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Aging with Elevated Autistic Traits: Cognitive Functioning Among Older Adults with the Broad Autism Phenotype

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Abstract

Background: Little is known about the impact of aging with autism spectrum disorder (ASD) on cognition. As a first step in addressing this gap in our knowledge, the current study examined cognitive functioning among older adults with elevated, but subclinical levels of autistic traits (i.e., the Broad Autism Phenotype; BAP) compared to older adults without the BAP.

Method: Forty older adults (aged 60-91, M=73 years) were recruited and classified as meeting criteria for the BAP (n=20) or not (control older adults, COA; n=20). Different components of executive function as well as episodic memory were measured using standardized performance-based neuropsychological assessments in addition to a self-report questionnaire of executive function difficulties.

Results: Despite no differences in age, sex ratio, educational history or IQ, the BAP group demonstrated poorer performance on measures of executive function and episodic memory compared to the COA group. The BAP group also self-reported more executive function difficulties in everyday settings. Moreover, differences in working memory and attentional shifting were maintained after accounting for the influences of IQ and both depression and anxiety symptoms.

Conclusions: These findings suggest that aging with the BAP confers additional risk to cognitive function for older adults. As the BAP forms a bridge in the continuum from typical to atypical levels of autistic traits, these findings suggest that individuals with ASD might also incur cognitive costs as they age into older adulthood.

Keywords: aging; broad autism phenotype; executive function.

Highlights

Adults aged >60 were classified as being on the Broad Autism Phenotype (BAP) or not, on the BAP Questionnaire (BAPQ).

Older BAP adults demonstrated poorer performance on three executive function measures and a measure of episodic memory.

Older adults who met the BAP criteria reported poorer real-world executive abilities.

Older adults who met the BAP criteria also reported higher levels of depression and anxiety.

Results suggest that autism traits as measured by the BAPQ may confer additional risk of cognitive decline in aging.

Introduction

The Broad Autism Phenotype (BAP) describes a set of subclinical behaviors in unaffected individuals that are associated with and qualitatively similar to the dyad of impairment (i.e., social-communication and restricted and repetitive patterns of behavior) found in autism spectrum disorder (ASD; Bolton et al., 1994; Constantino & Todd, 2003; Ronald et al., 2005; Ruzich et al., 2015; Skuse et al., 2005). Although these behavioral traits are expressed to a milder degree in the BAP than in ASD, examining the BAP may prove particularly insightful, especially vis-à-vis unique subgroups in ASD or where recruitment difficulties occur. For example, although there is growing awareness that the number of older adults with ASD is increasing due to an increasing aging population and our understanding of aging in ASD is strikingly limited, studies struggle to recruit older adults with ASD to participate in research (Stuart-Hamilton et al., 2009). Even when these studies are completed, they are often hampered with cohort issues wherein older adults with long-held ASD diagnoses are much more likely to have co-occurring intellectual disability compared to those now receiving the diagnosis in childhood, for example. Examining the BAP in older adults circumvents these issues while also informing aging with ASD.

With prevalence estimates of ASD being around 1% and the older adult population increasing, it is estimated that in the UK 153,000 individuals with ASD are over 60 years old (UK Office for National Statistics, 2017). It is not yet clear how the aging process impacts individuals with ASD. As studies of young adults have demonstrated differences in brain structure (e.g., Ecker et al., 2012, 2013; Wallace et al., 2010, 2013) and difficulties in some aspects of cognitive function (e.g., Sachse et al., 2013; Wallace, Kenworthy et al., 2016), adults with ASD may be more vulnerable to age-related declines compared to typical older adults (Geurts & Vissers, 2012). Alternatively, these differences in brain structure and cognitive function may mean that adults with ASD have always processed information differently from typical adults, and may be protected, at least to some degree, against age-related declines. So far the literature in support of either of these outcomes is limited; therefore, examining the BAP in older adults might provide insight into the likely outcome.

