An intervention to enhance cognitive flexibility in boys aged 11-13 with Autism Spectrum Disorder

Kiera Farrelly and Shelby Mace

Cognitive Flexibility is the ability to switch to a different thought or action, depending on a change in task or situational demand. Past research has argued that those with Autism Spectrum Disorder (ASD) show deficits on measures of cognitive flexibility, which may be due to deficits in executive functioning (Hill, 2004; Van Eylen et al., 2011). Consequently, the present work aims to develop an intervention to enhance cognitive flexibility for those with ASD. In the current study, twenty adolescent boys, aged 11-13 years old, completed a measure of cognitive flexibility: the Trail Making Test (TMT) (Partington and Leiter, 1949). Participants were randomly allocated to either a control or intervention group. For those in the intervention group, a three-week intervention programme was piloted, with the aim to address cognitive flexibility within a home and school setting. The intervention targeted cognitive aspects of flexibility using the Stroop Test (Stroop, 1935) and Wisconsin Card Sorting Test (Heaton et al., 1993), as well as social aspects of flexibility. Although both the control and intervention group improved when retested on a measure of cognitive flexibility, those in the intervention group improved to a greater extent. This study has implications for educational practice for children with ASD, and recommendations for future research are discussed.

Keywords: Autism Spectrum Disorder, Cognitive Flexibility, Intervention, Trail Making Test, ASD.

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ISSN: 2058-5551 (Online)
Introduction

Autism Spectrum Disorder (ASD) is typically classified by difficulties with social communication and interaction, hyper- / hyposensitivity to sensations, difficulties understanding or processing language, and rigid behaviour patterns (The National Autistic Society, 2014). As of 2011, it is estimated that ASD affects more than 1 in 100 people in the UK. Although this is not an official figure, as it is only based on epidemiological surveys; this roughly equates to 695,000 people, or 1.1% of the UK population (The National Autistic Society, 2014). It is also argued that ASD is four times more common in males, than in females (Baron-Cohen et al., 2011).

In particular, this article will focus on the rigid nature of behaviour in ASD, which tends to be exhibited via inflexible, repetitive behaviours, and may be linked to cognitive flexibility. Cognitive flexibility can be defined as “the ability to shift to a different thought or action according to changes in a situation” (Sanders et al., 2008, p.9). So, inflexibility in ASD may mean that a person may dislike changes to familiar routines or plans, stick to their own agenda, disregard others’ suggestions, and prefer to be in control of a situation (Jones, 2013). Thus, such inflexibility can commonly cause problems for individuals with ASD in everyday social situations.

Within the literature, it is argued that there are three main hypotheses surrounding the link that cognitive flexibility may have with ASD (Hill, 2004; Sanders et al., 2008):

1. Central Coherence Hypothesis: this refers to the trait of being detail-orientated, whilst possibly missing the ‘big picture’. This hypothesis suggests those with ASD may miss the changes within a given situation, or be unable to shift their focus towards new details or pieces of information, due to a maintained focus on initial stimuli.

2. Executive Dysfunction Hypothesis: inflexible behaviours are a result of a deficit in the frontal lobe, which impairs executive functions such as cognitive flexibility. Lopez and colleagues (2005) argue that these deficits may underlie the repetitive, stereotyped behaviours typically associated with ASD.

3. Empathising-systematising Hypothesis: this suggests that social and communication difficulties (which characterise ASD) may be due to developmental deficits in empathy. Empathising refers to the ability to identify and interpret the thoughts and feelings of others, whilst systematising refers to an interest in analysing or constructing systems. Individuals with ASD are said to have below-average empathy and intact/superior systematising abilities.
Current research in the field reviews cognitive flexibility in ASD in light of these three hypotheses (for further information, see Hill, 2004 or Sanders et al., 2008). Before further discussion, it must be noted that both the Empathising-systematising Hypothesis and the Executive Dysfunction Hypothesis have been linked to Theory of Mind (ToM) deficits (Baron-Cohen, 2002). ToM stipulates that ‘egocentric’ thinking makes it particularly difficult for those with ASD to understand another person’s point of view. This may explain the inflexible nature of those with ASD with regards to social interactions, as they find it difficult to adjust their thoughts or actions to account for another individual’s perspective. This echoes the difficulties outlined within the aforementioned hypotheses, leading some to suggest that ToM is simply a feature of executive dysfunction deficits (Hughes, 1998; Evans and Stanovich, 2013). Longitudinal research confirms this, suggesting that executive dysfunction and ToM skills are interrelated as a result of their similar developmental trajectories (Ozonoff and McEvoy, 1994). For example, it is difficult to expect a child to develop the skills to instinctively tune in to another person’s perspective if differences in brain structure initially disallow it.

