organ failure.

The neuropsychological evaluation includes measures of cognitive functioning, normal personality traits, and psychopathology. Participants have been followed for a maximum of nine epochs but most have been followed for two ($n = 504$), three ($n = 354$), or four ($n = 223$) epochs. The PASAT, which involves working memory, attention, and arithmetic, is one test in a larger battery of neuropsychological tests (see Appendix A), but it was added later in the research project, in approximately 1999. Participants completed the 3-second trial and the 2-second trial. In each trial, participants are instructed to serially add numbers less than 10, adding each new number to the number just previously given. In the 3-second trial, the numbers are presented every 3 seconds, and in the 2-second trial, the numbers are presented every 2 seconds. A total of 60 items are administered in each trial, and their scores are the number correct out of 60 in each trial. This study was approved by the Mayo Clinic Institutional Review Board.

Of the 657 participants enrolled in the study, 51 were lost to follow-up before the PASAT was added to the protocol and therefore never had an opportunity to attempt the task. Thus, since the addition of the PASAT to the battery, a total of 606 participants have had the

opportunity to complete the task. Of those, 31 participants (5.1%) either verbally refused to complete the task when given task instructions or the sample task, or verbally refused to continue the task after partial completion due to apparent frustration with the difficulty of the task. It is these 31 participants who form the quitters group. Nine of these subjects refused the PASAT in two test epochs, and 5 subjects quit the test in three test epochs; however, only the first quitting epoch was utilized for data analysis. Though it is a small percentage, no other test in the battery has this rate of refusal. The remaining 575 subjects formed the completers group.

Measures

As stated, the goal of this project is to better understand the contributions to this tendency to quit a challenging task. Our primary interest was on personality traits that may impact perseverance on such a difficult cognitive testing. A total of 70% (405/575) of completers and 81% (25/31) of quitters completed the NEO Personality Inventory-Revised (NEO-PI-R; Costa & McCrae, 1992). The NEO-PI-R was only recently added to the study battery in 2006. The NEO-PI-R is a 240-item self-report measure developed to operationalize the five-factor model of personality. There are five broad domain scales (Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness), each of which is further divided into six facet scales or subscales. The NEO-PI-R is not designed to measure pathology, but rather to describe a person's personality characteristics.

In addition to normal personality variants, all participants completed the Personality Assessment Inventory (PAI). The PAI is a 344-item self-report measure of psychopathology with a focus on capturing symptoms that may be related to Axis I disorders. It provides information on 22 nonoverlapping subscales including 4 validity scales, 11 clinical scales, 5 treatment scales, and 2 interpersonal scales.

Statistical analysis

We first explored predictive potential in the data by examining all correlations between PASAT quitting, NEOPI-R and PAI variables, age, gender, education, ApoE $\epsilon 4$ (apolipoprotein E type 4 allele) carrier status, and WAIS-R arithmetic total scores. Because the analyses were exploratory in nature, we considered both significant ($p < .05$) and marginally significant ($p < .10$) predictors as having potential value in classifying examinees. Next, we submitted all significant and marginally significant variables to a stepwise logistic regression to narrow the set to just the most relevant predictors (again using a liberal entry value of $p < .10$).

We next sought to determine the overall classification accuracy of the model. Unbalanced designs (as in the present sample) can lead to lower estimated predicted probabilities for the less common outcome and obscure the meaning of classification accuracy (see Cramer, 1998). Therefore, we used Monte Carlo methodology to account for these effects. One hundred replicated data sets were generated with 500 random draws each (i.e., 500 simulated participants per replication). Data were structured so that each draw consisted of a vector of normally distributed predictors (i.e., Depression, Excitement Seeking, age, and WAIS-R Arithmetic) with means and standard deviations taken from the present sample. We then simulated probabilities of PASAT quitting from the parameter estimates derived from the stepwise logistic regression. That is, we used the logistic model to compute probabilities from the simulated predictor variables and the observed regression weights. Data were forced to have proportionate outcomes (i.e., equal base rates) by altering the regression model's intercept. Then, using random uniform values, we discretized the probabilities into binary outcomes (i.e., simulated PASAT quitting vs. simulated PASAT completion). This introduced random error into the simulated data. Finally, we determined

the overall classification accuracy by dividing the total number of simulated true positives and true negatives by the total number of draws across replications.

