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ORIGINAL ARTICLE

Differences in Executive Functioning for children with additional learning needs and Autism Spectrum Disorder or Attachment Disorder

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Abstract
This study explored overlaps in diagnosis and characteristics of children (9–16 years old) with Autism Spectrum Disorder (ASD) and Attachment Disorder (AD) as they related to Executive Function (EF) to determine whether differences in EF would differentiate between the two conditions. A sample of 79 pupils with comorbid learning disabilities was examined in terms of their clinical diagnoses and psychometric traits, as well as on four EF tasks (WCST, Hungry Donkey, Stroop, and Tower of London). 25% of the sample met clinical diagnostic criteria for both ASD and AD, and a similar overlap was noted when using psychometric assessments. Little difference between the EF performances of individuals with ASD and AD was noted. There was slightly better AD performance on cold EF tasks requiring attentional shifting, and slightly better performance for ASD on hot tasks requiring inhibition. However, these differences would be of limited use in differentiating between the conditions for a learning-disabled population.

Keywords Autism Spectrum Disorder · Attachment Disorder · Executive Function · Differentiating Diagnoses

The current study explored overlaps in the diagnosis and characteristics of Autism Spectrum Disorder (ASD) and Attachment Disorder (AD), especially as they relate to Executive Function (EF) performances of individuals with ASD and AD. The aim was to determine whether any differences in EF functioning would be of use in differentiating between the conditions for a learning-disabled population. Executive functioning (EF) refers to an array of cognitive processes involved in top-down control of self-regulation, informing future-oriented behaviour (Roelofs et al., 2015),

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and adaption to the environment (De Vries & Geurts, 2015). EF develops most rapidly during the preschool years along with the growth of neural networks in the prefrontal cortex, but continues to develop into adulthood (Thompson & Steinbeis, 2020). These processes can be grouped into 'cold' and 'hot' components (Zelazo & Carlson, 2012): with cold components including working memory, planning, mental flexibility, sequencing, set-shifting, attention, problem-solving, verbal reasoning, multitasking and self-monitoring; while the hot components involve emotions, desires and beliefs (Miyake et al., 2000; Roelofs et al., 2015). Impairments or alterations in aspects of EF can impact the behaviours of the individual, and produce distressing consequences such as an inability to regulate emptions and behaviours (Chan et al., 2008; Colvert et al., 2008). It has also been suggested that examination of potential underlying cognitive functioning associated with developmental conditions, that may otherwise present similarly in terms of their behaviours, may be helpful in distinguishing the needs of those individuals (Hovik et al., 2017; Ozonoff & Jensen, 1999).

Alterations to EF abilities compared to the neurotypical population have been examined across a range of developmental disabilities and conditions, including extensive investigation for Autism Spectrum Disorder (ASD; Demetriou et al., 2018; Gilotty et al., 2002), and some analysis for Attachment Disorder (AD; Blair et al., 2018; Colvert et al., 2008). Both ASD and AD appear to show some level of alteration in EF relative to neurotypical peers. However, it is unclear whether these EF alterations differ between ASD and AD, as they do between other conditions (Bourke et al., 2020; Hovik et al., 2017). As such differences in EF have been suggested as a way of help to distinguish between disorders (Ozonoff & Jensen, 1999), this requires further invstigation. However, an issue complicating the understanding of differences may be the presence of comorbidities. As well as substantial overlap between presenting characteristics between ASD and AD (Davies et al., 2023; Davison, O'Hare, Mactaggart, Green, Young, Gillberg, & Minnis, 2015; Sadiq et al., 2012), both conditions have moderate to high levels of comorbidity with learning disabilities (Jang & Matson, 2015; Kildahl, Engebretsen, & Helverschou, 2019; Raaska, Elovainio, Sinkkonen, Matomäki, Mäkipää, & Lapinleimu, 2012). The presence of comorbid learning disabilities has been subject to little investigation regarding its impact on differentiation of ASD and AD (Davies et al., 2023), despite this group being of key interest to many special educators (Giltaij et al., 2015).

Altered EF has long been suggested to be associated with ASD, such as an inability to switch attention, and to underlie several of its behavioural presentations (see Geurts, de Vries, & van den Bergh, 2014; Hill, 2004, for reviews). Two large-scale meta analyses have confirmed, and added, to this suggestion (Demetriou et al., 2018; Lai et al., 2017). For individuals classed as having higher functioning ASD, Lai et al. (2017) noted children and adolescents were moderately impaired in terms of EF, including verbal and spatial working memory, cognitive flexibility and planning, and generativity. Similarly, Demetriou et al. (2018) analysed over 200 studies, involving in excess of 8,000 participants with ASD, which employed measures of concept formation, mental flexibility, fluency, planning, response inhibition, and/or working memory. The analysis found a moderate effect size for reduced EF, with similar effect sizes in each of the EF domains. However, Russell et al. (1996)

reported that, in contrast to higher functioning, verbal ASD (Bourke et al., 2020), EF differences between those with lower-functioning, non-verbal ASD and controls are much less pronounced. Similar lack of strong differences between children with and without ASD have been noted by Russell-Smith et al. (2014) and by Winsler et al. (2007).