In light of this, the present article aims to focus specifically on the Executive Dysfunction Hypothesis and associated research, whilst recognising that there may be overlap with ToM deficits, as discussed above. This is because it is argued that executive function and ToM are considered to be primary deficits of ASD (Ozonoff and McEvoy, 1994).

The Executive Dysfunction Hypothesis encompasses three main aspects of cognition used in everyday life: planning, cognitive flexibility, and inhibition (Hill, 2004). Deficits in these areas will inevitably impact upon social functioning, for example, cognitive flexibility has been argued to be associated with skills such as perspective taking and empathy (Shamay-Tsoory et al., 2002; Decety and Jackson, 2004; Harmon-Jones and Winkielman, 2007; Nielsen, Marrone and Ferraro, 2014). Such skills are shown to be impaired in patients with frontal lobe damage, indicating that these brain regions are associated with cognitive flexibility and thus executive dysfunction (Grattan et al., 1994). This provides additional support for a deficit in the frontal lobe as the executive dysfunction hypothesis states. Further research suggests that this could be applied to the primary impairments shown in ASD, namely cognitive flexibility and empathy, as these functions share the same neural substrate within the frontal lobe (Grattan et al., 1990). Therefore it is important that research attempting to address cognitive flexibility deficits in ASD also addresses these deficient perspective taking and empathy skills.

Cognitive flexibility is also considered a key aspect of education, and it is argued that creating flexible learning environments, which enable learners to transfer their knowledge
and apply it to different disciplines is essential (Spiro et al., 2013). Other research also suggests that cognitive flexibility predicts early reading skills, school readiness, enables better self-control, and is linked with lower levels of hyperactivity and inattention in educational settings (Blair and Razza, 2007; Colé, Duncan and Blaye, 2014; Farrant, Fletcher and Maybery, 2014). In relation to children with ASD specifically, Kenworthy and colleagues (2011) advocate it is paramount that executive functioning is taught as part of the curriculum. They argue that by doing so, this will enable teachers to spend more time teaching and less time addressing individual cognitive flexibility challenges. In light of this, it would beneficial to find ways to develop cognitive flexibility within education, which may in turn, help to address the difficulties that those with ASD face.

As a result, this research aims to trial an intervention programme to improve cognitive flexibility in day-to-day social scenarios within the home and school environment. More specifically, this research is at the request of an independent specialist school for boys with mild to moderate learning difficulties, including a substantial number of pupils with ASD. This is due to the fact that teachers and therapists alike often note that some pupils with ASD struggle with the cognitive aspects of flexible thought within classroom tasks, as well as the social interaction aspect in the wider school context. In addition to this, there is little research in this field to support them, especially research that looks at the effects of an intervention for ASD pupils conducted in an educational setting. Consequently, this research is considered to be a novel pilot study, aiming to investigate the effects of an intervention programme which, if successful, could be implemented in future within the school or at home to help tackle the difficulties that pupils with ASD may face. Since the intervention aims to define cognitive flexibility in a context that children will understand, role-play and visual fictional characters will be used to represent the features of cognitive flexibility/inflexibility. This is because it has been argued that many with ASD are visual learners and so it is easier for them to understand concepts when they are presented visually (Earles-Vollrath, Cook and Ganz, 2006).

In order to obtain a measure of cognitive flexibility within the current study it is necessary to use experimental methods. Generally, the Wisconsin Card Sorting Test (WCST: Heaton et al., 1993) is the only measure of cognitive flexibility that has consistently found a deficit within ASD (Van Eylen et al., 2011). This task measures each aspect of cognition (planning, cognitive flexibility, and inhibition) and assesses how quickly a person can change their card-sorting strategy, in response to a change in a given rule. However since many argue that executive functioning is a broad term rather than a unitary concept (Elliott, 2003; Hill, 2004; Anderson, Jacobs and Anderson, 2008), it is difficult to determine whether the WCST measures cognitive flexibility alone. Inevitably, there may be overlap with other executive
functions, meaning that it may also measure planning, organising, abstract reasoning, set-shifting, working memory and attention (Mitrushina et al., 2005).