There are a growing number of studies examining cognitive functioning in ASD across the adult lifespan. Many studies have focused on adults with ASD who have IQ in the normal range but studies

vary in which aspects of cognition are examined. For some abilities (e.g., semantic fluency, planning, verbal memory), adults with ASD have shown the same pattern of age-related decline as typical adults, that is, poorer performance with increasing age (Davids, Groen, Berg, Tucha, & van Balkom, 2016; Geurts & Vissers, 2012). However, different age-related trajectories in ASD have been noted in certain domains of cognition. A steeper age-related decline has been reported in visual memory, whereas phonemic fluency, working memory, digit symbol substitution, and category learning have demonstrated less age-related decline in ASD when compared to typical adults (Lever & Geurts, 2016a; Geurts & Vissers, 2012; Happé et al., 2016; Powell, Klinger, & Klinger, 2017). Many of the cognitive abilities examined can be classified as executive functions (EF). EF is an umbrella term used to describe goal-directed behaviors (including planning, cognitive flexibility/set-shifting, inhibitory control, and working memory), which are known to be prone to age-related decline.

To date, the domains of EF most commonly explored in aging with ASD are generativity/spontaneous flexibility (measured by verbal fluency), reactive flexibility (measured by Trails tasks or a modified Wisconsin Card Sorting Test), planning (measured by towers tests such as the Tower of London), and working memory (measured by spatial span or N-back tasks) (Davids, Groen, Berg, Tucha, & van Balkom, 2016; Geurts & Vissers, 2012; Lever & Geurts, 2016a; Lever, Werkle-Bergner, Brandmaier, Ridderinkhof, & Geurts, 2015; Powell, Klinger, & Klinger, 2017). Although all these EF abilities decline with increasing age, the age at which decline begins and the trajectories of decline differ across domains (Amieva, Phillips, & Sala, 2003; Baltes & Lindenberger, 1997; Hasher, Zacks, & Rahhal, 1999). Furthermore, although several studies exploring cognition in aging with ASD have utilized either the same or very similar measures, the pattern of results is inconsistent across studies (Davids et al., 2016; Geurts & Vissers, 2012; Lever, et al., 2015; Powell et al., 2017). While there are differences between the samples in these studies, there are no characteristics that obviously account for the pattern of results. Given that studies of children and young adults with ASD show both differences across domains of EF and in trajectories with age, it is imperative to explore age effects on EF widely in this early stage of ASD-aging research (Hill, 2004; Kenworthy, Yerys, Anthony, & Wallace, 2008; Wallace, Yerys et al., 2016).

To our knowledge, only one study has previously examined EF in later life within the BAP (Wallace, Budgett, & Charlton, 2016). Wallace, Budgett et al. (2016) examined self-reported BAP traits, EF difficulties, and both depression and anxiety in adults over 60 years old. Individuals who met criteria for being above cut-off on the BAP Questionnaire (Hurley, Losh, Parlier, Reznick, & Piven, 2007) reported more EF difficulties compared to those below the cut-off (i.e., COA). Furthermore, individuals classified as expressing the BAP, reported higher levels of depression and anxiety symptomatology than COA. Nevertheless, this study relied on self-ratings alone to characterize EF difficulties. To our knowledge, no studies have utilized performance-based measures to assess EF and other aspects of cognition among older adults with and without the BAP. Most other studies of cognitive functioning in the BAP have examined (young to middle-aged adult) parents and (mostly pediatric) siblings of children with ASD. Although results are mixed, many studies have demonstrated poorer EF abilities (particularly in planning and flexibility) in parents of children with ASD compared to parents of typically developing children (Delorme et al., 2007; Hughes, Leboyer, & Bouvard, 1997; Piven & Palmer, 1997), while others do not (Losh et al., 2009). These findings suggest that BAP traits could represent an additional risk factor, exacerbating normative age-related cognitive declines.

Additional factors that influence outcomes both in aging and in ASD are the presence of depression and anxiety. ASD is associated with higher rates of depression and anxiety among children and adolescents (Salazar et al., 2015; Strang et al., 2012). Similarly, among young and middle-aged adults, individuals with ASD are more likely to experience depression and anxiety compared to their same age peers (Croen et al., 2015; Lever & Geurts, 2016b). Paralleling these studies, high rates of depression and anxiety have also been identified in individuals with BAP traits (Wainer et al., 2013) and in family members of individuals with ASD (Ingersoll et al., 2011; Wilcox et al., 2003). To date, only one study has examined mood in BAP older adults, and found greater self-reported depression and anxiety in those meeting criteria for the BAP than COA (Wallace, Budgett et al., 2016). Rates of depression among neurotypical older adults are no lower than across the lifespan (Beekman, Copeland, & Prince, 1999). However late-life depression is also associated with poorer outcomes, including residual executive dysfunction even when mood has stabilized (Alexopoulos et al., 2005; Barch et al., 2012). Although some studies have suggested that anxiety may reduce in typical aging, other studies have found that rates of anxiety and presence of anxiety symptoms remains high in later

