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Cognitive Strengths in Neurodevelopmental Disorders, Conditions and Differences: A Critical Review

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Abstract

Neurodevelopmental disorders are traditionally characterised by a range of associated cognitive impairments in, for example, sensory processing, facial recognition, visual imagery, attention, and coordination. In this critical review, we propose a major reframing, highlighting the variety of unique cognitive strengths that people with neurodevelopmental differences can exhibit. These include enhanced visual perception, strong spatial, auditory, and semantic memory, superior empathy and theory of mind, along with higher levels of divergent thinking. Whilst we acknowledge the heterogeneity of cognitive profiles in neurodevelopmental conditions, we present a more encouraging and affirmative perspective of these groups, contrasting with the predominant, deficit-based position prevalent throughout both cognitive and neuropsychological research. In addition, we provide a theoretical basis and rationale for these cognitive strengths, arguing for the critical role of hereditability, behavioural adaptation, neuronal-recycling, and we draw on psychopharmacological and social explanations. We present a table of potential strengths across conditions and invite researchers to systematically investigate these in their future work. This should help reduce the stigma around neurodiversity, instead promoting greater social inclusion and significant societal benefits.

1. Introduction

Neurodevelopmental disorders are prevalent in approximately 5-7% of the general population (Bishop, 2010; Lamsal et al., 2018). They often occur from early childhood (Little, 2000), continuing into adulthood (Burns & Bukach, 2021; Dance et al., 2021; Ip et al., 2021), and are typically characterised by a pattern of difficulties in specific cognitive processes. For example, these can occur in sensory processing and social communication (autism spectrum condition, ASD), face recognition (prosopagnosia) or movement and coordination (developmental coordination condition - DCD/dyspraxia). Neurodevelopmental conditions present differently, with each case exhibiting a unique profile of difficulties and strengths (Márquez-Caraveo et al., 2021). As a result, identification of the particular disorder or condition is not always straightforward (Little, 2000), and often misunderstood in schools and elsewhere (Taneja Johansson, 2021; Truman et al., 2021). The individual may be labelled as ‘lazy’, ‘troublemaking’ or ‘difficult’ rather than being referred for appropriate support (Bigelow et al., 2021; Caçola et al., 2018), with implications for teacher-student relationships (Ward et al., 2021).

As a result, children with neurodevelopmental conditions can have poorer self-efficacy (Bigelow et al., 2021), meaning they feel unable to effect and produce change. These can drive higher levels of anxiety and depression that are often observed from an early age, which can continue into adulthood (Ambrose et al., 2021; Eyre et al., 2019; Tamplain & Miller, 2021). These problems further impact upon their performance in school and their professional achievements (Ambrose et al., 2021). It is significant that unemployment rates are significantly higher amongst people with neurodevelopmental conditions (Austin et al., 2019; Carter et al., 2023). Improving these outcomes will undoubtedly provide these individuals with considerable personal and psychological benefits, but also bring economic gains to society as a whole, with improved employment prospects and economic self-sufficiency (Krzeminska et al., 2019; Rappolt-Schlichtmann et al., 2018).

Early identification and support of such conditions are important for improving outcomes later in life (Koegel et al., 2014; Lee & Zwicker, 2021; May et al., 2021; Towle et al., 2020; Zwicker & Lee, 2021). In many countries, including the UK, it is often only after a diagnosis that people can access appropriate services, funding and support (Huang & Diamond, 2009). Diagnostic testing also provides a personal profile highlighting individual weaknesses and areas of relative strength (Márquez-Caraveo et al., 2021). This information can be used to utilise person-centred support and empowerment of the individual (Browder et al., 1997).

Sometimes however, parents, teachers and medical professionals may be under-informed about these conditions (Harris et al., 2015). As a result, parents can block access to clinicians if they view a diagnosis as a damaging label or stereotype which may hinder their child throughout life (Atherton et al., 2021). Similarly, the child may develop masking techniques to hide their difficulties to try to fit in with peers (Atherton et al., 2021). Parents have been reported to experience shock, self-blame, and feelings of isolation because of the poor understanding from others (Breen & Buckley, 2016) following a child’s diagnosis.

All of these difficulties could be due to the lack of knowledge surrounding the potential strengths in neurodevelopmental differences. If parents, children, and wider society could recognise both the struggles *and* associated skills, rather than just the stigma of neurodevelopmental conditions, then they may also experience considerable relief and acceptance following a diagnosis (Breen & Buckley, 2016). This is because a diagnosis should allow carers and teachers to understand the child's differences in a more positive way, and fully appreciate the extent of their abilities (Mackie et al., 2021). Research shows that children with neurodevelopmental differences who receive early support are likely to achieve improved physical and mental health, and more successful psychosocial, socioeconomic, self-care and personal outcomes (Eisenhower et al., 2021; Oliva et al., 2021; Towle et al., 2020; van den Heuvel et al., 2016). It is therefore important to increase understanding, and remove stigma, so that such cases can be readily identified and supported appropriately by parents, teachers, clinicians and researchers.

One way of accomplishing this is to embrace the 'Positive Psychology' perspective (Nicolson & Fawcett, 2015; Seligman, 2008; Seligman & Csikszentmihalyi, 2014), where we recognise areas that people with neurodevelopmental disorders perform just as well as, or indeed better than, the general population. A positive psychology approach offers an optimistic, individual-focused view of neurodiversity which has gained traction in the past decade across autism and dyslexia research (Baron-Cohen et al., 2011; Davis & Braun, 2011; Nicolson & Fawcett, 2015). However, there is currently a more limited literature regarding the positive skills and talents in people with other neurodiverse differences such as developmental coordination disorder (DCD)/dyspraxia, attention deficit hyperactivity disorder (ADHD), developmental aphantasia and Williams syndrome. We intend to remedy this in the current narrative review.

It is, however, crucial to emphasise here that both difficulties and strengths discussed in this paper will vary between individuals. As such, we take care to avoid generalisation and stereotyping of people who have these conditions. Individual differences play a role in all human cognition (Baron-Cohen & Wheelwright, 2003; Paul et al., 2021; Stephens et al., 2020), and neurodevelopmental conditions are similarly heterogeneous in nature. Whilst some people may display the skills and strengths reviewed here, others will not. It is also highly likely that there are additional skills and strengths that are not discussed.

This paper thus aims to provide a broad, empowering, and optimistic overview of the research that demonstrates potential behavioural and cognitive strengths across different neurodevelopmental conditions. First, we provide a narrative review of potential strengths that we have identified in the literature for each neurodevelopmental condition. Then secondly, we explore several theoretical motivations for the presence of such abilities in people with neurodevelopmental differences. These include a genetic basis of differences (Chaste & Leboyer, 2012), the neuronal recycling hypothesis (Dehaene & Cohen, 2007) and psychopharmacological theories (Bedard et al., 2004; Tannock et al., 1989). Plus, inter-related social theories (Chaste & Leboyer, 2012; Taylor & Vestergaard, 2022) such as behavioural adaption (Taylor & Vestergaard, 2022). In the latter section, we provide a summary of each perspective to help frame the strengths we identify here.

2. Method

The aim of the manuscript was to provide a synopsis of cognitive strengths across multiple neurodevelopmental conditions. Such strengths have to be identified in a close reading of papers that typically focus on deficit (i.e., there are thus no easy routes using keywords to assist in the search). A systematic review of this literature would have involved reading every single published paper for each condition (e.g., at the time of writing, a Google Scholar search revealed 218,000 papers on autism and 23,000 on dyslexia signified in the titles alone), which makes such a task highly impractical. To this end, a narrative/scoping review was conducted as the only viable alternative.