In addition, measures such as the WCST are often experimentally based and their application to real life is debatable. For example, Geurts, Corbett and Solomon (2009) question whether the current measures of cognitive flexibility used in research can ever encompass flexibility within a real-world setting. They argue that these measures may lead researchers to assume that everyday inflexible behaviours are the result of cognitive flexibility deficits. Thus, they state that it is not appropriate to generalise findings from cognitive measures and apply them to everyday social behaviours, because essentially they argue that these measures do not account for day-to-day behavioural flexibility.

On the other hand, the Trail Making Test (TMT: Partington and Leiter, 1949) is argued to be a good sensitive experimental measure for cognitive flexibility and executive function, and it is argued to have high ecological validity (Arbuthnott and Frank, 2000; Kortte, Horner and Windham, 2002; Mitchell and Miller, 2008; Sánchez-Cubillo et al., 2009). Therefore, the TMT may represent cognitive flexibility in a real-world setting, unlike other executive functioning tests. The TMT is a timed task where the participant must connect 25 dots as quickly possible, and it consists of two parts: part one involves numbers alone, and part two requires a switch between numbers and letters consecutively. This assesses the ability to switch between two tasks simultaneously, which is ultimately a requirement of cognitive flexibility. In addition, the TMT is considered to be among the most commonly used neuropsychological tests in clinical practice, and many studies argue that those with ASD show deficits on this measure (Goldstein, Johnson and Minshew, 2001; Goldstein et al., 2002; Minshew, Meyer and Goldstein, 2002; Rabin, Barr and Burton, 2005; Hill and Bird, 2006). These arguments combined, provide a strong rationale for the use of the TMT within the current study.

Therefore, an intervention programme using the TMT as a measure of cognitive flexibility will be piloted. The TMT will be used at first assessment as a baseline measure of participant’s cognitive flexibility, as well as during the second assessment as a re-test measure. Using the same test both before and after the intervention programme should assess whether there is an improvement in performance on the measure. However, due to the fact that all participants will be asked to complete the TMT twice, it has been taken into consideration that practice effects will be likely. Therefore, all participants may show an improvement on the TMT from first to second assessment. However, if the intervention programme is beneficial, then those in the intervention group should show more of an improvement on the TMT post-intervention than those in the control group. Thus, it is hypothesised that:
1) There will be a decrease in time taken to complete the TMT from first assessment to second assessment, for both the control and intervention groups.
2) The decrease in time taken to complete the TMT from first assessment to second assessment will be significantly bigger for the intervention group, compared to the control group.

Method

Participants

All participants were selected from a local independent specialist school in the South East of England, which caters for boys aged 8-18 years old who may be bright, but struggle in mainstream stream schools due to a mild to moderate specific learning difficulty. Twenty boys aged 11-13 years of age \( (M = 12.7 \text{ years old}, \ \text{Range} = 2.17 \text{ years}, \ SD = .64 \text{ years}) \) were randomly selected, and all had a diagnosis of ASD made by a relevant professional (i.e. psychiatrist or clinical psychologist). Participants with co-morbid learning difficulties were excluded.

Ethical Considerations

Consent was received from the school and workplace supervisor on behalf of the parents, prior to conducting the research. This was because parents are aware that the school routinely conducts internal research. All data was ensured of confidentiality, and all participants had the right to withdraw at any time.

Materials

Participants completed the Trail Making Test (TMT) (Partington and Leiter, 1949) as a measure of cognitive flexibility at baseline (first assessment) and after intervention (second assessment). This test was chosen because it was accessible for the age range, and due to the time constraints of undergraduate research, the test was conducted efficiently. The TMT is a two-part task consisting of 25 circles randomly distributed over A4 paper. In Part A the circles are numbered consecutively, and the participant is required to connect the circles in ascending order e.g. 1-2-3 (See Fig 1). However, in Part B, the circles include both numbers and letters, so there is the added task of alternating between them e.g. 1-A, 2-B, 3-C (See Figure 1). In both parts, the participant is required to complete the task as quickly as possible.
Figure 1. Example of completed Trail Making Test (part A and B) used during first and second assessment as a cognitive flexibility measure.