A relationship between EF and AD also has been mooted, but is less well established than that for ASD. Early caregivers are taken to provide models for the development of attentional processes (Belsky et al., 2010), and for behavioural modulation and inhibition (Bernier et al., 2010; Nelson & Bloom, 1997). Colvert et al. (2008) suggested that deficits in EF are present for children with attachment problems. The participants were 165 children adopted by UK families, and the study reported that EF deficit was higher for children who were subject to institutional deprivation (placement in an institution that did not provide adequate care or stimulation) for more than 6 months. Colvert et al. (2008) suggested that EF deficits mediate the development of attachment problems in these individuals, and impaired EF has been noted to mediate relationships between disorganised attachment and behaviour problems (Low & Webster, 2016).

However, although associations between EF and both ASD and AD have been explored, there is not enough evidence to judge any correspondences or diversities between these conditions in this regard, especially in groups with comorbid learning disabilities. A primary aim of the current study was to compare EF abilities across these conditions. There have been some reported differences in both child behavioural characteristics, and in parenting, between samples with ASD and AD (Davies et al., 2023). As both of these factors may impact EF (Helm et al., 2020; Sosic-Vasic et al., 2017), this ability may be differentially affected across the two conditions. For example, peer problems predict ASD diagnosis, and conduct problems predict AD diagnosis (Davies et al., 2023). Children with ASD show more ambivalent attachment styles, and those with AD more avoidant and anxious attachment styles (Davies et al., 2023), and a significant factor with regards to diagnosing AD is neglect and early childhood abuse (APA, 2013). Given the above suggestions regarding parenting (Bernier et al., 2010, 2012; Colvert et al., 2008; Helm et al., 2020; Sosic-Vasic et al., 2017), and the presence of greater conduct problems in those with AD (Davies et al., 2023), one prediction could be that EF is more impaired in children with AD than ASD, especially in relationship to ‘hot’ EF tasks that modulate behavioural/emotional control (Miyake et al., 2000; Roelofs et al., 2015). However, as several investigations have noted that these differences are not always noted (e.g., Russell et al., 1996; Russell-Smith et al., 2014; Winsler et al., 2007), a null finding remains a possibility.

Thus, the current study provided an initial investigation into the EF abilities of the individuals with ASD and AD, focusing on those with a learning disability. Analysis was performed both on the basis of medical diagnosis and psychometric-defined characteristics. It is unclear what the impact on EF of any overlap in diagnosis/classification would be, and the study provided an additional assessment of this comorbidity (Davies et al., 2023). As comorbid learning disabilities may play a role in modulating the expression of EF function (Russell et al., 1996), and as individuals with such a diagnosis are highly represented in special educational needs placements (Jang & Matson, 2015; Raaska et al., 2012), such a co-morbid group was the focus of the study.

Methods

Participants and Setting

Seventy-nine participants (61 male, 18 female) were recruited, aged 9–16 (mean = 13 *SD* ± 1.65) from a special school for pupils with statements of educational needs including Learning Difficulties, Autism Spectrum Disorder, and/or children known to Social Services for family issues additionally to any diagnosis. Given the wide range of different conditions available in this school, it was thought that this would be a good sample to use to include sufficient numbers of children with different disorders. To be legally included in the statement of educational needs, confirmation of the diagnosis was needed from an NHS clinician. Additional background information regarding social services involvement was included through the school-based social worker. All children had a diagnosis of learning disabilities, which was either mild or moderate. No children withs ever learning disabilities were included as it was thought the task would be too difficult for them, and would cause needless distress. All children were verbal and could read. There were 30 (38%) pupils with neither ASD or AD; 9 (11%) with ASD alone; 20 (25%) with AD alone; and 20 (25%) with both ASD and AD. The genders, mean ages of each group, and mean age at diagnoses are shown in Table 1, which shows little difference between the groups on either of these variables. The study was approved by the University Ethics Committee.

Diagnostic procedures

Autism Spectrum Disorder

Diagnosis was made through multi-disciplinary clinical diagnostic assessment, including a range of professionals independent of the current study, such as a paediatrician, speech and language therapist, and specialist psychologist. All diagnoses were made within the last three years. The DSM-5 criteria were employed for all diagnoses (which were all made within the last 8 years), with clarification from

Table 1 Genders (percnatge male), mean (standard deviation of sample for age and age at diagnosis for wach group of pupils

	Neither	ASD	AD	Both
n	30	9	20	20
Gender	24 m, 6f (80%)	7 m, 2f (78%)	16 m, 4f (80%)	14 m, 6f (70%)
Age	13.27 (1.4)	13.0 (2.1)	13.1 (1.6)	13.6 (1.9)
Diagnosis	6.0 (2.3)	6.2 (1.9)	5.9 (2.4)	6.5 (2.5)

the NICE Clinical Guideline, supported by psychometric tools, such as the Diagnostic Interview for Social and Communication Disorders, the Autism Diagnostic Interview – Revised, and Autism Diagnostic Observation Schedule. These form the basis for the diagnosis, facilitating the team and clinician's judgement on the final outcome and diagnosis. Assessment included observations across a wide range of settings with an autism-specific developmental and family history. An assessment of the needs and strengths of all family members was included, and full physical examination with tests and assessments for other conditions were conducted as appropriate by the paediatrician; the contents of the examination would vary according to the physician's judgment of what was required.