Given the ‘hidden’ nature of the cognitive strengths in the various papers, in order to conduct the review, search terms were entered into numerous academic search engines including SCOPUS, Science Direct and Google Scholar. These terms included key words such as ‘strengths’, ‘skills’, ‘abilities’, ‘superior’ in combination with ‘neurodevelopmental disorders’, ‘neurodevelopmental’, ‘special educational needs’, along with each condition individually, e.g., ‘autism spectrum disorder’, ‘developmental coordination disorder’, ‘dyspraxia’, ‘dyslexia’, ‘Williams syndrome’ and so forth. Many searches using such positive terms, however, yielded relatively few results. So, we also drew upon the expertise of colleagues to identify other avenues of research to include in our narrative/scoping review.

Whilst we acknowledge there are many neurodevelopmental conditions and differences to potentially select from (Bishop, 2010), this review focussed upon cognitive strengths in neurodevelopmental conditions and differences where there was some preliminary evidence of such strengths. These included five neurodevelopmental disorders as defined in the Diagnostic and Statistical Manual of Mental Disorders (DSM 5): autism spectrum disorder (Swanson et al.), dyslexia, developmental coordination disorder (DCD), attention deficit hyperactivity disorder (ADHD) and Williams syndrome. Alongside these, we included developmental aphantasia, a neurodevelopmental difference in which people experience no visual imagery (i.e. they are unable to picture an image in their mind’s eye; Speed et al., 2024). Despite not being identified as a ‘disorder’ in the DSM-5 (American Psychiatric Association, 2013; Monzel et al., 2023), nor viewed as such by several prominent researchers (Monzel et al., 2023; Zeman et al., 2020; although see: Blomkvist & Marks, 2023), we felt that it was important to include here. This is because a substantial number of individuals with developmental aphantasia can experience considerable distress when it is identified (Monzel et al., 2022). For the well-being of such individuals it is, therefore, important to identify any strengths associated with it, in order to counteract any negative feelings arising from the realisation that they may lack mental imagery.

We did search for potential strengths in several other neurodevelopmental conditions (including dyscalculia, developmental prosopagnosia and developmental language disorder) but were unable to identify any such strengths with sufficient confidence .

Whilst our paper is not a systematic review of psychological strengths in people with neurodevelopmental differences, it does offer a critical review, and potentially novel insights, into several important conditions. We hope that this may act as a stimulus for a major systematic review in the future.

3. Positives of Autism Spectrum Disorder (ASD)

Autism spectrum disorder (ASD; Swanson et al.) is a neurodevelopmental condition characterised by social and communication difficulties (Iuculano et al., 2014). Reports on the prevalence of ASD vary, but in 2011, it was estimated at 1% in the UK, and in the USA at 1.85% amongst 8-year-old children (Joon et al., 2021). Profiles of challenges and abilities in people with ASD can vary greatly. However, as with many neurodevelopmental disorders, there are often no outward signs of impairment so it may be considered a hidden disability(Bjørklund et al., 2020). While researchers spend considerable efforts attempting to identify cognitive processes that are impaired in ASD groups, it can be associated with many behavioural strengths (Goldfarb et al., 2019; Rowland, 2020; Wei, et al., 2015) that should be recognised and advocated.

For example, some people with ASD demonstrate superior understanding of details, rules, systems, and the ordering of objects (Baron-Cohen & Belmonte, 2005). Whilst some people with ASD may struggle to understand the nuances of group conversations and friendships (Bishop-Fitzpatrick et al., 2017; Black et al., 2022), they often have, in contrast, keen interests in understanding how things work (Baron-Cohen & Belmonte, 2005). This may include hyper-focus (Dupuis et al., 2022; Rowland, 2020) where children with ASD can focus their attentional abilities on a single task to an exceptional degree. For example, Dupuis et al. (2022) asked parents of children with and without ASD, how they would rate their child compared to other children when they are, 'engaging in tasks that require sustained mental effort; giving close attention to detail and; avoiding careless mistakes and ignoring extraneous stimuli'. Remarkably, greater levels of attentional strengths, including hyperfocus, were reported by parents of children with ASD (n = 131) than by parents of control children (n = 4726).This hyper focus was also linked with perseverance and perfectionism, which could be interpreted as potential strengths of people with ASD (Dupuis et al., 2022).

Other authors suggest this hyperfocus may manifest as a fascination with input-output relations and fixed rules in systems, processes or machines (Paul et al., 2021), e.g., the minutia of how timetables, trains and traffic lights work or the spinning of car wheels (Rynkiewicz et al., 2021). Some people with ASD are reported to have a strong interest in objects such as Lego, video games and gadgets (Cho et al., 2017) because they are predictable and follow unchanging laws.

This enjoyment of fixed rules and processes (Lei & Russell, 2021) may help explain why some people with ASD demonstrate enhanced mathematical ability (Iuculano et al., 2014) and strong abilities in other STEM subjects; it is because these topics rely heavily on formulae, rules and specific methods (Wei et al., 2013). This is reflected in the fact that people with ASD who attend college and university are significantly more likely to study

STEM subjects than the general population (Wei et al., 2013). Additionally, fathers of children with autism are over-represented in engineering, medicine, science and accountancy (Wheelwright & Baron-Cohen, 2001), hinting at a possible genetic basis for autism and abilities in these subjects.

However, despite these apparent strengths in some ASD students, approximately 25% of people with ASD have a mathematical learning disability (Barnett & Cleary, 2015). Only 10% of individuals with ASD have superior mathematical ability, whilst many perform below their neuro-typically developing (NT) peers in mathematics (Winoto et al., 2017). Plus, the number of ASD students enrolling on university courses overall is comparatively low, at 0.8% of the UK student population in 2018-19 (Lei & Russell, 2021; Wei et al., 2013). A recent meta-analysis found the aptitude of mathematical ability in children (aged 6-16) with ASD was lower than in control groups (Tonizzi & Usai, 2023). However, it is important to note that this may be due to the lack of opportunities to achieve the necessary support during school, which would later aid the transition to college or university (Gurbuz et al., 2019; Lambe et al., 2019). Particularly if they had not received an early diagnosis and appropriate, formative support (Wei et al., 2013). However, if more widespread early identification and educational intervention was implemented for children with ASD, perhaps many more of those with ASD may develop these superior skills (Tonizzi & Usai, 2023).

Another aspect of cognitive functioning that appears enhanced in autism is the more spontaneous and automatic ability to focus on local (specific) detail (Van der Hallen et al., 2015) as opposed to the nuances of social interaction and global visual processing and the extraction of gist (Vanmarcke et al., 2016). For example, Ven Der Hallen et al. (2015) reviewed 56 studies which had investigated this topic using a variety of cognitive assessments, such as the Navon Task (Van der Hallen et al., 2015). Navon tests may include, for example, a large ‘H’ comprised of small, lower case ‘S’ shapes. The task (example in Figure 1) identifies whether the participant tends to view the large (global) image or smaller (local) images first, to establish visual processing preference (Morris et al., 2021). A preference for, or faster visual local processing ability, indicates a keener focus on specific detail, as found in people with ASD (Van der Hallen et al., 2015).

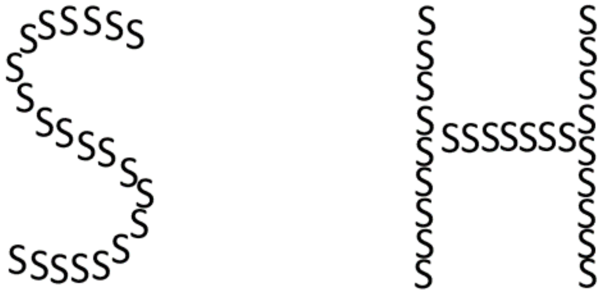


Figure 1. Example of stimuli used in a Navon task (Duchaine et al., 2007; Navon, 1977). The global (larger) and the local (smaller) letters were either consistent (e.g. global S, local Ss) or inconsistent (e.g. global H, local Ss). Preference was measured by response to either the global letter or the local letter. Individuals with ASD may display preference for local bias and specific details. Conversely, those with developmental prosopagnosia appear to exhibit a bias at viewing the global, rather than local, information (Duchaine et al., 2007), suggesting they may be better at seeing the bigger picture than control counterparts.