Performance on the task is measured via the time taken to complete each part of the test (measured in seconds). It is expected that time taken on Part B would usually be longer than that for Part A, due to the added complexity of rule-switching (Salthouse, 2011). Therefore, time is used as an indicator of cognitive flexibility on this task i.e. the faster the participant can complete Part B of the task, the better their cognitive flexibility.

Participants were randomly allocated to either a control or intervention group. Those in the control group did not take part in any intervention programme, whereas those in the intervention group received three sessions; each targeting different aspects of cognitive flexibility. One aspect of cognitive flexibility targeted was the social aspect to address deficient perspective-taking and empathy skills. For this, the researchers created two fictional characters to illustrate flexible thinking or inflexible thinking. Cards depicting typical social scenarios were then presented, and participants were encouraged to discuss how they could respond in a flexible or inflexible way of thinking. Another aspect of cognitive flexibility targeted was the cognitive aspect. For this, the session incorporated different paper based tasks that the participants had to complete, including the Stroop Test (Stroop, 1935) and the Wisconsin Card Sorting Test (Heaton et al., 1993). Since these tasks involve switching between two rules simultaneously, the participants were required to implement a flexible mode of thinking.
**Design**

A mixed factorial design was used, with all participants completing the TMT pre-intervention and post-intervention, regardless of whether they were allocated to the intervention group or the control group. As the researchers knew the participants, group allocation was random to ensure no experimenter bias when assigning the groups.

**Procedure**

In order to obtain a baseline measure, all participants completed the TMT. Participants completed the task individually under experimental conditions i.e. in a small, quiet room where they would not be distracted. Participants were timed as they connected the “trail” for Part A, and then timed again for Part B. If they made an error, the experimenter pointed it out immediately and the participant was allowed to correct it, including this in the completion time for the task. From this first assessment, participants were randomly assigned and evenly split to either a control group or an intervention group.

The intervention group received three, 30-minute intervention sessions over the course of three weeks, whereas the control group did not undertake any intervention. The sessions were conducted in a familiar informal setting (i.e. a classroom) and the first two focused on the social aspect of cognitive flexibility. Session one consisted of participants brainstorming what they thought the term ‘flexible thinker’ meant on paper. Two fictional characters were also introduced to illustrate flexible thinking and inflexible/rigid thinking. Cards were then used to depict typical social situations that could be encountered at school and at home, and participants were asked to discuss how these characters might respond. Session two focused on getting the participants to apply these ideas to themselves as opposed to the fictional characters. This was done by asking participants to recall situations where they felt they had been a flexible thinker both at school and at home.

Session three focused on the cognitive aspect of flexibility, whereby participants completed two paper-based rule-switching tasks: The Stroop Test (Stroop, 1935) and Wisconsin Card Sorting Test (WCST: Heaton et al., 1993). These tasks focus on the participant’s ability to switch between two rules simultaneously, which encourages the ability to think in a flexible manner. Although we recognised the flaws of using the WCST as a measurement of cognitive flexibility, the purpose of using the WCST and Stroop Test in the intervention was to train cognitive flexibility rather than to measure it. Specifically, this is guided by findings which argue that practice on these tasks can strengthen cognitive flexibility skills (Gallagher and Prestwich, 2012), which is inevitably the intention of the present study. In order to make
the tasks fun and interactive, an informal ‘competition’ was held between participants where they attempted to complete each of the tasks as quickly as possible.

After the intervention programme had finished, all participants (regardless of group assignment) were re-tested on the TMT in order to obtain a second assessment score. It is important to note that the layout of the TMT in the second assessment was changed in order to attempt to minimise any practice effects that may occur. The second assessment score obtained was compared to their first assessment (baseline) score, in order to assess any influence that the intervention programme may have had on the development of cognitive flexibility.