Reactive Attachment Disorder

Diagnosis of attachment difficulties was assessed in a range of ways by clinical psychologists, and social workers, who were independent of the current study. The procedure was dependent on the age of the child, along with clarification from NICE guidelines (National Institute for Health and Care Excellence, 2013), and a progressive use of assessment tools (Strange Situation Procedure; Q-Sort; Story Stems; Dynamic Maturational Model of Attachment; Child Attachment Interview), supporting clinical judgement. Diagnosis was also dependent on whether the children were known to Social Services for issues in the home environment, for reasons independent of any other clinical diagnosis. Additional background information regarding social services involvement was obtained through the school-based social worker.

Measures

Social Communication Questionnaire

(SCQ; Rutter et al., 2003) is used for the identification of ASD and its symptom levels. The scale has 40 items, with a total score ranging from 0 to 39, and a cut-off score of 15 indicating a high probability of ASD (Berument et al., 1999). The SCQ has excellent psychometric properties for reliability and validity (Rutter et al., 2003), and a sensitivity of 0.88, and a specificity of 0.86, for the discrimination of ASD (Chandler et al., 2007). The internal reliability of the scale (Cronbach α) for the present sample was 0.913.

Randolph Attachment Disorder Questionnaire

(RADQ; Randolph, 2000) screens for attachment disorder in children between 5 and 18 years, and distinguishes children with attachment disorder from those with conduct disorder or other psychiatric disorders. A child's score on the RADQ estimates the severity of AD. A RADQ score of 50–65 indicates the presence of AD, but the required score for a diagnosis is 66–75 for mild attachment disorder; 76–89 for moderate; and 90 and over for severe AD. For the purpose of this study, 66 was taken as the cut-off point. Randolph (2000) reported a test–retest reliability of between 0.82

and 0.85. Validity was reported as being established through the use of several techniques; item validity, criterion-references validity, construct validity and predictive validity (Randolph, 2000).

Apparatus

The Psychology Experiment Building Language (PEBL) software

(Mueller & Piper, 2014) is a programming language interpreter and compiler allowing behavioural tests for psychological experiments. The tests were run on the experimenter's laptop (Acer Aspire V3-571, with a 15.6″ screen at 1366 × 768 resolution). Tests are displayed on a monitor allowing control of stimulus presentation, response recording, and data collection. Tasks were chosen on the basis of the literature, and after discussion with the staff at the school, to ensure they would not be detrimental to the participants' well-being. The Hungry Donkey Task was utilised in response to these discussions as was more appropriate to the age of the participants than the Iowa Gambling Task.

Wisconsin Card Sorting Task

(WCST; Nelson 1976) assesses cognitive flexibility through attention switching ability and working memory. Participants are asked to sort cards by categories (shape, colour, number), and must establish the correct sorting method by trial and error (participants are told if a given choice is correct or not). The method of sorting changes without notification, and how long it takes to find the new method of sorting is measured. It was decided to use the switch cost, but not preservative errors, as differences between children with ASD have been observed to be more notable (Van Eylen et al., 2011). The switch cost is the difference between the mean reaction time on switch trials and the mean reaction time on maintain trials, with higher scores indicating less strong performance.

Hungry Donkey Task

(Crone & van der Molen, 2008) is a computerised version of the Iowa Gambling Task adapted for children. It is used to assess hot inhibition. The task presents four doors, from which each participant has to choose doors from which the donkey will obtain gains or losses. The aim is to get as many apples as possible, by selecting from the four doors to win apples to feed the hungry donkey. The stimulus display shows a donkey sitting in front of four doors, and each door corresponds to a key on the keyboard. Pressing a key displays an outcome showing the number of green apples won and red apples lost. A vertical bar on the side of the screen presents a performance index and amount of overall gain is displayed under the doors. Two options are characterised by high immediate gain (4 apples) but also high loss, and the other two are characterised by low immediate gain (2 apples) and low loss. Every 10 trials, door A presents five unpredictable losses of 8, 10, 10, 10, and 12 apples, and door B present one unpredictable loss of 50 apples, leading to an overall loss of 10 apples for each of these doors. Door C leads to five unpredictable losses of 1, 2, 2, 2, and 3 apples in every 10 trials, and door D has one unpredictable loss of 10 apples. Therefore, the net gain on every 10 trials of doors C and D is also equal – 10 apples. The main outcome measure is net gain, with higher gain being indicative of better inhibition. Participants are not told the properties of each door or the number of trials. They are, however, informed that they have to play many times and that they can switch doors as often as they like. The Donkey task has been used successfully with individuals with developmental disorders (Rahimi-Golkhandan et al., 2014).

Stroop Colour Task

(Stroop, 1935) is a task in which participants are asked to identify the colour of the text of words, while ignoring the actual word content, and assesses inhibition, cognitive flexibility, and selective attention, particularly cold inhibition with no emotional content (Homack & Riccio, 2004). Faster and more accurate of performance is taken as an index of stronger EF.

Tower of London Task

(TOL; Shallice, 1982) is a computerised task assessing planning and executive cognitive abilities. The task comprises a number of discs, and participant rearrange them to match a given configuration, with increased speed of completion and less moves required being indicative of better planning ability (Chang et al., 2011).

Procedure

Written parental consent was obtained for all participants, the participants were themselves briefed and informed of their right to withdraw at any time. Each participant was individually tested in a quiet room, and could be accompanied by a member of school staff if they chose. The room contained a computer, a desk, and a chair.