This processing bias for featural, local information is known as ‘weak central coherence’ (Happé & Frith, 2006; Tassini et al., 2022; Zmigrod et al., 2015). Children with ASD also demonstrated significant differences in activation patterns in the hippocampus and entorhinal cortex (Iuculano et al., 2014) that are known to play a vital function in arithmetic fact retrieval in children (Iuculano et al., 2014). These factors may also help underpin the superior mathematical ability demonstrated in some people with ASD and may be the result of a unique pattern of brain organisation (Iuculano et al., 2014).

Additionally, people with ASD may also display perceptual expertise (Iuculano et al., 2014) for example, the ability to rapidly and accurately recognize and categorize objects in a specialist subject such as birdwatching, chess and physics (Shen et al., 2014). Iucalano et al. (2014) found cortical regions typically involved in perceptual expertise such as the ventrotemporal occipital cortex (VTOC), may be utilized in novel ways in children with ASD (n = 18; Iuculano et al., 2014). For example, voxels predicting better numerical problem-solving ability in children with ASD overlap considerably with VTOC face-processing regions (Iuculano et al., 2014). These regions, particularly the fusiform gyrus, show high levels of plasticity which may be enhanced by functions that the individual has perceptual expertise or more practice in (Behrmann et al., 2006; Burns et al., 2019; Foss-Feig et al., 2016; Iuculano et al., 2014). The neuronal recycling hypothesis would suggest that if children with ASD pay less attention to faces during early development, then areas of the visual cortex that are typically used for face perception may become repurposed (Dehaene & Cohen, 2007), leading to enhanced ability for other stimulus categories of interest, such as numbers (Iuculano et al., 2014). Thus, this plasticity could be a contributory factor to their enhanced skills in this area. Indeed, it is possible there are other, unseen enhanced abilities in people with ASD which have yet to be found. This is because researchers often focus on challenges rather than superior skills in neurodevelopmentally diverse groups.

Conditions such as ASD have been widely considered as a disability and a hinderance to normal social functioning (Van der Hallen et al., 2015). It is important to consider that for some, their condition may be too severe to live independently or seek traditional employment, i.e. if they are non-verbal or have severe comorbid learning difficulties (Chapman & Veit, 2020). However, the job roles that some people with less severe ASD excel in (e.g., maths and science) are of high value to society (Baron-Cohen et al. 1997).

Focusing on the abilities of people with ASD may improve their vocational prospects. For example, Goldfarb (2019) suggests that people with ASD have skills which can be advantageous in the workplace, such as enhanced visual search abilities and a systematic work style (Goldfarb et al., 2019). Expertise in specific, focussed fields, associated with their characteristic special interests, for example in IT and engineering (Wei et al., 2013), gardening, gaming, technology and music (Goldfarb et al., 2019) could be of personal and financial value to both the individuals themselves and their employers (Dobusch, 2021; Goldfarb et al., 2019).

4. *Positives of Dyslexia*

Dyslexia is a neurodevelopmental difference characterised by phonological difficulty in distinguishing written and spoken phonemes (Von Karolyi et al., 2003). People with dyslexia therefore often struggle with the basic, underpinning skills used in the development of literacy, such as reading comprehension (Price et al., 2021), spelling and writing (Peter et al., 2021). As a result, they may fail to meet the demands of school, causing secondary difficulties such as inattention, poor behaviour, social withdrawal, and internalising failure (Parhiala et al., 2015). Sadly, these issues can impact upon their psychological wellbeing (Parhiala et al., 2015).

However, despite the many challenges demonstrated in the literature, there is evidence that some people with dyslexia exhibit areas of strength. These include creativity (Everatt et al., 1999) and art (Grant et al., 2020), with dyslexic adults consistently performing better in tasks requiring novelty, insight and innovative styles of thinking (Everatt et al., 1999). For example, when asked to list as many alternative uses as possible for a coke can, a brick and other everyday objects (Everatt et al., 1999; Torrance, 1966). Participants have also been asked to use basic shapes such as squares, circles and triangles to create drawings of objects or concepts and name the drawing (Argulewicz et al., 1979; Everatt et al., 1999; Torrance, 1966). Dyslexic participants demonstrated enhanced performance in these tasks by producing far more alternative uses for objects and object drawings than non-dyslexic controls (Everatt et al., 1999). They also exhibited superior creative problem solving when using insightful, innovative thinking to find novel or unusual solutions to problems (Everatt et al., 1999). Creative thinking is also a common theme identified in student teachers with dyslexia as they use innovative solutions to overcome their difficulties (Griffiths, 2012). For example, dyslexic teachers described how they would put printed word banks on tables and display key vocabulary on the walls for the children to use, but secretly they were there to help them too (Griffiths, 2012). Dyslexic teachers have also reported using creativity and drama to help pupils with their writing, with the schools acknowledging the novelty of the ideas (Griffiths, 2012).

It is important to recognise that the evidence in favour of enhanced creativity in dyslexia does have limitations. For example, meta-analyses have failed to fully confirm that dyslexia is associated with distinct superior abilities in verbal versus non-verbal creativity, or in creative outcomes, e.g., fluency in generating ideas or in their originality. An exploratory meta-analysis (Majeed et al., 2021) did however show adults with dyslexia significantly outperformed controls in creativity, in contrast to child/adolescent samples that did not (Majeed et al., 2021). We must therefore acknowledge that cognitive strengths in NDDs may not be obviously apparent throughout the entire lifespan (Majeed et al., 2021). This could be due to adults with dyslexia gaining additional experience being creative through constant adaption to environments and situations that are not designed to favour them - as described by the student teachers earlier (Griffiths, 2012). While meta-analyses favour adults with dyslexia exhibiting higher levels of creativity, we must be mindful that evidence demonstrated through exploratory analyses are weaker than that shown through confirmatory and/or pre-registered work. This topic may therefore benefit from further well-powered replications.

In addition to creativity, there are other limited reports of possible strengths in some people with dyslexia. Case studies of two gifted students with dyslexia revealed advanced vocabulary use, exceptional analytical abilities and problem-solving skills, along with a good sense of humour (Reis et al., 1997; Ruban, 2005). Anecdotally, in an opinion piece, engineering and athletics (Geschwind, 1982; Wang et al., 2016) and hypothetically, art (Chakravarty, 2009) have also been proposed as areas of skill in people with dyslexia.

It has also been suggested that some people with dyslexia have superior global visual spatial ability because they rely more heavily on peripheral vision (Schneps et al., 2011; Von Karolyi et al., 2003) as measured on the impossible illusion task (Von Karolyi et al., 2003). This task presents two-dimensional images of objects that seem to be three-dimensional but could not actually exist in three-dimensional space. This measures a participant's ability to scan the image, section by section, and successfully integrate the parts in order to comprehend if it would work as a whole object or not (Von Karolyi et al., 2003). The participant must scan globally to identify an object is impossible (Schacter, 1992). This is important because global, or holistic visual-spatial processing is linked with mechanical skill, carpentry, invention, visual artistry, surgery, and interpreting X-rays or magnetic resonance images (MRI; Von Karolyi et al., 2003).

A study by Schneps et al. (2011) identified a link between dyslexia and enhanced visual processing abilities that are particularly useful in astronomy (Schneps et al., 2011).

Firstly, when natural scene images are gaussian-blurred (i.e., using a filter that removes fine-grained details, replicating visual distortions found in many astronomical images), college students with dyslexia significantly outperformed non-dyslexics in learning the spatial contexts presented (Schneps et al., 2011). Secondly, they found that astrophysics students with dyslexia had greater accuracy in picking out the black holes from noise in astronomy images than non-dyslexics, because they had a visual bias for the periphery of a scene because their peripheral vision was enhanced (Wang et al., 2016).

