



Little Effect of Executive Functioning on Behaviour Problems of Those with Attachment or Autism Spectrum Disorders

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Abstract

Objectives This study explored whether executive functioning (EF) mediated the relationship between either autism spectrum disorder (ASD) or attachment disorder (AD) and behaviour problems for a sample of children with learning disabilities.

Methods A sample of 79 pupils with learning disabilities was examined in terms of their AD and ASD traits, their levels of behaviour problems and performance on four EF tasks (WCST, Hungry Donkey, Stroop and Tower of London) was assessed.

Results There were positive correlations between levels of ASD and AD and between both of these traits and behaviour problems. However, there was no relationship between these traits and EF, and no relationship between EF and behaviour problems.

Conclusions That there was little influence of EF as a mediator between these conditions and behaviour problems for a sample with learning disabilities suggests that EF has limited usefulness as a target for educational intervention in such a sample.

Keywords Autism spectrum disorder · Attachment disorder · Executive function · Differentiating diagnoses

It has been suggested that executive functioning (EF) difficulties are noted with typically developing young people who have experienced poor institutional care (Colvert et al., 2008; McDermott et al., 2012; Merz & McCall, 2011). That is, children exposed to poor institutional care for long periods of time can show deficits in EF that can persist after removal from the institution (Kreppner et al., 2001; Roy et al., 2004). For instance, Colvert et al. (2008) reported greater EF deficits, attachment problems and a ‘quasi-autism’ effect, with longer institutional deprivation, with EF mediating between attachment and behaviour problems. Additionally, it has been shown that EF can mediate between adverse early experiences and the development of later problem behaviours for typically developing children (Buss et al., 2012; Devine et al., 2016). For instance, Sulik et al. (2015) reported that the association between parenting ability and child externalising behaviour was mediated by the child’s EF ability, higher EF ability protecting against the effects of poor parenting skills.

Although there have been suggestions that EF has relationships to those with additional needs, and that it serves the same mediating function in these populations as for the typically developing population (e.g. Lawson et al., 2015), the situation with respect children with comorbid intellectual impairment remains unclear. Learning disabilities and intellectual function may play a role in the expression of EF (Russell et al., 1996; cf. Mahone et al., 2002), and this may impact its function in mediating between the presence of a condition and later behaviour problems, as pupils with learning difficulties, in addition to a developmental condition like AD or ASD, are highly represented in special educational needs placements (Jang & Matson, 2015; Raaska et al., 2012).

A relationship between EF and AD has been suggested (Colvert et al., 2008; Gambin et al., 2020; Low & Webster, 2016). For example, Gambin et al. (2020) noted that females with insecure attachment regarding their fathers displayed poorer EF than females with secure father attachments (this effect was not noted for boys). However, it should be noted that such relationships between EF and AD are sometimes very small in size (Davies et al., 2022a, b), and two unpublished theses have reported no such relationship (Foy, 2016; Marr, 2014). Marr (2014) found no statistically significant difference in EF between groups with children with and

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without AD. Similarly, from a research group independent to that which supervised Marr (2014), Foy (2016) noted no associations between AD and EF. Moreover, it has been suggested that EF mediates the relationship between AD problems and behaviour problems (Colvert et al., 2008; Low & Webster, 2016). Unfortunately, direct evidence regarding the potential mediating role of EF between attachment and behaviour problems is sparse and, sometimes, contradictory; for example, Foy (2016) noted no such association for children with AD. Thus, questions remain over the strength and nature of any relationships between AD and EF.

Altered EF has been associated with those with both higher (Lai et al., 2017) and lower (Demetriou et al., 2018) functioning ASD. However, it has also been noted that EF differences between those with lower-functioning ASD and intellectually matched controls are much less pronounced (Russell et al., 1996), a finding that was also noted by Davies et al., (2022a, b). So, while there should be a relationship between ASD and EF (Demetriou et al., 2018; Lai et al., 2017), its strength is still debated (Davies et al., 2022a, b; Russell et al., 1996), and there is little, if any, evidence as to whether EF mediates the relationship between ASD and behaviour problems, especially in a population with comorbid learning needs.