The first part of the experiment aimed the evaluation of EF, with the use of the PEBL software. All tasks were presented without modifying the default settings of the programme). These tasks together measured the ability for attention switching, working memory, and cold and hot EF. Participants were asked to complete the computerised versions of four EF tasks: WCST, Hungry Donkey Task, Stroop Colour Task, and ToL. Each participant was instructed verbally, and every task included written instructions displayed on the screen, using language that teachers assessed as appropriate to their reading abilities. The tests were presented to the participants randomly, and each took about 10 min to complete. Participants were offered the chance of breaks between tasks due to the long nature of the testing session, which they could request verbally or by sign, at any point they wished after completion of each task. After the completion of the EF tasks, the participants were debriefed verbally, and in writing, which outlined what the broad aims of the study. Participants were thanked for participating in the study, and given a lolly as a reward for participation. The AQ, SDQ, SCQ, and RADQ were completed by staff at the school independently of the EF tasks, but within the same week as the tests were performed. Background information regarding clinical diagnoses was completed from the pupils' statements of educational needs.

Results

Diagnostic and Classification Overlap

Of the 79 participants, all had a learning disability: 30 had sole learning disability; 9 had additional ASD diagnosis; 20 had additional AD diagnosis; and 20 had both an additional ASD and AD diagnoses. The were 29/79 (36%) participants of the sample with an ASD clinical diagnosis. The group with ASD diagnosis had a significantly higher SCQ score (12.27 ± 1.81) than the group without ASD diagnosis (7.26 ± 1.03), $F(1,77) = 13.13$, $p < 0.001$, $\eta^2_{p=}$ 0.146[0.030:0.288], $p(H_1/D) = 0.982$. There was a less pronounced difference between the ASD (66.37 + 30.69) and no ASD (53.84 ± 23.72) diagnosis groups in terms of the RADQ scores, $F(1,77) = 4.11$, $p = 0.046$, $\eta^2_{p=}$ 0.051[0.000:0.168], $p(H_1/D) = 0.468$. There were 40/79 (50%) of the sample satisfying criteria for an AD diagnosis. The group with AD diagnosis had a significantly higher RADQ score (80.05 ± 18.54) than the group without AD (36.28 ± 12.13), $F(1,77) = 153.22$, $p < 0.001$, $\eta^2_{p=}$ 0.666[0.538:0.743], $p(H_1/D) = 0.999$. There was also a significant difference between the AD (14.82 + 8.69) and no AD (4.71 ± 5.71) groups in terms of SCQ scores, $F(1,77) = 37.11$, $p < 0.001$, $\eta^2_{p=}$ 0.325[0.161:0.463], $p(H_1/D) = 0.999$.

The sample mean score on the SCQ was 9.83 (± 8.91), and 27/79 (34%) of the sample scored positive for ASD. The sample mean for the RADQ was 58.44 (± 26.99), and 32/79 (41%) scored positive for AD. The Pearson correlation between the SCQ and RADQ was, $r = 0.602$, $p < 0.001$. There were 39 (49%) with neither ASD or AD, 8 (10%) with ASD alone, 13 (17%) with AD alone, and 19 (24%) with both ASD and AD.

Table 2 shows the numbers of participants with clinical diagnosis and psychometrically-defined classifications. Cohen's Kappa revealed a moderate agreement between the diagnoses and psychometric classifications of 0.472, $p < 0.001$.

Table 2 Numbers of participants with clinical diagnosis and psychometrically-defined classifications

		Clinical Diagnosis			
		Neither	ASD	AD	Both
Psychometric Classification	Neither	27	8	4	0
	ASD	3	1	1	3
	AD	0	0	9	4
	Both	0	0	6	13

Executive Function and Clinical Diagnosis

Figure 1 shows the group mean z scores for the six metrics across the four EF tasks for those with no diagnosis, ASD only, AD only, or both diagnoses. The scores are represented as z-scores as they had very different metrics from one another. Inspection of these data reveals few striking differences and a high degree of variance in the data. This impression is supported by the results of a multivariate analysis of variance (MANOVA) conducted on the four diagnosis groups with the six scores as dependent variables, which revealed no significant difference between the groups, *Wilks' Lambda* = 0.733, $F(18,198) = 1.28$, $p = 0.204$, $\eta^2_{p\,=}$ 0.104[0.000:0.107]. However, although not an ideal test statistic, Roy's GCR was significant, GCR = 0.214, $F(6,72) = 2.57$, $p = 0.026$, $\eta^2_{p\,=}$ 0.176[0.000:0.273]. Follow-up analysis of variance (ANOVAs) revealed that none of the group comparisons on individual DVs were significant using a Bonferroni correction (0.05/6 = 0.008). However, when this was relaxed, there was a significant difference between the diagnostic groups for WCST switch cost, $F(3,75) = 2.75$, $p = 0.049$, $\eta^2_{p\,=}$ 0.053[0.000:0.121], $p(H_1/D) = 0.075$. Tukey's Honestly Significant Difference (HSD) tests revealed that only the group with both diagnoses differed from the group with neither diagnosis, $p < 0.05$. The difference between the groups on the ToL moves score approached significance, $F(3,75) = 2.23$, $p = 0.067$, $\eta^2_{p\,=}$ 0.043[0.000:0.107], $p(H_1/D) = 0.056$. Tukey's HSD tests revealed that both the group with an ASD and neither diagnosis each differed from AD and both groups, ps < 0.05.