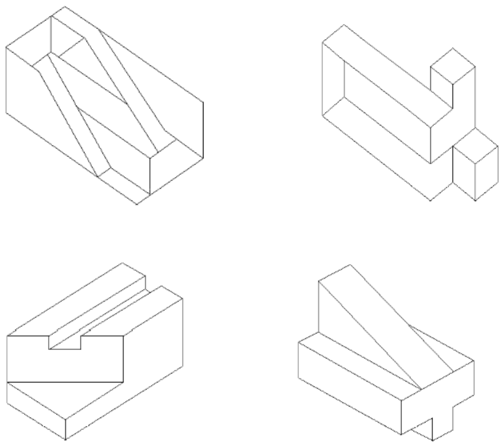


Figure 2. Examples of stimuli used in the Impossible Illusion Task (Von Karolyi, 2003; Schacter et al., 1990). The objects in the top row are structurally impossible whilst those on the lower row are structurally possible. Individuals with dyslexia appear superior at judging these images as impossible than their control counterparts (Von Karolyi et al., 2003). This suggests they may have unique visual-spatial skills which might be beneficial in mechanics, surgery, invention, carpentry, and medical and astrophysics imaging.

Schneps et al. (2007) proposed that within the brain, the central and peripheral visual fields are structurally segregated and differentiated by anatomical and functional characteristics (Schneps et al., 2011). While the central field is utilised for tasks such as visual search for specific details, the periphery is used for rapid processing over broad regions. Evidence suggests that peripheral bias is high in many people with dyslexia, hence they have strong peripheral vision and visual comparison skills (Geiger et al., 2008; Grant, 2020). This is in contrast to specific featural, or local processing speed strengths identified in some people with autism (Lebreton et al., 2021). It has been suggested that dyslexia is associated with neurological advantages that are useful in careers where this type of visual processing can be applied, such as in radiology, astronomy, and cellular microscopy (Schneps et al., 2012; Taylor & Vestergaard, 2022).

However, people with dyslexia may have difficulties accessing the higher and further education required to master such skills without strong early educational support (Schneps et al., 2011). This is arguably reflected in the fact that, as in ASD, people with dyslexia are disproportionally underrepresented at university (Schneps et al., 2011). They are also likely to require additional support from their institutions to contend with the large amount of reading that is required to complete such courses (Ruban, 20005). Ruban and Reis (2005) use the phrase 'aptitude-achievement discrepancy' to describe such phenomena. This means many pupils with learning difficulties such as dyslexia often have much higher aptitude than their educational attainments in the current education systems demonstrate (Ruban, 2005).

It is also of note though that unlike ASD, no superior strengths have been found in mathematical skills in children with dyslexia (Simmons & Singleton, 2009). However, these researchers also demonstrated that the maths skills of children with dyslexia were no poorer than the non-dyslexic control group (Simmons & Singleton, 2009). This is interesting because skills in which neurodevelopmentally diverse people perform equally with peers, are often much less reported in the scientific literature (Rappolt-Schlichtmann et al., 2018). We would like to propose that areas of equal performance with the rest of society might also be considered a strength in this context, against a recurrent backdrop of reported challenges and problems. Having a clear picture of the ways in which they are ‘the same’ as other people, plus knowledge about group strengths (along with group difficulties), may be crucial in providing a complete picture of each neurodevelopmental difference. This may help increase self-belief, education, employment and life outcomes in people with neurodevelopmental differences.

Ruban and Reis (2005) also suggest that students with dyslexia demonstrated improved individual performance in maths when supportive strategies were allowed in the classroom and in exams, such as emphasis on word problems, calculator use and additional time for assignments (Ruban, 2005). This further highlights the importance of an early diagnosis as many of these strategies are only permitted once a difficulty has been formally identified by a professional (Ruban, 2005).

5. Strengths in Developmental Coordination Disorder (DCD)

Developmental coordination disorder (DCD), also referred to as dyspraxia, primarily affects movement and coordination (motor) ability in approximately 6% of the population (Smith et al., 2021). It causes significant difficulties with everyday tasks that most people take for granted such as driving (Gentle et al., 2021), using zips, cleaning teeth, self-care (Kirby et al., 2008), handwriting, and taking part in exercise (Cairney et al., 2013). Challenges may change through the lifespan but persist into adulthood (Licari et al., 2018; Purcell et al., 2015). Whilst most DCD studies also focus heavily on deficits and difficulties, there is some evidence that the condition may be associated with cognitive strengths.

For example, whilst empathy was traditionally considered a challenge for people with DCD (Cummins et al., 2005), Tal-Saban and Kirby (2020) found that their levels of empathy appeared no different from controls (n = 42 without comorbid ADHD or ASD). Curiously, the standard deviations of the DCD empathy scores were 64% larger than controls. This could occur if there were a higher frequency of high empathy DCD individuals than in the control group. Although it is important to note that this would likely be offset by some DCD cases who are atypically low in empathy. Thus, while empathy may be a disproportionate strength in some people with DCD, it may also be an extreme weakness in certain cases too.

Children with DCD are also reported to avoid activities that they may not succeed in, for example in some sports (Cairney et al., 2013; O'Dea et al., 2020). A parent interview-based study reported that children (*n* = 13) with DCD avoid risks, show strengths in observation rather than participation in activities, and are not physically adventurous (Missiuna et al., 2006). Traditionally these findings may have been considered a weakness or disadvantage for people with DCD, however they may be repositioned as a strength. These traits indicate some people with DCD may be more risk-averse generally than their peers, which could be considered a possible asset within settings that require such careful, deliberated behaviours (Dong, 2014).

It has also been suggested that young people with DCD (n =13) may be particularly creative with respect to how they spend their free time, including writing stories, reading, drawing and making up songs (Zwicker et al., 2018). Such interests have the potential to become signature strengths for individuals if they are supported and nurtured. The use of laughter and humour as a coping mechanism when dealing with DCD’s challenges has also been reported (Zwicker et al., 2018) which may indicate a sense of humour as a strength of the condition.

Anecdotal literature from both an interpretative phenomenological study of six 13 year olds (Payne et al., 2013) and Scott-Robert & Purcell’s (2020) book, suggests people with

DCD can empathise with peers when they discuss their social vulnerability (Payne et al., 2013), and are good at embracing diversity and attuning to others (Scott-Roberts & Purcell, 2020) in group settings. They advocate that people with DCD also exhibit high levels of resilience and determination, and creative problem solving developed through navigating their on-going challenges (Scott-Roberts & Purcell, 2020). Few of these qualities, however, have been empirically tested and reported, so much of the information about such strengths in people with DCD is based on anecdotal evidence. Unfortunately we were unable to identify any neural underpinnings for the strengths found in people with DCD. Future research is therefore key to systematically identifying skills, strengths and abilities in people with DCD and identifying associated brain functionality and differences.

6. Strengths in ADHD

Attention-deficit hyperactivity (ADHD) is a neurodevelopmental disorder characterised by inattentiveness, hyperactivity and impulsiveness (Christiansen et al., 2021). ADHD traits can have a detrimental effect on both educational attainment and employment opportunity in later life (Christiansen et al., 2021). However, certain aspects of ADHD, including hyperactivity and risk-taking, have been positively associated with self-employment (Verheul et al., 2016; Wismans et al., 2020). This means that whilst ADHD traits have traditionally been seen as a difficulty, they may also be viewed as a strength.