This current study sought to ascertain if EF is more impaired in children with AD than ASD. This study provides an initial investigation into the EF abilities of the individuals showing AD and ASD traits and a learning disability, as this group is highly represented in special educational needs placements (Jang & Matson, 2015; Raaska et al., 2012). It employed a range of psychometric tool measure attachment disorder and autism traits in this population and related them to performance on a battery of EF tasks.

Methods

Participants

Seventy-nine participants (61 male, 18 female) were recruited, aged 9–16 (mean = 14 $SD \pm 1.78$) from a special school, which has pupils in total 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. General information was requested from the parent or caregiver about their child (age, ethnicity, gender and known diagnosis).

Given the wide range of children, 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 a diagnosis was needed from an independent NHS clinician. All children had a diagnosis of learning disabilities. G-Power

calculations suggest that for 80%, with a rejection criterion of $p < 0.05$, and a medium effect size ($r = 0.3$), that 64 participants would be needed to detect a significant relationship between variables.

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. The tests were presented to the participants randomly, and they were offered the chance of breaks between tasks due to the long nature of the testing session.

After the completion of the EF tasks, the participants were debriefed, 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.

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 (Charman et al., 2007). The internal reliability of the scale (Cronbach α) for the present sample was 0.913; McDonald's $\omega = 0.825$.

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).

Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2006) is a self-report questionnaire consisting of 50 statements that measure traits associated with ASD. Participants respond on a 4-point scale, using the responses “definitely disagree,” “slightly disagree,” “slightly agree” and “definitely agree”, to each item. Scores can range from 0 to 50, with higher scores indicating more autism traits. A clinically significant cut-off point is taken to be 32. The scale has an internal consistency (alpha) of 0.80 (Baron-Cohen et al., 2006).

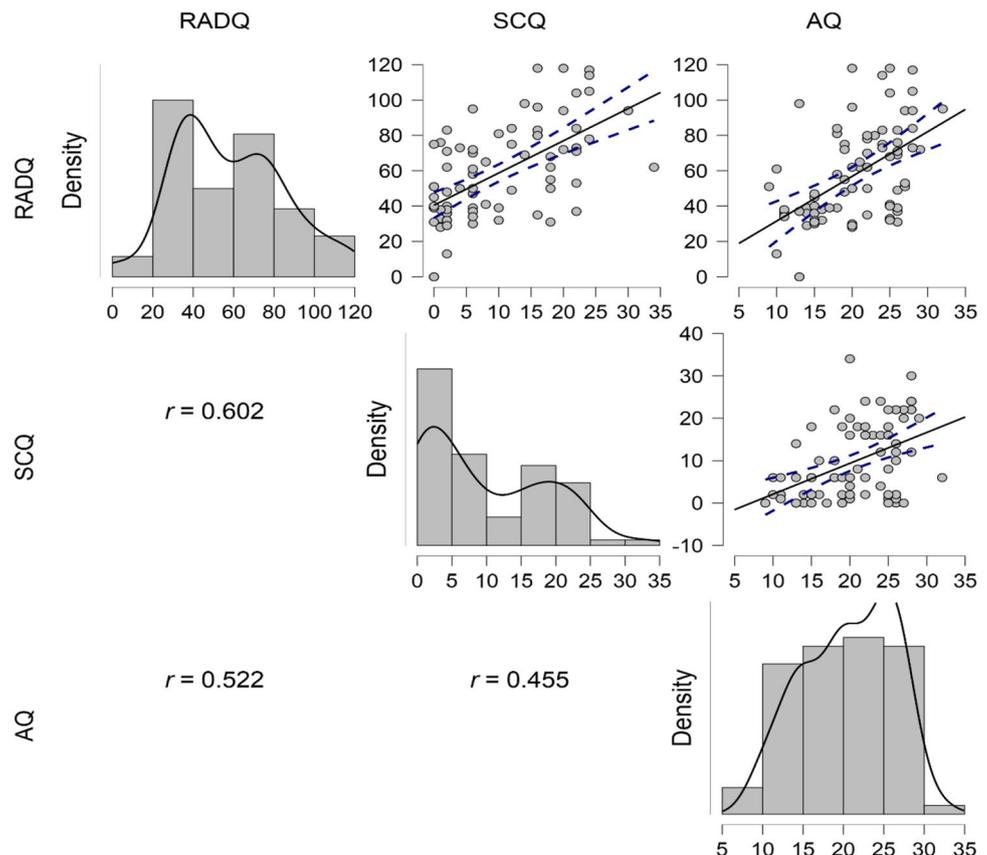
The Psychology Experiment Building Language (PEBL) software (Mueller & Piper, 2014) is a programming language interpreter and compiler allowing behavioural tests for psychological experiments. The tests were run on the experimenter’s laptop (Acer Aspire V3-571, with a 15.6” screen at 1366 × 768 resolution). 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, 2004) 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.