life (Mehta et al., 2003; Vink, Aartsen, & Schoevers, 2008). Furthermore, anxiety has been found to be more common in older adults living in care homes or with comorbid health problems, as well as remaining highly associated with presence of depression (Bryant, Jackson, & Ames, 2008; Vink et al., 2008). Therefore autistic older adults reporting depression and anxiety may be at an elevated risk for poorer outcomes and cognitive decline.

This study investigates whether the presence of the BAP among healthy older adults (aged 60-91 years), negatively impacts cognitive (including EF) performance and self-ratings of real-world EF as compared to COA. Previous research indicates that individuals who endorse high BAP traits experience greater self-reported everyday EF difficulties than COA. Therefore, we predict a similar pattern based on performance-based measures wherein older adults who meet criteria for the BAP will demonstrate poorer cognitive performance across domains and report more EF difficulties in everyday life. Additionally, we expect to find greater endorsement of depression and anxiety symptoms in BAP than COA, though the hypothesized performance-based cognitive deficits in the BAP relative to the COA group are predicted to persist even after accounting for these elevated depression and anxiety symptoms.

Method

Participants

Forty native English-speaking community-dwelling older adults situated in London and the South-East of England were recruited for this study (age range=60-91 years, see Table 1 for demographic details). Individuals over 60 years old were recruited through local community groups (e.g., Bowling Clubs, Women's Groups, Golf Clubs, Retirement Communities), with additional targeted recruitment occurring for family members with a first or second degree relative with ASD through online adverts (e.g., Research Autism, National Autistic Society) and through a preexisting database established by the GoldAge Research Lab. Previously obtained effect sizes (Cohen's d=1.15-1.99) from our study of BAP vs. non-BAP older adults using self-report EF measures (Wallace, Budgett et al., 2016) suggest

that the current sample is sufficient in size to identify an effect based on power = 95% and alpha=.05 for two-tailed analysis.

All individuals gave written informed consent prior to participation and all research was carried out per the Declaration of Helsinki. This study received ethical approval from the Goldsmiths University Ethics Committee. Individuals were offered £5 for their participation in the study, and up to £10 for their travel expenses.

Measures

Questionnaires were administered prior to the in-person assessment, and were completed either on paper distributed via post or online using Qualtrics Survey Software (www.qualtrics.com). All individuals completed the Broad Autism Phenotype Questionnaire (BAPQ; Hurley et al., 2007), the Geriatric Depression Scale (GDS; Yesavage, 1988) the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988), and the Behavior Rating Inventory of Executive Function, Adult version (BRIEF-A; Roth, Isquith, & Gioia, 2005) from which the Behavioral Regulation Index (BRI) and Metacognition Index (MI) were calculated. Cronbach's alphas were calculated for each of the self-rating measures and were all good to excellent (BAPQ, α=.859; GDS, α=.881; BAI, α=.860; BRIEF-A, BRI α=.921, MCI α=.972).

An in-person neuropsychological assessment battery was administered by a trained research assistant. Participants completed the Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975) as a screener for possible cognitive impairment and the Wechsler Test of Adult Reading (WTAR) adjusted for age and sex (Wechsler, 2001) to estimate premorbid full scale IQ (FSIQ). A standardized neuropsychological assessment battery was selected to allow comparison to age-normative data. The domains of EF were selected based on previous research demonstrating age-effects or ASD-related differences. Tasks administered were the Delis-Kaplan Executive Function System (DKEFS; Delis, Kaplan, & Kramer, 2001) subtests of Trail Making (Number-Letter Switching minus Motor speed) to measure reactive flexibility and Verbal Fluency (phonemic fluency) to measure spontaneous flexibility from the. From the Wechsler Memory Scale-IV (WMS-IV; Wechsler, 2009)

subtests Letter-Number Sequencing and Digit Span measured working memory, and Logical Memory Immediate Recall measured episodic memory.