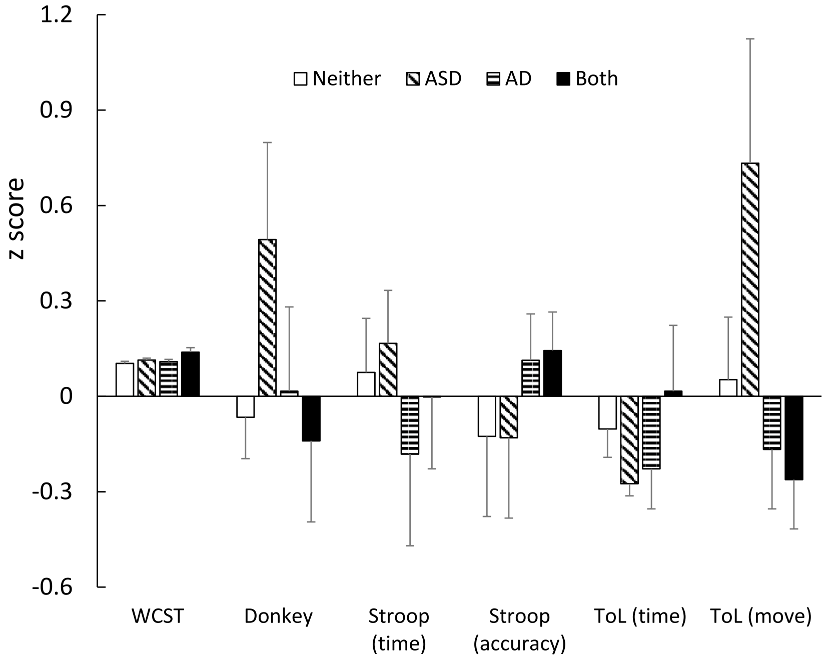

Fig. 1 Group mean z scores for the six metrics across the four EF tasks for those with no diagnosis, ASD only, AD only, or both diagnoses. Error bars = standard error