Fig. 1 Pearson correlations between these scales for the entire sample, along with histograms showing the distribution of scores, and scatterplots showing 95% confidence limits for each relationship



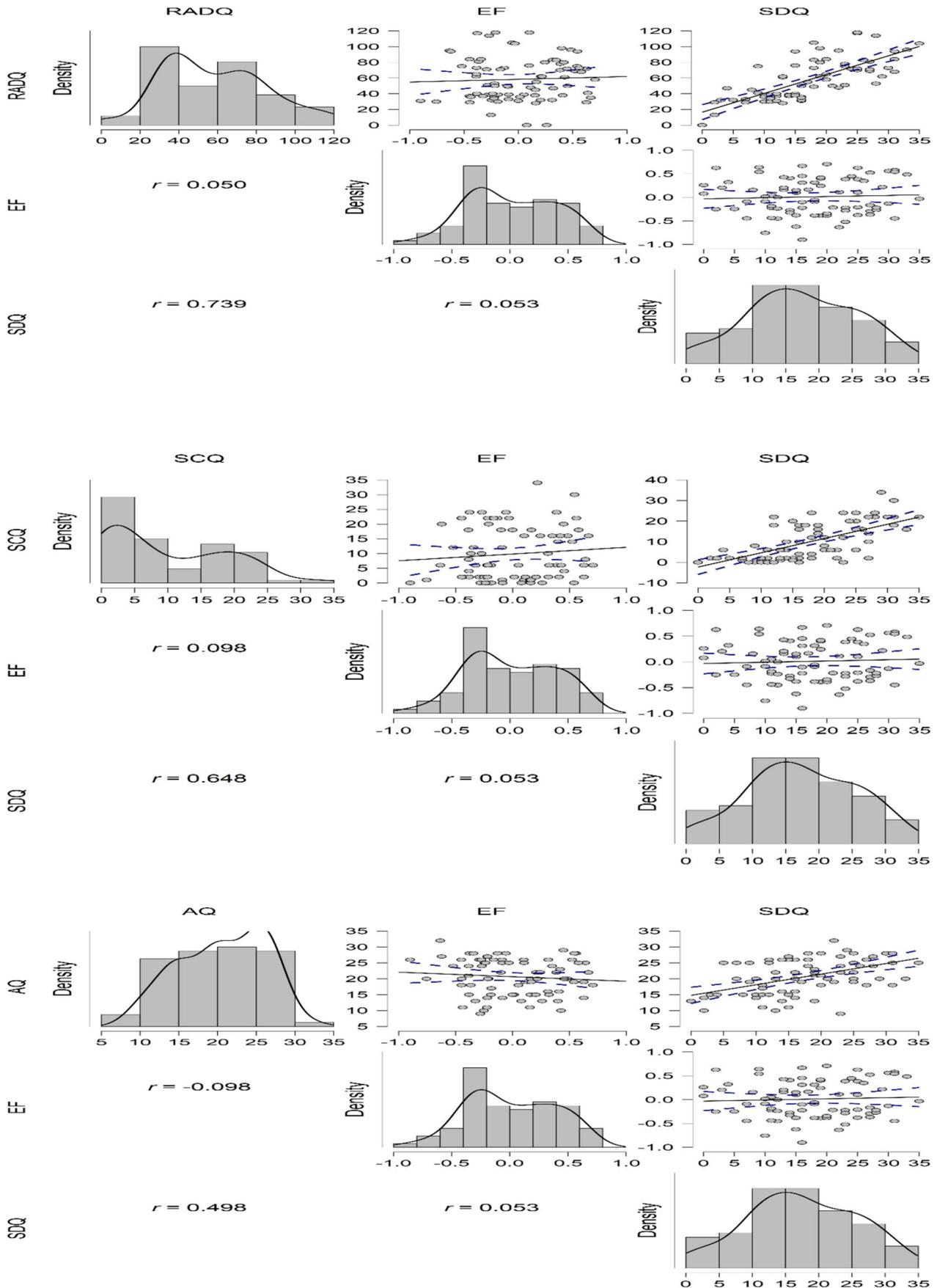


Fig. 2 Pearson correlations between attachment (RADQ; top panel), autism (SCQ; middle panel) and autism traits (AQ; bottom panel) and EF and behaviour problems (SDQ), along with histograms for the distribution, and scatterplots showing 95% confidence limits

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 the 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 presents 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 the participant rearranges 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).

Results

The sample mean for attachment problems (RADQ) was 58.44 (± 26.99 ; range = 0–119), with 22 pupils scoring above the cut-off for attachment problems. For ASD (SCQ), the mean score was 8.84 (± 6.19 ; range = 0–34), with 32 pupils scoring above the cut-off. For ASD symptoms (AQ), it was 20.83 (± 5.57 ; range = 9–32), with 8 scoring above the

cut off. Examining the overlap in those scoring above cut-off for both AD (RADQ) and ASD (SCQ) shows that 39/79 (43%) scored below cut-off for both condition, 9/79 (11%) scored above cut-off for AD but not ASD, 9/79 (11%) scored above cut-off for ASD but not AD, and 23/79 (29%) scored above cut-off for both, $X^2(1) = 21.962$, $p < 0.001$, $\phi = 0.527$. AS numbers scoring above cut-off for AQ were small; these data were not analysed.

Figure 1 shows the Pearson correlations between these scales for the entire sample, along with histograms showing the distribution of scores and scatterplots showing 95% confidence limits for each relationship. As can be seen from these data, all of these measures were significantly positively related to one another, and the correlations showed medium-strength relationships between the variables.