Statistical Analyses

All statistical analyses were performed using SPSS (version 22.0; IBM Corp., 2013). BAP and COA group differences in demographic variables were analyzed using χ^2 and analysis of variance (ANOVA). ANOVA was also used to evaluate differences between BAP and COA groups on age-normed neuropsychological task performance and self-ratings of EF difficulties. These analyses were rerun using analysis of covariance (ANCOVA) to confirm that any group differences were not attributable to the influence of IQ, anxiety (BAI), and depression (GDS) symptoms. Pearson correlations were performed on the whole sample to explore associations between BAP traits continuously and EF abilities.

Results

Demographics

No differences in demographic characteristics were observed between the BAP and COA groups regarding age, sex ratio, education level, MMSE score, or estimated FSIQ (see Table 1 for full demographics). Consistent with recruitment strategy and expectations, individuals in the BAP group (n=10) were more likely to have a family member with a diagnosis of ASD than the COA group (n=2; χ^2=7.619, p=.006). The BAP group also reported significantly higher levels of depression and anxiety compared to the COA group (see Table 1). In the BAP group seven individuals reported depression in the mild range and two reported severe depression, compared to one COA who met criteria for mild depression. Five individuals in the BAP group were classified as reporting moderate anxiety, compared to none of the COA.

Group differences

One-way ANOVAs revealed that individuals in the BAP group performed significantly worse than individuals in the COA group on DKEFS Trail Switching, WMS-IV Letter-Number Sequencing, Digit Span, and Logical Memory Immediate Recall. No statistically significant difference was observed in DKEFS Verbal Fluency task performance (see Table 2 and Figure 1 for details). A follow-up ANCOVA

controlling for FSIQ as well as depression (GDS) and anxiety (BAI) ratings found the same pattern of results (see Table 2).

INSERT FIGURE 1 ABOUT HERE

Individuals in the BAP group reported significantly more EF difficulties on the BRIEF-A, based on the Behavioral Regulation Index and Metacognition Index, than individuals in the COA group (see Table 2).

An alternative cut-off score for the BAPQ has been proposed by Sasson et al. (2013); if this more conservative cut-off is applied to the current sample the BAP group is reduced to 15 individuals. Nevertheless, analyses repeated with this alternative cut-off remain unchanged from the results presented above.

Correlational Analyses in the Whole Sample

Pearson correlations were performed to examine associations between variables of interest. EF variables of Letter-Number Sequencing and Digit Span both correlated significantly with the presence of BAP traits, indicating poorer working memory performance in the presence of more endorsed BAP traits across the entire sample (see Table 3). Neither flexibility measure (reactive flexibility, Trails Switching-Motor speed; spontaneous flexibility, Verbal Fluency) correlated with BAP traits. Self-reported EF difficulties measured by the BRIEF-A (both Behavioral Regulation and Metacognition Indices) also correlated significantly with BAP traits, indicating poorer real-world EF abilities in the presence of higher BAP traits.

The pattern of correlations among EF measures was mixed, with many tasks demonstrating high correlations (ie Digit Span and Letter-Number Sequencing) while other correlations did not reach statistical significance (ie Trail Switching and Verbal Fluency). On the BRIEF-A self-report Behavioral

Regulation and Metacognition Indices were strongly correlated. Correlations between self-report EF abilities and EF task performance were also mixed. Only the BRIEF-A Behavioral Regulation Index correlated significantly with Letter-Number Sequencing performance (see Table 3).

Post-hoc Analyses: Graphical representation of the associations between BAPQ and task performance suggested possible non-linear associations. Therefore quadratic associations were explored. The quadratic models were significantly associated with BAP traits for the two working memory models, indicating that both very low and very high BAP traits were associated with poorer performance (see Figure 2). Quadratic models did not improve the fit for the associations between BAP traits and either the episodic memory measure (Logical Memory), or the two non-significant measures of flexibility (Trails Switching minus Motor; Verbal Fluency).