Figure 2 shows the group-mean z scores for the EF tasks for those with and

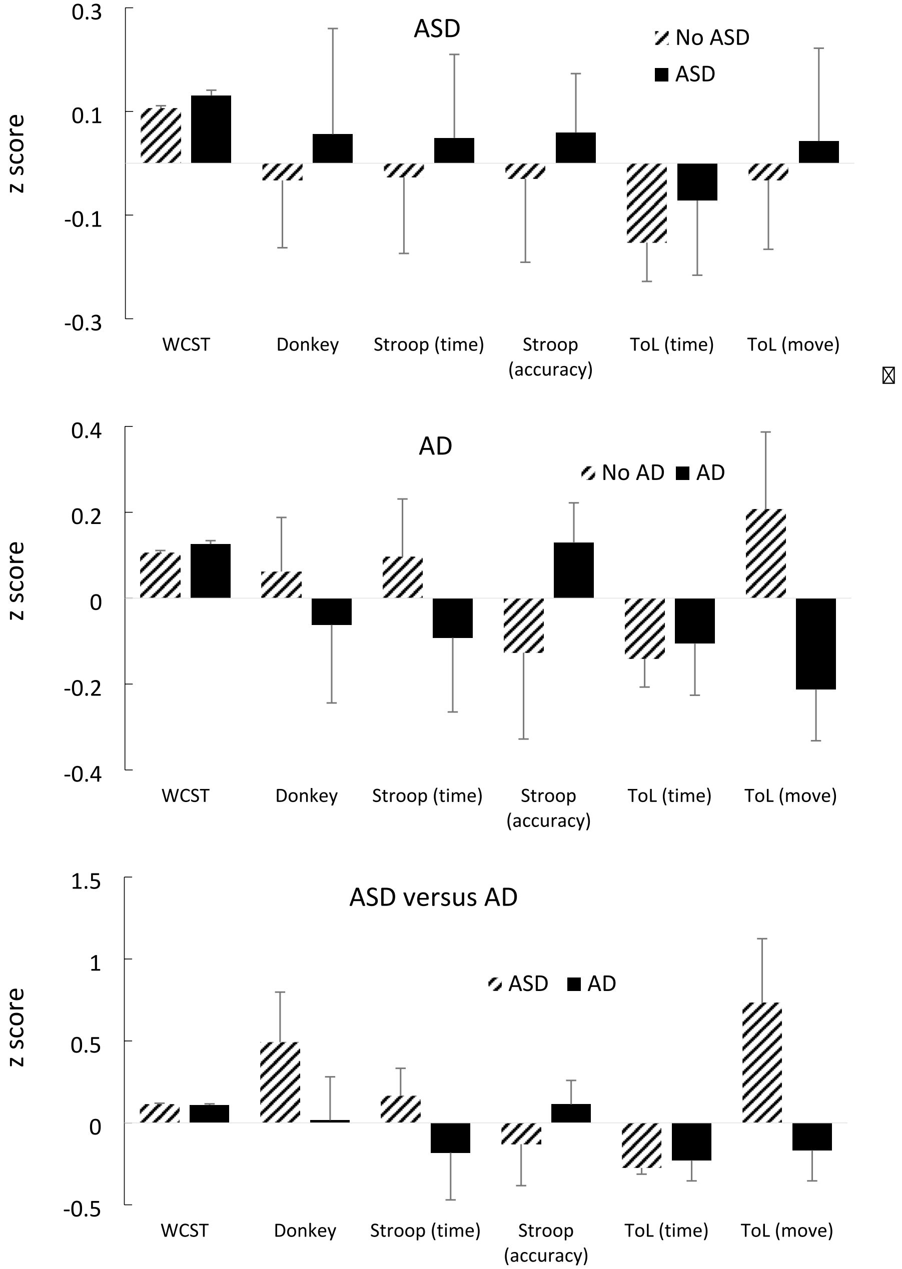

Fig. 2 Group-mean z scores for the EF tasks for those with and without an ASD diagnosis (top panel), with and without an AD diagnosis (middle panel), and with an ASD or AD diagnosis only (bottom panel). Error bars = standard error

without an ASD diagnosis (top panel), those with and without an AD diagnosis (middle panel), and those with an ASD or AD diagnosis only (bottom panel). A discriminant function analysis conducted to differentiate ASD and no ASD diagnoses found no function significantly differentiated the groups, *Wilks Lambda* = 0.915, $X^2(6) = 6.555$, $p > 0.30$, $\varphi = 0.288$. Although, WCST did display some discrimination function (0.920), all other EF scores did not (< 0.30). A discriminant function analysis conducted to differentiate between AD and no AD found the first function approached significance, *Wilks Lambda* = 0.884, $X^2(6) = 9.121$, $p = 0.083$, $\varphi = 0.339$. According to the structure matrix, the first function included more ToL moves (0.613), a lower WCST switch cost (-0.572), and lower Stroop accuracy (-0.367), with Stroop time (0.269), Donkey (0.176), and ToL time (-0.081) less strongly associated. The function predicted the presence of AD with 65% accuracy. Although a discriminant function analysis conducted to differentiate between ASD and AD found no function significant, *Wilks Lambda* = 0.752, $X^2(6) = 6.832$, $p = 0.337$, $\varphi = 0.294$. According to the structure matrix, more ToL moves (0.778), and stronger Donkey performance (0.358), but not Stroop accuracy (-0.297), Stroop time (0.279), WCST (0.130), and ToL time (-0.07381), predicted ASD with 69% accuracy.

Executive Function and Psychometric Measures

Figure 3 shows the group mean z scores for the six metrics across the four EF tasks for the psychometrically-defined no classification, ASD only, AD only, or both classifications. Inspection of these data reveals a very similar pattern to that obtained

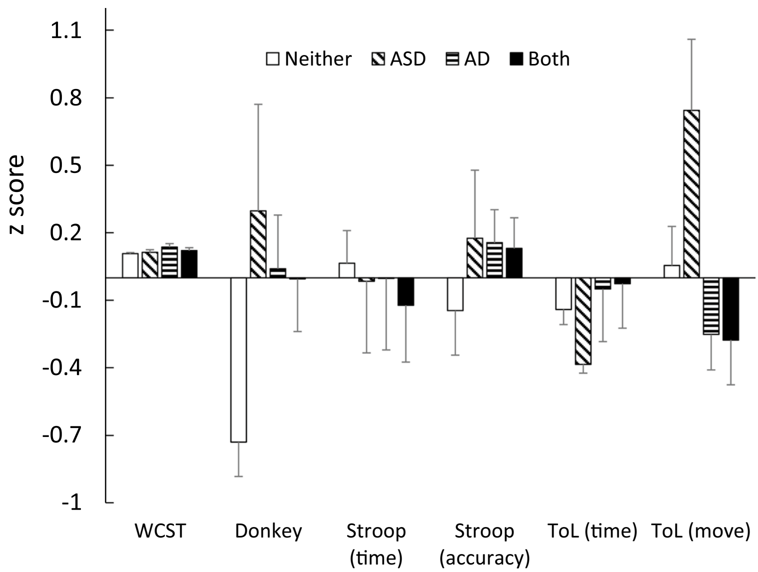

Fig. 3 Group mean z scores for the six metrics across the four EF tasks for those with no classification, ASD only, AD only, or both classifications. Error bars = standard error

from the clinical diagnosis, with few striking differences, except for Donkey and ToL moves, and a high degree of variance in the data. This impression was supported by the results of a MANOVA conducted on the four classification groups with the six scores as dependent variables, which revealed no significant difference between the groups, *Wilks' Lambda* = 0.918, $F(18,198) = 0.92$, $p > 0.50$, $\eta^2_{p\,=}$ 0.077[0.000:0.069]. As with the clinical diagnoses, although not an ideal test statistic, Roy's GCR approached significance, GCR = 0.164, $F(6,72) = 1.97$, $p = 0.082$, $\eta^2_{p\,=}$ 0.141[0.000:0.230]. Follow-up ANOVAs revealed that none of the group comparisons on individual DVs were significant using a Bonferroni correction (0.05/6 = 0.008). However, when this was relaxed, the difference between the classification groups for the ToL moves score approached significance, $F(3,75) = 2.55$, $p = 0.062$, $\eta^2_{p\,=}$ 0.092[0.000:0.203], $p(H_1/D) = 0.062$. Tukey's HSD tests revealed that both the group with an ASD and neither diagnosis each differed from AD and both groups, ps < 0.05.