**Results**

In order to examine participant’s change in performance from Part A to Part B of the TMT, one score was calculated for the first assessment and one score was calculated for the second assessment. It is argued that this is the most effective way to assess the difference in time taken to complete both parts of the test (Salthouse, 2011). This was done by:

Time taken on Part B of TMT - time taken on Part A of TMT = first/second assessment score

\[ B - A = \text{first/second assessment score} \]

\[ 120.5 - 43.9 = 76.6 \text{ seconds (first assessment score)} \]

\[ 70.3 - 30.9 = 39.4 \text{ seconds (second assessment score)} \]

For the means of the first and second assessment scores, for the control and intervention groups, see Figure 2.

However in order to enable statistical analysis, an overall ‘difference’ score was then calculated for each participant. This assessed any change in participant’s performance from first assessment to second assessment:

First assessment score – second assessment score = overall ‘difference’

\[ 76.6 - 39.4 = 37.2 \text{ seconds} \]

For the mean difference scores for both the control and intervention groups, see Figure 3.

It is important to note that a decrease (in time taken) from the first assessment score to the second assessment score, is indicative of an improvement on the cognitive flexibility measure (TMT).
Descriptive statistics

It must be noted that due to absence, two participants did not attend all intervention sessions and so were removed from the subsequent analysis.

As can be seen from the descriptive statistics (see Table 1), not only did the intervention group show a decrease in their time taken to complete the TMT from first assessment ($M=55.34$, $SD=41.36$) to second assessment ($M=21.18$, $SD=13.55$), but the control group also showed a decrease from first assessment ($M=42.18$, $SD=27.61$) to second assessment ($M=29.26$, $SD=23.61$). However, this decrease appears to be larger for the intervention group. Statistical analysis will now be used to determine whether the results are significant.

Table 1: Descriptive statistics for first assessment, second assessment and difference scores showing mean (M), standard deviation (SD) and confidence intervals (CI).

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<tr>
<td><strong>Controls</strong></td>
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<tr>
<td>First assessment</td>
<td>42.18</td>
<td>27.61</td>
<td>24.03</td>
<td>59.72</td>
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<tr>
<td>Second assessment</td>
<td>29.26</td>
<td>23.61</td>
<td>14.26</td>
<td>44.26</td>
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<tr>
<td><strong>Intervention</strong></td>
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<tr>
<td>First assessment</td>
<td>55.34</td>
<td>41.36</td>
<td>20.76</td>
<td>89.92</td>
</tr>
<tr>
<td>Second assessment</td>
<td>21.18</td>
<td>13.55</td>
<td>9.86</td>
<td>32.50</td>
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<td><strong>Difference</strong></td>
<td>34.18</td>
<td>33.38</td>
<td>6.25</td>
<td>62.06</td>
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Figure 2. Mean assessment scores (Time taken on Part B of TMT minus time taken on Part A of TMT) for the control and intervention groups, for both first and second assessment. Error bars show 95% confidence interval (CI).
Figure 3. Mean difference scores (first assessment score minus second assessment score) for the control and intervention groups. Error bars show 95% confidence interval (CI).

Preliminary Analysis

Firstly, it was important to determine whether the control and intervention groups were equivalent at the first assessment. This was to be sure that any differences found were due to the manipulation (i.e. the intervention) as opposed to any possible confounding effects of individual differences. Since the data did not meet parametric assumptions, mainly due to a small sample size (n <30), non-parametric analyses were used. A Mann-Whitney test was conducted and no significant differences were found: \( U = 40.0, \ z = -0.62, \ p = .57, \ r = .14. \) Thus individual differences are unlikely to have confounded the results, and so it can be said that any significant differences within the main analysis are likely to be a result of the intervention.

Main Analysis

Since descriptive statistics suggest that both groups show a decrease in their time taken from first assessment to second assessment, it was necessary to determine the main effect of time (first assessment versus second assessment) irrespective of group. A Wilcoxon test revealed a statistically significant decrease in time taken from first to second assessment, \( T = 23.0, \ z = -3.06, \ p = .002, \) with a medium to large effect size \( (r = .48). \) This supports Hypothesis 1 as it suggests that irrespective of group membership, all participants showed a decrease in time taken to complete the TMT from first assessment to second assessment.
In order to address Hypothesis 2, a Mann-Whitney test was conducted and a significant effect was found: \( U = 24.0, z = -1.85, p = .032, r = .41 \). This indicates that although both groups showed a decrease in their time taken to complete the TMT from first assessment to second assessment, this effect was significantly larger for the intervention group. Therefore, statistical analysis confirms the directionality that can be seen from the descriptive statistics: that those in the intervention group have improved to a greater extent on a measure of cognitive flexibility, compared to the control group. Thus, it could be argued that this may be due to a result of the intervention programme.