Discussion

The present study, for the first time, documents performance-based differences in cognition, particularly EF, among older adults with elevated BAP traits compared to COA. These performance-based EF differences were maintained even after accounting for the influence of IQ and both depression and anxiety symptoms. Moreover, this study corroborates our own previous findings (Wallace, Budgett et al., 2016) of higher self-ratings of EF difficulties in BAP older adults compared to COA. Taken together, these findings converge to suggest that the BAP provides additional risk to neurotypical aging, even beyond well-documented risk factors (e.g., depression). Given that the BAP forms a bridge in the continuum from typical to atypical levels of autistic traits, these findings suggest that individuals with ASD might also incur cognitive costs as they age into older adulthood.

Older adults with elevated BAP traits experienced greater cognitive difficulties, particularly within domain of working memory, and episodic memory compared to those in the COA group. The pattern of results was consistent when examining both group differences (BAP vs. non-BAP groups) and correlations with BAP traits examined dimensionally. Difficulties with components of EF, including working memory and attentional switching, are common features in typical cognitive aging (Nyberg, Lövdén, Riklund, Lindenberger, & Bäckman, 2012), and working memory has been found to be impaired in some studies of older adults with ASD using both performance-based measures (Geurts &

Vissers, 2012) and self-ratings (Davids et al., 2016). Our findings suggest that these EF impairments extend to older adults who endorse high BAP traits, highlighting the additional risk that BAP traits could confer to aging, particularly to areas already at risk for neurotypical age-related decline. However, associations between BAP traits and working memory also demonstrated significant non-linear effects. Results suggested that very low and very high BAP traits were associated with poorer working memory performance, whereas moderate BAP traits were associated with better working memory performance. It is important to note that these results were due to post-hoc comparisons and in a relatively modest sample, and therefore should be treated with caution. More broadly, this study joins others in linking the BAP with poorer EF than comparably aged control groups across the lifespan. For example, parents and siblings of children with ASD have demonstrated poorer EF using both performance-based measures and behavioral ratings scales when compared to parents and siblings of typically developing children (Delorme et al., 2007; Hughes et al., 1997; Piven & Palmer, 1997). However, not all domains of EF are associated with presence of BAP traits and some discrepant results were observed. A group difference between BAP and COA was observed in the reactive flexibility measure (Trails-Switching minus Motor speed), but the correlation with BAP traits did not reach significance. Both the group and correlational analyses suggest that for a measure of generativity / spontaneous flexibility (measured by verbal fluency) performance is not associated with BAP traits. This may suggest different trajectories of age-related change cross EF domains in the BAP, or reflect the fact that semantic knowledge is relatively spared in aging. Importantly, the current study not only replicates, but also extends our prior finding of poorer self-reported EF to include poorer EF task performance among those older adults self-rated as exhibiting the BAP compared to COA (Wallace, Budgett et al., 2016). However, it is important to point out that although self-ratings indicated more difficulty in the BAP than COA group, the standardized scores did not suggest clinically significant impairments, on average.

In keeping with both our previous findings and studies in young and middle-aged adults, individuals with BAP traits reported higher levels of depression and anxiety compared to COA (Wallace, Budgett et al., 2016; Ingersoll & Wainer, 2011; Wilcox et al., 2003). Although at the group level mean scores were not above the criteria for depression or anxiety concerns, seven individuals in the BAP group did meet this criterion. More specifically, five BAP older adults were above the threshold for both

depression and anxiety concerns, with two additional individuals above criterion for depression only. In comparison, only one member of the COA group self-rated depression symptoms indicating concerns. In typical aging, depression and anxiety are associated with increased social isolation (Taylor & Lynch, 2004), and there are complex bidirectional associations between depression and dementia (Bhalla & Butters, 2011). Therefore, presence of difficulties regulating mood even at a subclinical level may be a risk factor for poor outcomes in individuals aging with elevated autistic traits.