RESULTS

Table 1 presents the means, standard deviations, and correlations between PASAT quitting and the NEO-PI-R predictor variables, as well as the significance of each correlation. As can be seen, none of the five primary domains of the NEO-PI-R (Neuroticism, Extraversion, Openness, Agreeableness, or Conscientiousness) or the two PAI variables of interest (ANX or ARD) were significantly correlated with PASAT quitting. However, three facets of the Neuroticism scale (Hostility, Depression, and Vulnerability to Stress) were significantly correlated with the criterion. In each case, those who completed the PASAT were lower than those who quit on these Neuroticism variables. In addition, one facet of the Extraversion scale (Excitement Seeking) demonstrated a trend towards significance, in this case with the quitters scoring lower than the completers. Of the demographic and cognitive variables (presented in Table 2), only age and WAIS–R Arithmetic were significantly correlated with PASAT quitting. The quitters were older and had lower Arithmetic scores. Notably, these two variables demonstrated the highest two correlations with the criterion in the sample.

Table 2 notes that there is no difference between groups on educational achievement. We evaluated select other cognitive measures in the battery in order to ensure that there were no broader differences between the groups on cognitive ability or premorbid baseline estimates. Specifically, there were no differences between groups on MMSE (Folstein, Folstein, & McHugh, 1975) score (29.6 vs. 29.5, $p = .15$), WAIS–R Information subtest scaled score (11.9 vs. 12.1, $p = .56$), or WAIS–R Vocabulary subtest scaled score (12.1 vs. 12.1, $p = .76$). There were also no differences on memory testing: Auditory Verbal Learning Test (AVLT; Rey, 1958), long-term memory trial (9.2 vs. 8.2, $p = .11$), AVLT Mayo Older Adult Normative Studies (MOANS; Ivnik et al., 1992) Learning Efficiency Index (99.5 vs. 100.9, $p = .58$), AVLT MOANS Delayed Recall Index (99.5 vs. 98.3, $p = .67$), AVLT MOANS Percent Retention Index (98.7 vs. 98.3, $p = .89$), Rey-O Complex Figure Test (Osterrieth, 1944; Rey, 1941) delayed recall (18.3 vs. 17.4, $p = .48$), the Free and Cued Selective Reminding Test (FCSRT; Ivnik et al., 1997) total free recall (87.4 vs. 84.1, $p = .12$), and FCSRT total cued recall (24.4 vs. 27.8; $p = .12$).

We next submitted the Hostility, Depression, Vulnerability to Stress, and Excitement Seeking facet scales of the NEO-PI-R to a stepwise logistic regression analysis along with the age and WAIS–R Arithmetic variables (Table 3). The final model reduced to four predictors: Depression, Excitement Seeking, age, and WAIS–R Arithmetic. Of these, age and WAIS–R Arithmetic appeared to account for the majority of predictable variance. PASAT quitters were older, performed worse on the WAIS–R Arithmetic subscale, were more prone to depression, and were less excitement seeking.

Results from the logistic regression analysis revealed that 95% of examinees were correctly classified by the model; however, this estimate is biased by the rare occurrence of quitting among the participants (i.e., the model simply predicted that all examinees would complete the test). Our Monte Carlo study of classification accuracy provided an estimate of 76% accuracy. This estimate suggests that PASAT quitting can be predicted with moderate accuracy by a combination of personality, cognitive, and demographic variables.

DISCUSSION

In our study of normal cognitive aging, the PASAT is a challenging neuropsychological measure included in the battery. This is the only test that participants occasionally refuse to

complete due to frustration with the task. Specifically, in this sample, 5% refused the task or quit the task prior to completion.

Our primary aim was to determine whether personality factors were related to this quitting behavior. Unlike previous studies of personality and adherence (Courneya et al., 2002; Jerant, Chapman, Duberstein, & Franks, 2009), which looked at personality traits associated with general nonadherence to study tasks in randomized control trials, our investigation focused on the personality traits associated with quitting a challenging cognitive task. We hypothesized that this behavior would be related to personality factors, such as high Neuroticism or low Conscientiousness. In this sample, the NEO-PI-R personality facets of depression (from the Neuroticism domain) and excitement seeking (from the Extraversion domain) were the most useful in predicting quitting on the PASAT. However, it must be noted that the effect sizes were small, suggesting that personality traits do not account for the majority of the variance in this quitting behavior.