Successful entrepreneurs such as Richard Branson (founder of the Virgin Group) and Ingvar Kamprad (founder of IKEA) both publicly acknowledge their ADHD symptoms as motivators in their decision to become self-employed (Verheul et al., 2016). As personal autonomy and risk characterise entrepreneurship, those who enjoy careful planning and structure may be less well suited to entrepreneurial activity. However, pragmatic action

(Crook & McDowall, 2023), without prolonged deliberation (as may be found in people with ADHD) is sometimes a key element in successful entrepreneurship (Yu et al., 2021). People with ADHD often display traits of novelty and sensation seeking, and are easily bored, thus they are more likely to develop new ideas and products (Yu et al., 2021) and may therefore be better suited to this type of work (Yu et al., 2021). Other features that may attract people with ADHD include variability of tasks, the freedom to change the work to meet their preferences and needs, and flexible working hours (Lerner et al., 2019; Patel et al., 2021). In this environment their difficulties may become their strengths and some people with ADHD can therefore perform well in private enterprise (Yu et al., 2021).

In employment however, jobs are not always designed with neurodiversity in mind (Yu et al., 2021) so the symptoms of ADHD frequently appear to have a detrimental effect on both typical educational attainment and employment opportunities in later life (Christiansen et al., 2021). There are though reports of people with ADHD (n = 6) being effective salesmen, as they have high energy levels, persistence, good use of humour and may also be very persuasive (Sedgwick et al., 2019).

The specific ADHD traits highlighted by Sedgwick (2019) can be viewed in a positive light, including participants who describe generating many ideas which jump from one to the next (Grotewiel et al., 2023; Sedgwick et al., 2019) but then also having an increased focus (a hyper-focus) on interesting tasks (Sedgwick et al., 2019). Hyper-focus has previously been considered a deficit when measured in task-switching studies, but ADHD participants reported that intense concentration was a strength (Sedgwick et al., 2019). People with ADHD described it as a ‘state of flow’ which helped them to be more creative and productive (Sedgwick et al., 2019). Sedgwick (2019) also identified a theme of adventurousness, spontaneity and thrill-seeking in participants with ADHD. In some circumstances, these traits may be viewed as reckless and negative, and may be a factor contributing to the reported high levels of poor educational outcomes, criminality, substance misuse, socio-economic disadvantage (Holst & Thorell, 2020; Mannuzza, 2008). Conversely, if they have an intrinsic motivation to succeed, abundance of energy, will-power and persistence, then ADHD traits can be utilised in a positive, brave way to experience adventure and success (Sedgwick et al., 2019). Whilst this study cannot be generalised to the wider ADHD population, this phenomenological approach offers a rich insight into the experience of those with ADHD and is arguably of value when considering strengths and skills in people with neurodevelopmental differences.

7. Strengths in Williams Syndrome

Williams syndrome is a genetic neurodevelopmental condition characterised by distinctive facial features, heart problems, connective tissue abnormalities, and growth and developmental delays (Mervis & Becerra, 2007). The condition may also cause difficulties in spatial cognition and visual processing (Gathercole & Alloway, 2006). Williams syndrome occurs in approximately 1 in 7500 people (Strømme et al., 2002) making it less common than some other neurodevelopmental disorders. However, several strengths and talents have been identified in people with Williams syndrome. These include superior language and vocabulary skills found in 18 young people aged 9 to 23 (Karmiloff-Smith et al., 1995) using the British Picture Vocabulary Scale, (Dunn et al., 1982) and the TROG (Test for Reception of Grammar; Bishop, 1983). Both tests involve listening to a word or sentence and selecting the picture from options that best illustrates that word's meaning to identify understanding of vocabulary (Bishop, 1983; Dunn et al., 1982).

Possibly as a result of realising their enhanced language ability early in development and playing to their strengths (Karmiloff-Smith et al., 1995), people with Williams syndrome are also reported to display extreme friendliness towards adults, from whom they receive language based interactions (Karmiloff-Smith et al., 1995). Their superior language performance may however be underpinned by atypical language processing and neural structuring (Karmiloff-Smith et al., 1995). For example, there is some evidence of greater cerebellar lobule volume in people with Williams syndrome (Bellugi et al., 2014; Jernigan & Bellugi, 1990; Karmiloff-Smith et al., 1995). The cerebellum is thought to be important for recognising the intentions and emotions of others, which supports social understanding (Ferrari et al., 2022). This region is considered part of the neural networks responsible for both visual attention (Brissenden & Somers, 2019) and social interactions (Metoki et al., 2021; Van Overwalle et al., 2020; Wong et al., 2019).

Conversely, in people with ASD, who are less social than those with Williams syndrome, these lobules are smaller (Courchesne et al., 1988; Karmiloff-Smith et al., 1995). More recent studies also point to greater volumes and connectivity between the cerebellum and the fusiform gyrus (Haas et al., 2013; Jackowski et al., 2009; Reiss et al., 2004) in people with Williams syndrome, and poor functioning in these regions in people with ASD (Amore et al., 2021; Hadjikhani et al., 2004; Oblak et al., 2010; van Kooten et al., 2008). Such differences in structure and connectivity in regions responsible for social cognition (Ferrari et al., 2022; Metoki et al., 2021; Van Overwalle et al., 2020; Wong et al., 2019) may hint at underpinning explanations for the typified differences in social abilities between these two neurodiverse groups (Karmiloff-Smith et al., 1995).

Whilst individual performance varied, overall group strengths have also been identified in auditory processing and phonemic awareness in people with Williams syndrome (Miezah et al., 2020). Auditory processing refers to the processing of auditory signals along the central auditory nervous system (Sardone et al., 2019). This includes the understanding of speech, or following one voice in a noisy environment, or when several people are speaking at once (Sardone et al., 2019). These strengths in Williams syndrome have been suggested to arise as a result of different processing in neural language systems (Karmiloff-Smith et al., 1995). Furthermore, young people with Williams syndrome have also been found to exhibit superior skills when recognising both facial identity and emotion than their typically developing peers (Ibernon et al., 2018; Karmiloff-Smith et al., 1995). However, these skills may be ameliorated by poor visual search skills, spatial cognition and problem solving (Karmiloff-Smith et al., 1995; Scerif et al., 2004).

It has been suggested that people with Williams syndrome do not demonstrate racial bias), which could be considered a major social strength in how they may respond to people of different races. This is unusual as most people display preference for their own ethnic group and differentiate from other ethnicities by the age of three (Santos et al., 2010). Santos et al. (2010) proposes that this may be due to decreased neural activity in the amygdala and the fusiform facial area in Williams syndrome which reduces the signalling of social threat usually associated with other racial groups. This further contributes to their extreme, indiscriminate friendliness (Santos et al., 2010).

It is clear that there is significant individual variation in the cognitive profiles of people with Williams syndrome (Miezah et al., 2020). Contrary to the deficit-based view of William's syndrome, evidence suggests people with Williams syndrome may have some superior skills such as highly developed social abilities and musical talents (Ibernon et al., 2018; Martíínez-Castilla & Sotillo, 2008; Royston et al., 2019).