To examine EF, the scores from each of the four tests: Donkey, Stroop (time and accuracy), ToL (time and moves) and WCST, performance on the tasks was converted into a z-score for that task to ensure that all tasks were measured on the same scale. Where necessary, the z-scores were reversed, so that a positive z-score reflected better EF functioning. The mean of these 6 scores was then taken for each participant to create an overall EF functioning score. The mean overall EF score for those scoring above the AD (RADQ) cut-off was 0.06 (± 0.41 ; range = -0.64 to 0.63), and this was -0.02 (± 0.36 ; range = -0.90 to 0.71) for those below cut-off for AD. A *t*-test (with Bayes statistics displayed for the appropriate hypothesis) revealed that these scores were not significantly different, $t(77) = 1.98$, $p = 0.142$, $d = 0.24$, $p(H_0/D) = 0.608$. For those above the cut-off for ASD (SCQ), the overall EF mean was 0.05 ($+0.37$; range -0.82 to 0.67), and this was -0.01 (± 0.38 ; range -0.90 to 0.71) for those below cut-off for AD, $t < 1$, $p > 0.40$, $d = 0.17$, $p(H_0/D) = 0.691$.

Figure 2 shows the Pearson correlations between attachment (RADQ; top panel), autism (SCQ; middle panel) and autism traits (AQ; bottom panel) with both the overall EF score and behaviour problems (SDQ), along with histograms showing the distribution of scores and scatterplots showing 95% confidence limits for each relationship. Inspection of these data shows that attachment, ASD and autism traits all correlated positively with behaviour problems. However, none of these three scales correlated with overall EF functioning, and EF functioning did not correlate with behaviour problems (SDQ).

Table 1 shows the Pearson correlations between attachment (RADQ), ASD (SCQ) and autism traits (AQ) and each of the scores for the EF tasks. Inspection of these data shows, only a small negative correlation between the AQ score and performance on the Donkey task.