Quitters were higher than completers on the depression facet and lower than completers on the excitement seeking facet. According to the NEO-PI-R test authors, higher scores on the depression facet are related to being prone to sadness as well as being easily discouraged. Higher scores on excitement seeking are related to craving excitement and stimulation as well as liking noisy environments. They suggest this is related to some aspects of sensation seeking. Low-scoring individuals feel little need for such stimulation and may prefer more low-key environments. Perhaps individuals higher in excitement seeking have more tolerance for the rapid-paced and challenging task that is the PASAT, while those who quit the task are more prone to being easily discouraged. Again, we caution that the associations between quitting and these traits were small and therefore leave much to be understood about the causes of this quitting behavior by research participants. Nevertheless, we hope that this exploratory, but hypothesis-driven, approach to considering the causes of missing data could serve as a model for future research on the topic.

Evaluation of premorbid baseline indicators, as well as other aspects of the larger cognitive battery, reveals that the quitter group did not show generally lower premorbid baseline estimated abilities or lower memory functioning than the completer group. Thus, the quitting behavior does not appear related to lower cognitive abilities.

Another hypothesis to consider is whether quitting behavior in neuropsychological studies heralds evolving cognitive change, even though the group as a whole does not appear to have lower cognitive abilities. Neurodegeneratively based dementias such as Alzheimer's disease, dementia with Lewy bodies, and frontotemporal dementia have been found to have an extended preclinical phase with neuropathological involvement of cognitively salient structures (particularly frontotemporal cortices) and neurochemical systems (such as acetylcholine and dopamine). Future studies correlating "quitter status" with brain imaging and longitudinal cognitive trajectories may clarify this further.

Limitations to this study include the small sample size of the quitting group. This was not an experimentally manipulated group; rather, we evaluated those with a natural history of quitting the test. This was a relatively rare event given the large percentage of those who completed the PASAT, but it is the only task in our battery that individuals refused to complete or discontinue out of frustration. Thus, despite the small sample, it is useful to attempt to understand factors that may contribute to this behavior in clinical trials. It is also important to note the exploratory nature of our analyses. We fully intend to present these ideas as preliminary in the hope that this will encourage further evaluation of quitting behavior in neuropsychological studies. Similarly, despite the significance of our results, the variance accounted for is modest. This leaves much unexplained about the contributions to

quitting behavior in the context of challenging neuropsychological measures in cognitively normal older adults.

In sum, it appears that in our sample of cognitively normal older adults, inability to tolerate the PASAT and ultimately refusing the task is at least partially related to the personality facets of low excitement seeking and high vulnerability to depression, as well as increased age and poor mental arithmetic ability. Given the relationship with WAIS–R arithmetic scores, quitting the PASAT may also be related to comfort with math or math skill, but we do not have a direct measure of math comfort or basic math skill.

Exercising one's mind has been suggested to protect against cognitive decline (e.g., Smith et al., 2009). Yet, pushing oneself to focus and complete mental arithmetic is often unpleasant and difficult. Our study suggests that persons who thrive on high stimulation and who are less prone to becoming discouraged may be more likely to engage in such behaviors. Future studies might correlate such personality traits to those who comply with challenging mental tasks or, given the study by Courneya et al. (2002), physical tasks. Finally, in light of our findings, we encourage investigators involved in longitudinal projects related to cognitive aging to be thoughtful about the potential contributors to missing data, including the impact of normal personality traits.

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APPENDIX A

Listing of the complete neuropsychological battery

- Wechsler Memory Scale–Revised Orientation subtest
- Dementia Rating Scale–2 (DRS–2)
- Wechsler Adult Intelligence Scale–Revised (WAIS–R) selected subtests: Information, Digit Span, Vocabulary, Arithmetic, Similarities, Block Design, Digit Symbol
- Auditory Verbal Learning Test (AVLT)
- Boston Naming Test (BNT)
- Controlled Oral Word Association Test (COWAT)
- Token Test
- Benton Facial Recognition Test
- Judgment of Line Orientation (JLO)
- Wisconsin Card Sorting Test (WCST)
- Benton Visual Retention Test (BVRT)
- Free and Cued Selective Reminding Test (SRT)
- Personality Assessment Inventory (PAI)