Figure 4 shows the mean z scores for the four EF tasks for above and below the psychometric threshold for ASD (top panel), those above and below the psychometric threshold for AD (middle panel), and those with ASD or AD classifications only (bottom panel). A discriminant function analysis conducted to differentiate psychometrically-defined ASD and no ASD found no function significantly differentiated the groups, *Wilks Lambda* = 0.976, $X^2(6) = 1.801$, $p > 0.90$, $\varphi = 0.150$. Although the functions for greater WCST switch cost (0.668), less Stroop time (-0.431), and higher Donkey scores (0.398) were associated with an ASD classification (other functions < 0.30). A discriminant function analysis conducted to differentiate between AD and no AD classifications found the first function was not significant, *Wilks Lambda* = 0.887, $X^2(6) = 8.908$, $p = 0.179$, $\varphi = 0.335$. The function for fewer ToL moves (-0.640), shorter ToL time (0.331), greater WCST switch cost (0.576), and greater Stroop accuracy (0.329) were associated with AD with a 70% accuracy. Although a discriminant function analysis conducted to differentiate between ASD and AD found no function significant, *Wilks Lambda* = 0.603, $X^2(6) = 8.087$, $p = 0.232$, $\varphi = 0.320$. According to the structure matrix, more ToL moves (0.889), greater ToL time (-0.312), and greater switch cost (-0.308) predicted ASD with 72% accuracy.

Discussion

The objective of the study was to examine differences between ASD and AD using EF tasks for a sample of young people with learning disabilities. The study found that there was substantial overlap in the diagnosis and classification of ASD and AD, which replicated previous work (Mayes et al., 2017; Sadiq et al., 2012). There were few differences between the EF performances of individuals with ASD and AD, and any differences would be of limited use in differentiating between the conditions for a learning-disabled population. Despite adopting as lenient a set of analytic approaches as possible, which allowed for multiple searches for differences in the same data set, little difference between the EF performances of individuals with ASD and AD was noted. Certainly, none that would help to serve to differentiate