8. Strengths in Developmental Aphantasia

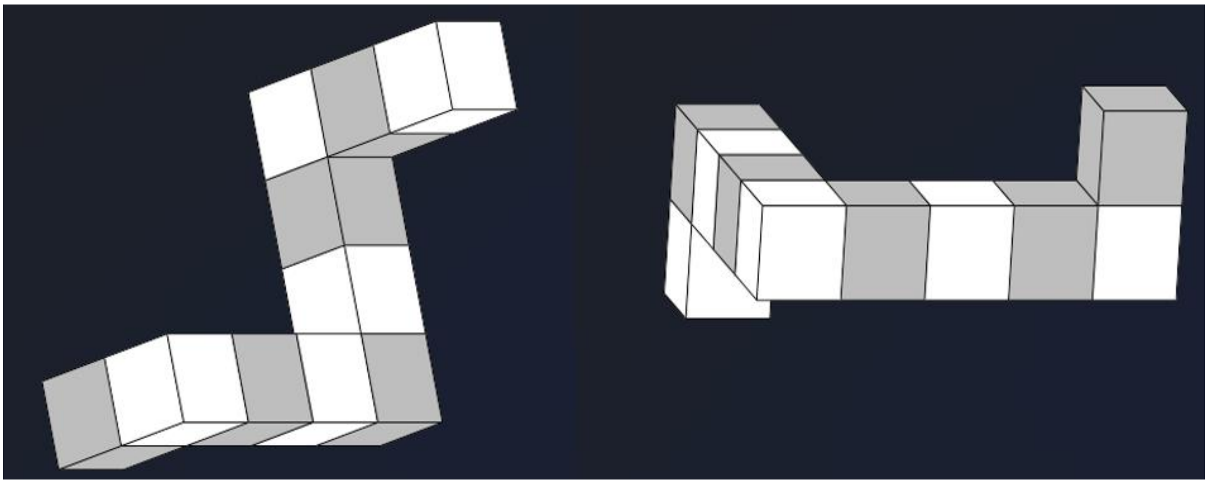
Developmental aphantasia may be considered a neurodevelopmental condition (Dance et al., 2021) affecting 2-3% of people from early childhood (Fox-Muraton, 2021). It is typified by the inability to form voluntary visual imagery in high functioning individuals (Bainbridge et al., 2021). For example, people with aphantasia are unable to visualise in their mind's eye a clear image of a sunset (Dance et al., 2021), familiar routes, people (Zeman et al., 2010), or monuments and buildings (Zeman et al., 2010). Aphantasia may also sometimes affect the ability to visualise personal memories of important events or people, and to dream (Dawes et al., 2020).

There is some evidence that despite these difficulties in imagining mental constructs, people with aphantasia develop alternative cognitive strategies to compensate (Fox-Muraton, 2021). For example, a study investigating the ability to memorize and draw real world scenes in people with aphantasia (n = 61) identified equally good spatial memory (Bainbridge et al., 2021). People with aphantasia were able to position objects at accurate locations with the correct sizes despite being unable to visualise the objects or locations in their mind (Bainbridge et al., 2021). Aphantasia participants demonstrated strong abilities on this drawing task with significantly fewer errors in memory, fewer falsely recalled objects, and less correction of their drawings than controls (Bainbridge et al., 2021). Participant reports suggested the use of strategies such as representing information through a symbolic or verbal code to remember locations, along with accurate spatial representations, compensating for missing visual imagery (Bainbridge et al., 2021). This may suggest that their reliance on spatial and semantic memory systems is a more accurate processing strategy, than relying upon a confabulated episodic mental image which visually recreates the scene in the mind's eye (Bainbridge et al., 2021).

The types of careers people with aphantasia choose may also provide clues about their potential strengths. For example, Zeman et al (2020) identified that people with aphantasia were significantly less likely than controls to have employment in arts, design and entertainment, occupations careers. Instead, they were more likely to be in jobs associated with STEM subjects. It is entirely possible however that these findings might be underpinned by the aphantasia participants being more highly educated than controls in this study, or the association between ASD and aphantasia. No data was collected to identify the potentially confounding role of comorbid conditions, thus future studies may be required to investigate this further. However, regardless of comorbidity, people with aphantasia were found to seek employment in STEM, and presumably therefore demonstrate ability in these activities (Zeman et al., 2020). As with all findings however, ability will vary between individuals.

Pounder et al (2018) found that people with aphantasia (n = 20) perform significantly more accurately than controls on a mental rotation tasks. These tasks involve identifying whether images of three-dimensional cube patterns are identical when they are rotated to different perspectives (Shepard & Metzler, 1971). The authors considered this may be due to reliance on spatial imagery, which is a separate and intact cognitive ability in people with aphantasia (Pounder et al., 2021). This is an alternative to visual imagery processing, which is typically used by controls in this task (Pounder et al., 2021). This highlights a further visual skill exhibited by a neurodiverse group.

Keogh and Pearson (2018) also reported a potential tendency for above average spatial imagery scores in people with aphantasia. The authors suggested this possible tendency may be due to separate neural networks, with one being used during static object imagery and another used during mental rotation or three-dimensional spatial imagery. They propose that people with aphantasia may have a severe deficiency in the ventral 'what' (static object) pathway from the striate cortex to the inferotemporal cortex (Goodale & Milner, 1992), but no issues in the 'where'(spatial) pathway (Keogh & Pearson, 2018) from the striate cortex to the posterior parietal region (Goodale & Milner, 1992). This hypothesis suggests aphantasia is not due to a lack of metacognition (meaning the ability to introspect, or be aware of thoughts and images in their own mind; Keogh, 2018), and that these may be areas of strength in people with aphantasia (Keogh & Pearson, 2018). Hypothetically, it is also possible that people with aphantasia (*n* =267) may have reduced susceptibility to re-living traumatic events in vivid sensory detail (Dawes et al., 2020). This may be considered a benefit of the condition, although this does not protect them from all symptoms of trauma (Dawes et al., 2020).



Example of Mental rotation stimuli used in Shepard and Metzler type tests used in Pounder et al. (2018). Example image provided by Jost and Jansen (2020). The participant has to decide whether these are identical (match) or different (no match). In this example the correct response is “no match”. Individuals with aphantasia appear more skilled than the control population in such tasks. Curiously, such superior skills may be similar to those found in dyslexia, where the latter judge impossible images better than controls.

9. Positives of Other Neurodevelopmental Conditions

There are of course many other neurodevelopmental conditions for which dedicated strength related sections are not included. This is because the evidence base was too weak, or absent, to review. For example, people with developmental prosopagnosia suffer lifelong difficulties recognising faces (Burns et al., 2023; McConachie, 1974). Studies into this group have yielded minimal cognitive strengths using the Navon task, reading and self-reports, although many of these have been contradicted upon replication (Behrmann et al., 2005; Bennetts et al., 2022; Burns & Bukach, 2021, 2022; Duchaine et al., 2007; Svart & Starrfelt, 2022). Research on possible strengths in developmental dyscalculia (Kosc, 1974) and developmental language disorder (problems with language, DLD; Bishop, 2017) are similarly less clear. Within the DLD literature there are some strengths mentioned such as independence and prosocial behaviour (McGregor et al., 2023), however no cognitive abilities were found through empirical study. We therefore recommend that further research would be beneficial to identify areas of cognitive strength in broader neurodevelopmental conditions alongside those discussed in more detail above.

10. Theoretical Explanations of Strengths in people with Neurodevelopmental Conditions.

Having reviewed some of the potential strengths in neurodevelopmental conditions, it is now important to consider their possible causes. This should help researchers studying strengths in the future to identify and test these causes in their work. We therefore provide multiple theoretical explanations for such strengths in this section. While it is possible to consider them individually, they may also be viewed through the lens of the neoconstructivist perspective (Karmiloff-Smith, 2009). This latter viewpoint proposes cognitive profiles are based on several interacting factors that we discuss here; such as genetics, environment and biology (Karmiloff-Smith, 1998, 2009).

10.1. Genetic basis of skills

There is strong evidence that neurodevelopmental conditions are hereditary to some extent (Chaste & Leboyer, 2012; Doust et al., 2022; Fry et al., 2022; Kleppestø et al., 2022; Mattheisen et al., 2022; Nisar et al., 2022). It may therefore be that strengths and weaknesses persist through generations (Meilleur et al., 2015). This could be due to congenital differences, for example variance in dopamine D4 and D5 receptor genes in children with ADHD (Li et al., 2006; Thapar & Stergiakouli, 2008), differences in areas of the *AUTS2* gene in children with dyslexia and ASD (Doust et al., 2022) and deletions of *GTF2I* and *GTF2IRD1* genes in William's syndrome (Kleberg et al., 2023). Certain genes may also overlap across several disorders (Chaste & Leboyer, 2012; Doust et al., 2022; Kundakovic &

Jaric, 2017). There are suggestions that prior to the industrial revolution, ADHD traits such as hyperactivity (Reiss et al., 2022) and dyslexic traits such as curiosity for explorative search (Taylor & Vestergaard, 2022) may have been crucial for hunter-gathering activities (Reiss et al., 2022), and thus critical for species survival (Reiss et al., 2022). These traits may be less conducive to formal classroom learning and sedentary workplace occupations, but can still have value and importance for society (Taylor & Vestergaard, 2022).