TABLE 1

Group differences on the personality variables

		PASAT completers		PASAT quitters		r	p
		M	SD	M	SD		
NEO-PI-R Neuroticism	N1: Anxiety	43.56	9.58	46.54	10.28	.07	.14
	N2: Hostility	45.77	9.26	49.79	7.82	.10	.04
	N3: Depression	44.14	9.13	48.25	9.85	.10	.03
	N4: Self-Consciousness	46.44	8.89	45.79	7.70	-.02	.73
	N5: Impulsiveness	46.33	9.37	47.29	6.76	.02	.62
	N6: Vulnerability to Stress	45.45	9.15	50.62	7.52	.13	.01
NEO-PI-R Extraversion	E1: Warmth	49.05	9.02	46.92	8.39	-.05	.26
	E2: Gregariousness	50.93	9.24	49.63	9.94	-.03	.50
	E3: Assertiveness	51.58	10.40	51.29	10.81	-.01	.89
	E4: Activity	53.39	9.49	53.42	8.04	.00	.99
	E5: Excitement Seeking	48.66	9.46	47.96	9.28	-.02	.72
	E6: Positive Emotions	47.45	9.16	44.13	5.43	-.08	.08
NEO-PI-R Openness	O1: Fantasy	50.56	9.85	48.00	9.79	-.06	.22
	O2: Aesthetics	51.73	9.93	51.96	8.64	.01	.91
	O3: Feelings	49.10	8.97	50.71	8.61	.04	.39
	O4: Actions	51.02	9.87	54.17	8.35	.07	.13
	O5: Ideas	49.43	8.64	47.29	8.22	-.06	.24
	O6: Values	49.56	10.26	47.88	8.63	-.04	.43
NEO-PI-R Agreeableness	A1: Trust	52.14	10.24	50.08	10.85	-.05	.34
	A2: Straightforwardness	50.78	10.34	48.38	9.59	-.05	.27
	A3: Altruism	52.95	8.87	53.25	8.08	.01	.87
	A4: Compliance	54.18	8.35	54.04	7.10	.00	.94
	A5: Modesty	52.18	8.74	52.42	4.85	.01	.89
	A6: Tendermindedness	52.34	9.13	51.13	11.34	-.03	.53
		52.44	9.30	51.67	6.96	-.02	.69
		50.96	9.69	51.25	6.29	.01	.88
		51.44	9.67	52.12	10.48	.02	.74
		50.24	9.49	49.33	8.99	-.02	.65

		PASAT completers		PASAT quitters		r	p
		M	SD	M	SD		
NEO-PI-R	C1: Competence	54.40	9.41	53.46	7.28	-.02	.63
Conscientiousness	C2: Order	48.32	10.23	46.25	8.94	-.05	.33
	C3: Dutifulness	53.42	8.60	51.71	7.73	-.05	.34
	C4: Achievement Striving	49.91	9.68	48.79	10.58	-.03	.58
	C5: Self-Discipline	49.12	10.39	45.67	10.41	-.08	.11
	C6: Deliberation	54.20	9.55	55.04	10.68	.02	.68
PAI ANX		45.63	6.83	47.23	7.18	.05	.21
PAI ARD		44.97	8.14	45.20	10.06	.01	.88

Note. PASAT = Paced Auditory Serial Addition Test; NEO-PI-R = NEO Personality Inventory-Revised, T scores; PAI ANX = Personality Assessment Inventory Anxiety scale, T score; PAI ARD = Personality Assessment Inventory Related Disorder scale, T score.

TABLE 2

Group differences on the demographic and cognitive variables

	PASAT completers		PASAT quitters		r	p
	M	SD	M	SD		
Age (years)	55.81	11.60	66.00	8.91	.19	<.001
Gender (% female)	69		81		.06	.16
Education (years)	15.65	2.43	15.42	2.13	-.02	.61
ApoE ϵ 4 status (% carriers)	43		48		.02	.61
WAIS-R Arithmetic	11.64	2.58	9.74	2.79	-.16	<.001

Note. PASAT = Paced Auditory Serial Addition Test; WAIS-R Arithmetic = Wechsler Adult Intelligence Scale-Revised Arithmetic age-corrected scaled score. ApoE ϵ 4 = apolipoprotein E type 4 allele.

Stepwise logistic regression of combined personality, demographic, and cognitive variables

TABLE 3

Results of stepwise entries			Final model parameter estimates		
Step added	Variable	Cumulative R ² upon entry ^a	B	Exp(B)	p
1	WAIS-R Arithmetic	.13	−0.44	0.65	<.001
2	Age	.24	0.11	1.11	<.001
3	N3: Depression	.27	0.05	1.06	.02
4	E5: Excitement Seeking	.29	−0.05	0.95	.06

Note. WAIS-R Arithmetic = Wechsler Adult Intelligence Scale-Revised Arithmetic subscale; N3 = NEO Personality Inventory-Revised, Depression facet; E5 = NEO Personality Inventory-Revised, Excitement Seeking facet.

^a Nagelkerke index of pseudovariance accounted for.