Finally, it is important to consider limitations and future directions. The present study includes a relatively small sample; however, given replication and convergence with findings in our previous study using an independent sample of older adults and consistent results across analyses, we are reassured that these findings are not due to chance alone. Moreover, the poorer EF performance in the BAP group remained after accounting for IQ as well as depression and anxiety symptoms. This suggests that although the BAP group reports greater anxiety and depression symptoms (consistent with children, adolescents, and adults with ASD: Croen et al., 2015; Lever & Geurts, 2016b; Salazar et al., 2015; Strang et al., 2012), at least some significant portion of this poorer performance is attributable to the BAP specifically. In other words, the BAP is not simply capturing a group with higher anxiety and/or depression who are more vulnerable to EF and other aging-related effects on cognition. A further caveat with regard to the sample presented here, is the inclusion of a relatively high proportion of females compared to many ASD studies. However, previous studies examining rates of the BAP in parents of children with versus ASD and typically developing children have found that the ratios of males to females meeting criteria for the BAP are not as male predominant as found in samples of individuals with ASD. Across four studies examining rates of BAP in parents of ASD and typically developing children, the mean proportions of individuals meeting BAP criteria were as follows: 22.5% of mothers and 30.1% of fathers of children with ASD versus 8.6% of mothers and 14.8% of fathers of typically developing children (Bora, Aydin, Sarac, Kadak, & Kose, 2017; Ruta, Mazzone, Mazzone, Wheelwright, & Baron-Cohen, 2012; Sasson et al., 2013; Wheelwright, Auyeung, Allison, & Baron-Cohen, 2010). Further and larger studies examining how gender impacts EF in both ASD and the BAP across the lifespan are needed, particularly given recent findings suggesting the presence of greater real-world EF problems in girls compared to boys with ASD (White et al., 2017).

Another important next step is to extend this research to include neuroimaging to identify neural markers of aging-related differences associated with the BAP. For example, do well-established gray and white matter changes during aging become exacerbated in older adults with the BAP and/or are they linked with these cognitive differences? In conclusion, taken as whole, the current study provides further evidence that the BAP might exacerbate age-related cognitive changes, though longitudinal studies are needed to establish this link more definitively.

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Figure 1. Comparison of age scaled mean scores of neuropsychological assessments within the Broad Autism Phenotype (BAP) and Control Older Age (COA) groups.

Note: *p<.05, **p<.01, ***p<.001

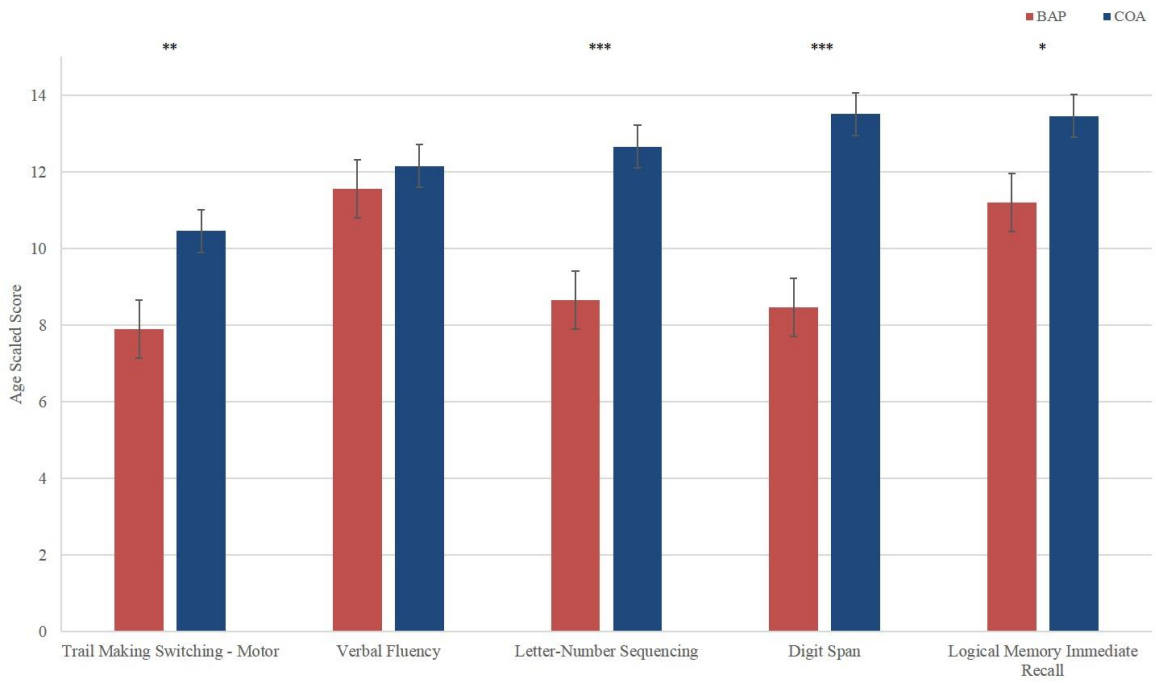

Figure 2. Linear and quadratic fits for associations between BAP traits and working memory (Letter-Number Sequencing; Digit Span) and episodic memory (Logical Memory). Letter-Number Sequencing: Linear R^2=.17, p=.009; Quadratic R^2=.24, p=.007; Digit Span: Linear R^2=.18, p=.006; Quadratic R^2=.25, p=.005; Logical Memory: Linear R^2=.11, p=.04; Quadratic R^2=.12, p=.10.