To summarise:-

- There was no significant difference between the two groups at first assessment (suggesting no effect of individual differences).
- Hypothesis 1: Both the intervention group and control group showed a decrease in mean time taken between first and second assessment (as shown by the descriptive statistics). This was confirmed by a significant overall difference between first and second assessment, irrespective of group membership.
- Hypothesis 2: However, the intervention group showed a significantly bigger decrease in time taken to complete the TMT from first to second assessment when compared to the control group.
- In sum, although there was an overall significant decrease from first to second assessment for both groups, this decrease was significantly bigger in the intervention group when compared to the control group.

Discussion

Past research has suggested that executive dysfunction within ASD can lead to deficits in cognitive flexibility, and that interventions within schools are essential to address this (Hill, 2004; Kenworthy et al., 2011). Therefore, this study looked at whether a three-week intervention programme could improve cognitive flexibility in boys aged 11-13 years old with a diagnosis of ASD. The participants were randomly allocated to either a control condition (with no intervention programme), or an intervention condition (targeting social and cognitive aspects of flexible thought).

It was hypothesised that:

Hypothesis 1: There will be a decrease in time taken to complete the TMT from first assessment to second assessment, for both the control and intervention groups.
Hypothesis 2: The decrease in time taken to complete the TMT from first assessment to second assessment will be significantly bigger for the intervention group, compared to the control group.

Specifically addressing Hypothesis 1, the results suggest that irrespective of group allocation, the majority of participants showed a decrease in time taken to complete the TMT from first assessment to second assessment. This effect was expected to occur to some extent, as reflected within the hypothesis, due to the fact that all participants were tested twice on the TMT. Some argue that repeat testing may lead to so-called ‘practice effects,’ meaning that a participant may improve due to a result of the testing, rather than a manipulated variable (Johnson, Hoch and Johnson, 1991; Bartels et al., 2010). With reference to this study, it is possible that these effects did occur to an extent, despite researchers varying the layout of the TMT for the second assessment.

However the important finding lies within Hypothesis 2, which assessed whether the improvement was significantly bigger for those in the intervention group, compared to the control group. It was indeed found that those in the intervention group showed a significantly bigger decrease in time taken to complete the TMT from first to second assessment when compared to the control group. Therefore, it can be inferred that an intervention programme for students with ASD, specifically one targeting social and cognitive aspects of flexibility, may enhance their ability to adapt accordingly to changes in their environment. In turn, it could be argued that an intervention such as the one piloted, could improve the cognitive flexibility deficit that is argued to exist in those with ASD (Ozonoff and McEvoy, 1994; Hill, 2004; Sanders et al, 2008).

Possible reasons for why the intervention may have been successful in this manner could be deduced from the Executive Dysfunction Hypothesis. The role-play task within the social aspect of the intervention addressed executive functions such as perspective taking and empathy (Shamay-Tsoory et al., 2002; Decety and Jackson, 2004; Harmon-Jones and Winkielman, 2007; Nielsen, Marrone and Ferraro, 2014). What is more, the cognitive aspects of executive functioning, such as flexibility and inhibition (Hill, 2004), were also trained in the intervention using cognitive tasks i.e. the WCST and the Stroop Test. Consequently, because the present study examines cognitive flexibility in relation to executive functions, it could be inferred that the improvement shown in the intervention group is associated with an improvement in executive functioning.

Additionally, it might also be argued that the structured classroom-based intervention time was sufficient to allow those with ASD to practice cognitive skills specific to improving cognitive flexibility. Whereas outside of a controlled environment, there are too many
irrelevant distractors that may overload the executive function network, and thus impede children with ASD from improving in this specific area (Adams and Jarrold, 2012).