Table 1 Pearson correlations between attachment (RADQ), ASD (SCQ) and autism traits (AQ) and each of the scores for the EF tasks

Variable	RADQ	SCQ	AQ
Donkey	-.011	.003	-.231*
Stroop time	.018	.080	.148
Stroop accuracy	.019	.066	.034
Tower of London time	.056	.127	.082
Tower of London moves	.171	.045	.123
WCST switch cost	-.043	.057	-.114

* $p < .05$; ** $p < .01$; *** $p < .001$

Discussion

The current study investigated whether the EF abilities mediated between attachment problems, autism traits and behaviour problems for individuals with a learning disability as there is limited and contradictory evidence regarding these relationships for a population with comorbid learning difficulties. The study revealed that there were positive associations between attachment problems (RADQ), autism traits (both SCQ and AQ) and behaviour problems. There were also high levels of association between each of these measures and each other. However, there were no differences in EF associated with either attachment problems (RADQ) or autism traits (SCQ) in this sample. Moreover, EF did not mediate between either attachment or autism and behaviour problems.

That attachment and ASD problems were highly related to one another, and that there was significant overlap between those scoring above psychometrically defined cut-off for both conditions, corroborates previous investigations of this relationship (Davies et al., 2022a, b; Davies et al., 2022a). Similarly, that there were strong relationships between each of the conditions and behaviour problems is consistent with previous demonstrations of this relationship (Bates & Bayles, 1988; Osborne & Reed, 2009). These data suggest that differentiation of AD and ASD may be difficult on the basis of either psychometric evaluation or on the presence of overt behaviour problems (Davies et al., 2022a, b; Mayes et al., 2017).

The lack of any strong relationship between attachment problems and EF is in line with several previous demonstrations of such a null result (Davies et al., 2022a, b; Foy, 2016; Marr, 2014). Although some previous studies have noted such a relationship (Colvert et al., 2008; Gambin et al., 2020; Low & Webster, 2016), these tend to be with typically developing children rather than those with a comorbid learning need. Similarly, the current data are in agreement with those reported in an unpublished thesis by Foy (2016), who found EF did

not mediate the relationship between AD problems and behaviour problems. This stands in contrast to data from populations lacking an additional need (Colvert et al., 2008; Low & Webster, 2016). Likewise, there was no relationship between ASD and EF and no mediation of the relationship between ASD and behaviour problems by EF. This replicates previous findings for this population (Davies et al., 2022a, b; Russell et al., 1996) and suggests that the additional needs reduce the relationship between ASD and EF (Demetriou et al., 2018; Lai et al., 2017).

The role of learning disabilities and intellectual function has been suggested as critical when considering the impact of EF (Mahone et al., 2002; Russell et al., 1996). The precise mechanism of action of learning difficulties on EF is unclear, but since pupils with learning difficulties in addition to a developmental condition like AD or ASD are highly represented in special educational needs placements (Jang & Matson, 2015; Raaska et al., 2012), this may be a significant consideration in employing EF either as a diagnostic tool or as the focus of any intervention for such a group (Otero et al., 2014; Wallace et al., 2016).

Limitations and Future Research

These current findings do not rule out an important role for EF in non-learning disabled groups or those attending mainstream education. It should also be acknowledged that 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 as a diagnostic or intervention. 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. A further limitation in this study was that intelligence quotient was not measured due to permissions around accessing children in the locality of the research. There were restrictions in terms of test-retest concerns with local policy. Future research would benefit from considering the additional comorbidities and measuring the impact of these on overlapping presentations, utilising full cognitive profiles alongside both attachment and EF measures.

Author Contribution JD: designed and executed the study, assisted with the data analyses and wrote the paper; PR collaborated with the analysis of the data and wrote part of the results and paper.

Data Availability All data are available at the Open Science Framework (<http://osf.io/e5jh7>).

Declarations

Ethics Approval and Consent to Participate The study was approved by Swansea University Ethics Committee. Written parental consent was obtained for all participants, and the participants were themselves briefed and informed of their right to withdraw at any time.

Competing Interests The authors declare no competing interests.

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