It is also essential to consider that a genetic pre-disposition for neurodevelopmental differences may also be compounded by psychological and environmental factors which may affect variation in behavioural phenotypes. Differences in perinatal events (Goulardins et al., 2015; Karmiloff-Smith, 1998; Kundakovic & Jaric, 2017) and/or the home or school environment can thus affect outcomes (Thapar & Stergiakouli, 2008). For example, if children with dyslexia have parents who dislike or struggle to read due to dyslexia, then they may be less likely to engage in reading activities (Hulme & Snowling, 2016). Parents who have ASD may avoid unnecessary social situations and large groups to prevent discomfort (Black et al., 2023; Hampton et al., 2022), thus their children may be less exposed to wider social experiences and possibly experience more isolation (Marriott et al., 2022). Through a range of environmental and experiential factors, the genetic heritability of neurodevelopmental differences may be amplified. Conversely, if parents with dyslexia have particular interests in the creative arts or natural sciences (Reiss et al., 2022; Ruban, 2005), or if parents with ASD have strong interests and ability in maths or computing (Bressan, 2018), then they may also help nurture these inherited tendencies in their children. Thus, people with neurodevelopmental differences may exhibit common strengths along with their concurrent difficulties not only through genetic heritability, but also because of familial abilities and interests that they are exposed to and encouraged to engage with.

10.2 Altered neural circuits and neuronal recycling

Brains can exhibit remarkable neural plasticity (Haigh et al., 2022; Izadi-Najafabadi et al., 2020; Liu et al., 2019; Robert et al., 2023). Modular accounts of neurocognition argue that the brain is made up of highly distinct regions that serve specific cognitive and behavioural functions (Baars, 1993; Fodor, 1983; Shallice, 1988). Despite this, when these regions fail to develop behaviours commonly associated with them, they may become repurposed for other functions (Meilleur et al., 2015). For example, in individuals who are congenitally blind, vast regions of the visual cortex in the absence of visual inputs appear to become recycled for alternative cognitive abilities (Battal et al., 2020). Thus such individuals can exhibit potentially superior auditory skills (Battal et al., 2020; Rokem & Ahissar, 2009; Wan et al., 2010) with these linked to altered visual cortex responses to auditory information (Collignon et al., 2011; Kupers & Ptito, 2014; Vetter et al., 2020). Similarly, auditory memory for words (Hötting & Röder, 2009; Pasqualotto et al., 2013) can also be enhanced in people with congenital blindness due to their broader structural and functional brain reorganisation (Pasqualotto et al., 2013).

Given that many neurodevelopmental conditions are characterised by a reduction of ability in certain functions, such as face recognition or movement skills, then it seems intuitive to assume that similar cortical recycling may occur in such individuals (Grelotti et al., 2005; Whyte et al., 2016). For example, it was proposed earlier that some people with ASD benefit from greater neuronal processing power when completing cognitive tasks for which they have become recycled to contribute towards, such as maths (Dehaene & Cohen, 2007; Iarocci et al., 2006; Iuculano et al., 2014). It was also found that enhanced auditory processing and phonemic awareness in people with Williams syndrome (Miezah et al., 2020) has been considered a result of adapted neural processing in language regions (Karmiloff-Smith et al., 1995).

Such neural repurposing for enhanced cognitive skills in people with neurodevelopmental differences is analogous to how the visual cortex helps the blind hear (Vetter et al., 2020). However, there is still much work to be done in this area, as researchers rarely look to whether neuronal recycling has taken place in neurodevelopmental conditions (Burns & Bukach., 2021). We therefore hope that by identifying multiple areas of strengths in those with NDDs in our review, investigators are able to utilise this information to guide future neuroimaging work.

10.3 Behavioural Adaptation

As the world is arguably not well designed for people with neurodevelopmental conditions, they often find themselves having to adapt to try and fit in (Dobusch, 2021; Taylor & Vestergaard, 2022). This may result in creative, divergent thinking to work around their own cognitive, behavioural or physical limitations (Gutiérrez-Ortega et al., 2023). For example, dyslexia is associated with difficulties learning by rote (Cottrell, 2003; Shaywitz, 1996), which is thought to cause their limitations in acquiring automaticity with their multiplication tables (Miles & Miles, 2004) i.e., while most children can automatically answer 7 x 7 is 49 due to months of verbally rehearsing such lists, this skill is often not fully acquired in those with dyslexia. As a result, those with the condition will utilise a remarkable range of creative solutions to generate the correct answers, e.g., they may understand the rules to easily compute 10 x 7, and then subtract 3 x 7 from this total. These creative solutions can lead to people with dyslexia being able to answer complex mathematics problems, despite not being able to automatically answer 7 x 7 (Miles & Miles, 2004). Similar adaptations are thought to occur in other neurodevelopmental conditions (Liu et al., 2011).

Of course, it is not just creativity and originality that can become enhanced through behavioural adaptation. Those with neurodevelopmental conditions may also have to develop new skills when their own abilities are limited. For example, people with dyslexia can struggle with reading, and as a result, may develop skills with touch typing and spelling apps (Kariyawasam et al., 2019; Raza et al., 2017). Those with dyslexia, ASD or DCD may also utilise text-to-speech and voice-to-text software (Bonifacci et al., 2022; Dawson et al., 2019), to counter slower and untidy handwriting abilities. The use of such aids not only enables them to take part in learning (Lorusso et al., 2024) and employment opportunities (Kruse et al., 2024) they may otherwise find challenging, but can also contribute to them developing excellent technological abilities (Goldfarb et al., 2019; Wei et al., 2013).

There may also be additional positive effects arising from the need to seek out alternative activities and developing specific interests. People with ASD report having hyper-attention for objects and pastimes that they have an extreme interest in (Cho et al., 2017; Rynkiewicz et al., 2021). Instead of choosing to socialise with colleagues after school or work, they may spend time doing or researching their subject of interest, e.g., gaming, chess, trains, or maths as examples, or meeting up with people who have the same specific interests (Cho et al., 2017). Thus, their behavioural adaption to survive in a world they find challenging may lead them to excel in unique activities.

Of course, there will be social situations where it is not possible to work around or avoid social schedules and expectations, for example at school or work. People with neurodevelopmental conditions will therefore often report having to develop masking skills to hide their discomfort and difficulties in public (Atherton et al., 2021; Cook et al., 2022). Whilst it should be noted that such an internalisation of problems can have a detrimental impact on mental health and self-esteem (Atherton et al., 2021), it may conversely aid in the development of skills such as strong internal resilience and personal coping mechanisms. These can include humour (Harrowell et al., 2017), acting skills (Naniwadekar et al., 2016) and planning ahead (Griffiths, 2012). Some also report developing an increasing empathy, advocacy and caring for others, because they hate to see others suffer as they have (Tal-Saban & Kirby, 2020; Payne et al., 2013). In this way, society built for ‘neurotypicals’ is challenging and must be addressed; however, some challenges may result in compensatory skills and strengths for the neurodiverse individual.