The findings from the present study have potential real-world implications as the results suggest that an intervention programme used in education may be beneficial. It is important to consider cognitive flexibility in education, because it is often linked to the ability to think creatively and independently within many disciplines, which in turn, is often related to higher academic achievement (Pintrich and de Groot, 1990; Spiro et al., 2013; Sternberg, 2003; Van Grinsven and Tillema, 2006). Therefore, it is important to argue that we should foster cognitive flexibility and creativity within the classroom by creating flexible learning environments, where children are encouraged to think in a non-rigid manner, and to expand their thinking. This is particularly relevant for those with ASD who find this skill challenging. Considering that cognitive flexibility is associated with many skills such as empathy, perspective taking, early reading ability, school readiness and self-control (Shamay-Tsoory et al., 2002; Decety and Jackson, 2004; Blair and Razza, 2007; Harmon-Jones and Winkielman, 2007; Colé, Duncan and Blaye, 2014; Farrant, Fletcher and Maybery, 2014; Nielsen, Marrone and Ferraro, 2014), it seems apparent that cognitive flexibility should become a definitive aspect of education, especially for those with ASD. Therefore it could be argued that the application of intervention programmes, such as the one detailed above, may improve cognitive flexibility in students, and may aid deficits found in ASD. These findings are of particular importance to the school that requested this research, as intervention programmes, such as this, may demonstrate a way to address both the cognitive and social deficits of flexibility that teachers see those with ASD struggling with at school.

Nonetheless, there are still alternative explanations to consider regarding these findings, which future research should use as a basis to build upon. Firstly, although this study aimed to use an ecologically valid intervention targeting real-life situations that a child may face at school, the TMT is still very artificial and was administered under strict, experimental conditions. This may mean that whilst the intervention may be fostering the behavioural trait of flexibility, the TMT primarily assesses the cognitive sense of flexibility (shifting between two tasks). Thus, it may be difficult to draw links between any effects of the intervention programme and an improvement on the TMT.

To combat this, it would be recommended in the future that a more comprehensive assessment of cognitive flexibility be used. For example, Martin and Anderson (1998) argue that the Cognitive Flexibility Scale (Martin and Rubin, 1995) is a thorough measure of both behavioural and cognitive measures of flexibility. In addition to this measure, a battery of tests could be used in conjunction with each other, which may eliminate the so-called
'practice-effects' outlined earlier in relation to Hypothesis 1. It is also argued that using multiple measures can account for individual differences, especially for those with ASD (Vanegas and Davidson, 2015). Unfortunately due to time constraints and restricted access, it was not possible to obtain such measures to use within this study. In addition, considering that this research was originally intended as a pilot study, the TMT was fit for the purpose of assessing any changes in cognitive flexibility, due to it being quick and easy to issue. However since this research indicates that intervention programmes could be beneficial for improving cognitive flexibility in ASD, a future recommendation would be to assess whether these effects are still found when additional and more comprehensive measures of cognitive flexibility are used.

Secondly, due to this research being intended as a small-scale pilot study, the sample studied was limited, both in number and populated from one school. Considering that ASD is a heterogeneous disorder and on a spectrum (Lord et al., 2000), it would be interesting for future research to study whether children at more severe ends of the spectrum differ in their levels of cognitive flexibility, when compared to children at the milder end of the spectrum. Lastly, due to this study being conducted over a time period of three weeks it is questionable whether the effects found would be maintained long-term. Therefore, a longitudinal study would be necessary to determine whether these benefits could be sustained over time.

In conclusion, the current study established whether an intervention programme could improve cognitive flexibility in boys aged 11-13 years old with ASD, within an educational setting. It is argued that an intervention programme would be beneficial for these individuals, particularly one targeting day-to-day cognitive and social aspects of flexibility. However due to time constraints and restricted access to materials, it may be possible that the effects shown could be due other confounding variables, which have been considered in the discussion. As a result of this, future research ought to include a more comprehensive measure of cognitive flexibility, as well as assessing whether an improvement in cognitive flexibility could be maintained over time.

Acknowledgements

Firstly, we would like to thank the staff at the school in which this research took place, especially Tanya and Claire for their guidance and support with this research project. We are very grateful to have had the opportunity to conduct this research whilst on placement, and enhance our psychological skills and knowledge.
Secondly, our thanks to Dr Paul Sowden for his assistance and helpful comments during the write up of our article, and to the SURJ editorial team and peer reviewers for their support, time and constructive feedback throughout the entire process.

And lastly, a huge thank you to the boys at school who took part in this pilot study, without whom, this research would not have been possible.

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