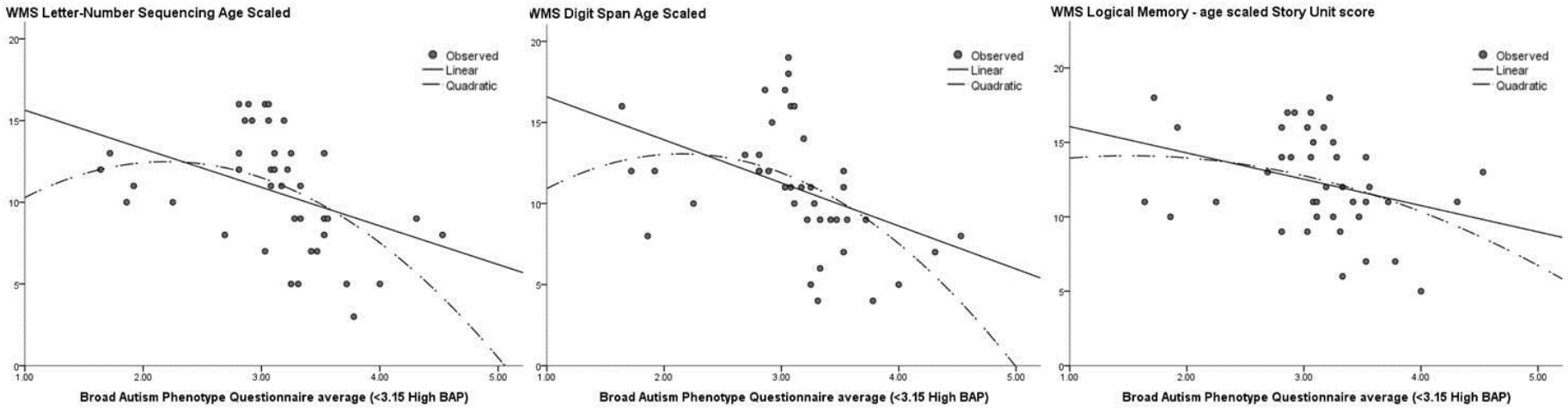

Table 1. Demographic characteristics of the BAP and COA groups

		Whole Sample (n=40)	**BAP (n=20)**	**COA (n=20)**	**Group Difference**	**Effect Size (Cohen's d)**
Age, years	*M (SD)*	73.05 (7.80)	73.80 (8.28)	72.30 (7.42)	F(1,38)=0.36, *p=.55*	d=0.20
Sex	*male:female*	14:26	9:11	5:15	χ^2=1.76, *p*=.19	d=0.43
Family member with ASD diagnosis	*yes:no*	12:28	10:10	2:18	χ^2=7.62, *p*=.006**	d=0.97
Highest Education	*None*	2	1	1	χ^2=7.00, *p*=.32	d=0.92
	School to 16	15	9	6		
	School to 18	8	4	4		
	Undergraduate	9	5	4		
	Postgraduate	6	1	5		
WTAR FSIQ, controlled for education and sex	*M (SD)*	106.43 (7.78)	104.65 (8.58)	108.20 (6.63)	F(1,38)=2.14, *p*=.15	d=0.48
MMSE	*M (SD)*	28.93 (1.02)	28.65 (1.27)	29.20 (0.62)	F(1,38)=3.05, *p*=.09	d=0.57
BAPQ, mean score	*M (SD) Range*	3.11 (0.61)	3.53 (0.37)	2.69 (0.51)	F(1,38)=36.58, *p*<.001***	d=1.96
		1.64-4.53	1.64-3.11	3.17-4.53		
GDS	*M (SD)*	6.88 (5.81)	9.60 (6.34)	4.15 (3.69)	F(1,38)=11.05, *p*=.002**	d=1.08
BAI	*M (SD)*	9.03 (7.83)	12.50 (5.56)	5.55 (5.22)	F(1,38)=9.62, *p*=.004**	d=1.00