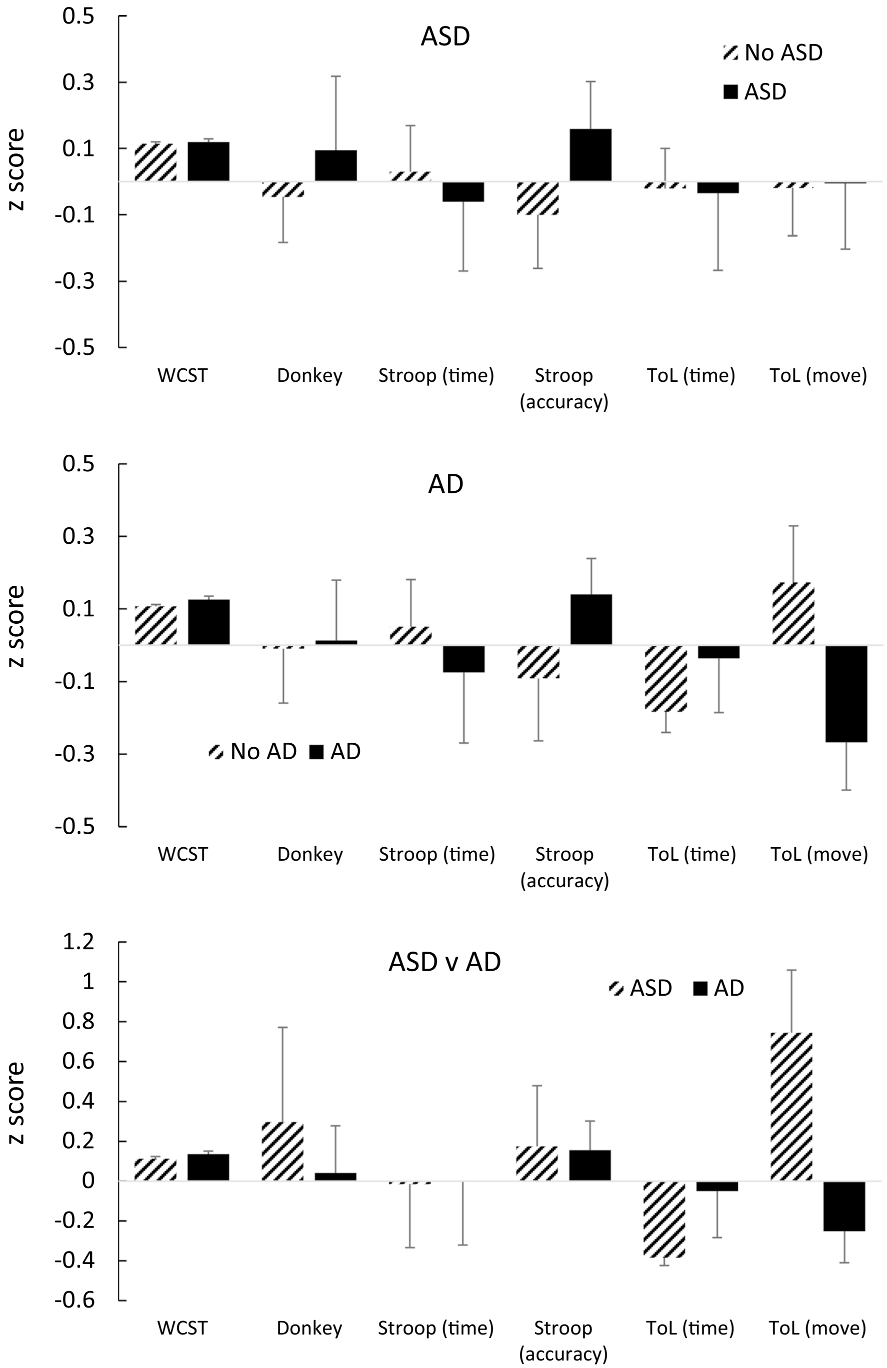

Fig. 4 Group-mean z scores for the EF tasks for those with and without an ASD classification (top panel), with and without an AD classification (middle panel), and with an ASD or AD classifications only (bottom panel). Error bars = standard error

between the conditions for a learning-disabled population, which represents a substantial section of the special school population (Giltaij et al., 2015; Jang & Matson, 2015). The EF abilities of those with AD have not received a great deal of attention (Colvert et al., 2008), but that little difference was noted between those with ASD and a learning disabled control replicates previous reports of a lack of difference (Russell et al., 1996), and stands in some contrast to the findings from a higher-functioning groups (Demetriou et al., 2018; Lai et al., 2017).

These results corroborate the substantial overlap between ASD and AD, both when clinical diagnoses and psychometric methods are employed (Davies et al., 2023; Davison et al., 2015; Sadiq et al., 2012). The percentage of children meeting both the criteria for ASD and AD was about 25%, which was a little lower than previous studies in samples lacking a learning disorder (Davison et al., 2015; Sadiq et al., 2012), which tended to report about 60% overlap. These current data give strength to the argument that overlap between ASD and AD can exist (Mayes et al., 2017; Sadiq et al., 2012), and is evident in a group of individuals with learning disability.

The EF abilities of those with ASD in the current sample were not significantly different from learning disabled individuals with neither ASD nor AD, which replicates previous findings for this sample (Russell et al., 1996). However, the numerical pattern of performance on these EF tasks for the ASD group was similar to that which might be predicted for this group. The ASD group had better performance (i.e. they displayed less disinhibition) on the hot EF tasks (Donkey), but worse performance (i.e., they found switching rules harder) on the cold EF tasks (WCST, ToL). However, these differences were very small, and, even if a larger sample had been employed to increase power, would not have been strong effects important in clinical or educational terms.

The EF performance of the group with AD was more discriminable from, and stronger than, a group without AD, especially in terms of cold EF tasks such as ToL and WCST. This does not corroborate the previous suggestions of impaired EF in those with attachment problems (Colvert et al., 2008). This difference from previous studies could be due to the comparison in the current study being with individuals with learning disabilities rather than typically developing individuals. In terms of the differences between this group and the group with ASD, there were few of note, suggesting that EF on its own will not discriminate between the conditions. Given the power considerations inherent in any study, it is worth noting the numerical differences in the data (albeit with caution, given the lack of strong statistical findings). The AD group had numerically worse performance on the hot EF task (Donkey), and slightly better performance on the cold tasks (WCST) than the ASD group, which could be predicted (Miyake et al., 2000; Roelofs et al., 2015). However, these differences were so small as to be of limited use in applied settings.

The current results do not rule out differences in EF in non-learning disabled groups, and perhaps not in those attending mainstream education – those data have not been collected or analysed. That is, those groups may display differences in EF from each other, but the current data do not allow those conclusions to be reached. The lack of striking differences may be due to power limitations, but it is worth noting that the effect sizes, and Bayes statistics suggest that any effect will be small, and this will limit its potential usefulness. Moreover, extremely lenient statistical approaches were adopted in order to find any semblance of a difference between ASD and AD groups.

It may be that the presence of the condition, itself, does not impact EF. Factors such as caregiving may be equally important in the development and expression of these abilities. Early caregivers are taken to provide models for the development of executive functioning (Belsky et al., 2010; Bernier et al., 2010; Nelson & Bloom, 1997). For example, maternal sensitivity, mind-mindedness, and autonomy support have all been found to predict EF (Bernier et al., 2010; Bernier, Carlson, Deschênes, & Matte-Gagné, 2012). It may be that these aspects are more important than the presence of a diagnosis of psychometrically-measured trait for EF expression. Parenting is known to be disrupted in groups with both ASD and AF albeit in different ways. For example, parents of children with AD report greater levels of parenting stress than parents of children with ASD, with limit setting mediating the relationship between parenting stress and child behaviour problems for parents of children with ASD but not for parents of AD (Davies et al., 2023). These differences may be important for future studies to assess.

In summary, there was substantial overlap in the diagnosis and classification of ASD and AD. There were few differences between the EF performances of individuals with ASD and AD, and any differences would be of limited use in differentiating between the conditions for a learning-disabled population.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest The authors report no conflicts of interest.

Research involving human participants and/or animals Ethical approval was given by the Ethics Committee of the Psychology Department of the University in accordance with the Helsinki agreement.

Informed consent All participants gave their informed consent for participation. Caregivers of the participants gave their informed consent for their children's participation. The Headteachers of the schools gave their informed consent for their pupils' participation.

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