Note: M, Mean; SD, Standard deviation; BAP, Broad Autism Phenotype; COA, Control Older Adult; WTAR FSIQ, Wechsler Test of Adult Reading Full-scale IQ estimate; MMSE, Mini Mental State Exam. *p<.05, **p<.01, ***p<.001

Table 2. Comparison of BAP and COA groups on neuropsychological task performance and executive function self-ratings.

	BAP (n=20)	**COA (n=20)**	**Group Difference**	**Effect Size,Cohen's d (Estimated sample size per group †)**	**Group Difference controlling for FSIQ, BAI, and GDS**	**Effect Size, Cohen's d (Estimated sample size per group †)**
Neuropsychological Measures						
Trail Switching - Motor	7.9 (2.83)	10.45 (2.65)	F(1,38)=8.68, *p*=.005**	d=0.96 (n=25)	F(4,35)=3.13, *p*=.086	d=0.57 (n=68)
Verbal Fluency	11.55 (3.69)	12.15 (2.94)	F(1,38)=0.32, *p*=.57	d=0.18 (n=804)	F(4,35)=1.26, *p*=.27	d=0.36 (n=168)
Letter-Number Sequencing	8.65 (3.18)	12.65 (2.68)	F(1,38)=18.48, *p*<.001***	d=1.36 (n=16)	F(4,35)=8.80, *p*=.005**	d=0.96 (n=25)
Digit Span	8.45 (2.72)	13.50 (3.04)	F(1,38)=30.67, *p*<.001***	d=1.75 (n=10)	F(4,35)=15.23, *p*<.001***	d=1.27 (n=15)
Logical Memory Immediate Recall	11.20 (3.35)	13.45 (2.98)	F(1,38)=5.03, *p*=.03*	d=0.71 (n=53)	F(4,35)=0.42, *p*=.52	d=0.21 (=492)
BRIEF-A Sub Scales						
BRI t-score	53.55 (12.38)	46.20 (7.84)	F(1,38)=5.03, *p*=.03*	d=0.71 (n=53)	F(4,35)=0.14, *p*=.71	d=0.12 (n=1504)
MI t-score	56.40 (14.49)	47.65 (11.78)	F(1,38)=4.39, *p*=.04*	d=0.66 (n=61)	F(4,35)=0.13, *p*=.72	d=0.12 (n=1504)

BAP, Broad Autism Phenotype; COA, Control Older Adult; *p<.05, **p<.01, ***p<.001; † Sample size calculation performed using G*Power based on Cohen's d, with power = 95% and alpha=.05 for two-tailed analysis.

Table 3: Correlations between EF and BAPQ variables

	BAPQ	Trail Switching	Verbal Fluency	Letter-Number Sequencing	Digit Span	Logical Memory Immediate Recall	BRI t-score
Trail Switching - Motor	r=-.213, p=.188	-	-	-	-	-	-
Verbal Fluency	r=-.032, p=.844	r=.039 p=.811	-	-	-	-	-
Letter-Number Sequencing	r=-.409, p=.009 **	r=.419, p=.007 **	r=.531, p<.001 ***	-	-	-	-
Digit Span	r=-.426, p=.006 **	r=.455, p=.003 **	r=.484, p=.002 **	r=.788, p<.001 ***	-	-	-
Logical Memory Immediate Recall	r=-.326, p=.040 *	r=.549, p<.001 ***	r=.460, p=.003 **	r=.584, p<.001 ***	r=.518, p=.001 **	-	-
BRI t-score	r=.576, p<.001 ***	r=-.311, p=.051	r=-.213, p=.188	r=-.326, p=.040 *	r=-.252, p=.117	r=-.367, p=.020 *	-
MI t-score	r=.549, p<.001 ***	r=-.216, p=.181	r=-.109, p=.505	r=-.204, p=.206	r=--.293, p=.066	r=-.224,p=.165	r=.771, p<.001 ***

*p<.05, **p<.01, ***p<.001