10.4 Impairments in one cognitive domain can mean superior skills in another

Reduced abilities in one area of cognitive functioning can result in surprisingly enhanced skills in another. One example of this is found in individuals with ADHD. While they can demonstrate low working memory capacity (Kofler et al., 2010), they conversely display superior creative thoughts and abilities to overcome limitations in a more innovative manner than controls (Taylor & Vestergaard, 2022). They also exhibit strong originality in divergent-thinking tasks (Taylor & Vestergaard, 2022). Several studies have observed a negative correlation between working memory capability and divergent thinking ability. Given that reduced executive functioning and working memory can be common in neurodevelopmental conditions, it seems reasonable to assume this will be offset with an enhanced flow of ideas (Fugate et al., 2013). Thus, it is important for researchers, clinicians, parents and teachers to not focus entirely on the negatives that can be associated with NDDs, but to recognise that there will often be an overlooked benefit in other areas.

10.5 Psychopharmacological

Many neurodevelopmental disorders are comorbid with ADHD (Bart et al., 2010; Kirby, 2020; Nobusako, 2021; Richardson & Ross, 2000; Rong et al., 2021; Tal-Saban & Kirby, 2020; Taurines et al., 2012). As a result, such individuals will often have their ADHD treated with medication (Boland et al., 2020). These drugs can lead to enhancements in a wide variety of cognitive abilities, including response inhibition (Aron, 2003; Tannock et al., 1989), visuo-spatial working memory (D'Aiello et al., 2022), motor coordination (Bart et al., 2010) and attention (Losier et al., 1996; Pitzianti et al., 2020). Despite this, it is common for studies examining cognitive ability in NDDs to not report whether participants have comorbid ADHD, or if they are undergoing any pharmacological treatments (Bainbridge et al., 2021; Duchaine et al., 2007; Mervis & Becerra, 2007; Pounder et al., 2018; Schneps et al., 2012; Sedgwick et al., 2019). Potentially some superior skills found in NDDs may be a result of medication. It is difficult to estimate how widely this has impacted the broad NDD literature, but it highlights to authors the importance of identifying comorbidities in NDDs, and any treatments they are undergoing. Only by doing so can we hope to understand what role psychopharmacological agents are playing in NDDs enhanced cognitive abilities and behaviours.

10.5 Type I Errors

It is important to note that a simple reason for cognitive strengths appearing in the literature is because they are Type I errors, i.e., when the null hypothesis is true, significant NDD versus control group differences will occur 5% of the time when using an alpha of .05. This is apparent when you examine the plotted effect sizes of multiple studies together as we do in meta-analyses. For example, Majeed et al. (2021) showed individual studies in the verbal creativity dyslexia literature has positive (i.e., enhanced in dyslexia), negative (i.e., poorer in dyslexia) and null (no different) results. However, once pooled together, the null hypothesis appears to potentially be true. This means we should treat a single positive finding with caution, prior to a well-powered replication. Once direct replications have been accomplished (i.e., using the same tasks), conceptual replications (i.e., different types of tasks) can be performed to test the extent to which this apparent strength may generalise to other situations. Once enough studies are present in the literature, a meta-analysis can provide evidence for the effect more convincingly.

It is of course important to carefully recruit from neurodevelopmental populations we are studying, and match them appropriately to control samples. Only by doing so will we be able to accurately estimate potential strengths, weaknesses, and areas of comparable performance to the general population. Unfortunately, many factors risk biasing our conclusions about NDDs, including different recruitment approaches (e.g., Bazelmans et al., 2023) shifting inclusion criteria (Burns et al., 2023; Burns, 2023; Lopes et al., 2020; Russell et al., 2019), and the types of people willing to help with research (Haas et al., 2016). We must therefore be mindful of these to counteract their effects, or at least recognise them as limitations, when researching strengths in NDDs.

10.6. Summary of Theoretical Explanations for Strengths in Neurodevelopmental Conditions

We can see that enhanced cognitive abilities in neurodevelopmental conditions are grounded in multiple theoretical viewpoints. It is important to note that each of these reviewed above should not be thought of as distinct perspectives in isolation from one another. As the neo-constructivist approach proffers (Karmiloff-Smith, 2009), it is inevitable that there will be complex interactions across each of these accounts. Thus, future researchers must consider each of these when examining potential strengths in neurodevelopmental conditions. Only through such an understanding will we be better equipped to identify and nurture such abilities.

10.7. Limitations

We present a summary of some of the strengths identified across and within each neurodevelopmental condition in Table 1. It is apparent from this that there is a lack of systematic assessments for cognitive strengths. Whilst some findings are anecdotal or less conclusive than would be ideal, our intention is to call attention to potential cognitive abilities in people with a wide range of neurodevelopmental differences. By doing so, we hope future researchers will attempt to replicate the positive findings, and systematically test those where evidence is absent or only weakly supported. Implementing a transdiagnostic approach in future research, where potential strengths are identified across multiple neurodevelopmental conditions, rather than within individual disorders, will help support a more affirmative view of neurodiversity.

In many of the studies we reviewed, data files were not publicly available. This makes it difficult to identify the percentages of individual NDD participants scoring disproportionately above the control mean. Authors subscribing to Open Science protocols such as sharing data files (Hagger, 2022; Hardwicke et al., 2022) in future work should remedy this issue. Examining effect sizes of group-based strengths, and the prevalence of exceptionally gifted individuals within neurodiverse groups, would help reduce stigma and counteract the deficit-based view of NDDs. Moreover, it is very difficult to perform systematic reviews or meta-analyses on cognitive strengths due to a lack of consistent keywords to search for. We therefore recommend that authors testing strength-based hypotheses, or reporting findings of NDDs exhibiting cognitive superiority, include in their paper's keywords or title the word "Strengths". If all authors do this going forward, then it will make identifying and assessing the evidence base much easier in the future.

It should be noted many neurodevelopmental conditions were not include in our review because the evidence base was so weak or lacking. For example, developmental prosopagnosia is a lifelong condition characterised by recognising faces. Only one paper explicitly examined strengths (Svart & Starrfelt, 2022), and they were subjective reports of self-perceived abilities including good memory, reading and spelling abilities, musicality, and maths (Svart & Starrfelt, 2022). Unfortunately, these were inconsistent between cases, with some cases reporting them as strengths and others as weaknesses. Only artistry and social abilities were the only reported strengths that were not offset by negative reports (Svart & Starrfelt, 2022). Whilst our aim here was to unearth strengths across a range of neurodevelopmental conditions and differences, including some less well-known differences, it was not within the scope of this work to include all neurodevelopmental conditions and differences. However, future work may well want to consider Tourette's syndrome, Rett's syndrome, cerebral palsy, specific learning disabilities or Down syndrome.

11. Conclusions

This review of the literature has identified significant common strengths in a variety of neurodevelopmental disorders. We present a summary of them in *Table 1.* for easy inspection by the reader, and to help identify potential commonalities and contrasts across different conditions. For example, people with ASD appear to have superior local visual processing skills allowing them to focus on small detail more easily (Lebreton et al., 2021). By contrast, those with dyslexia have been shown to demonstrate a preference for peripheral or global vision granting them superior ability to read or infer the gist of a wider scene (Duchaine et al., 2007; Schneps et al., 2012). It is highly possible that some other strengths may exist in all these groups but have not yet been tested and identified as strengths literature in limited. Further strengths may have been inadvertently found during previous deficit-based studies, but excluded or unreported due to the assumption by researchers that they were Type

I errors (Van der Hallen et al., 2015), i.e., strengths ignored as spurious effects due to their focus on a deficit model of this disorder.

	ASD	Dyslexia	DCD	ADHD	Williams Syndrome	Aphantasia
Global vision preference		[Blue]				
Local visual search speed	[Black]					
Social communication					[Blue]	
Empathy/Theory of mind			[Green]		[Yellow]	
Humour		[Yellow]	[Yellow]			
Ability in STEM subjects	[Yellow]	[Blue]				[Green]
Hyper focused/special interests	[Blue]			[Yellow]		
Smaller word-length effect						
Creativity/innovative thinking		[Blue]	[Yellow]	[Yellow]		[Yellow]
Semantic Memory						[Green]
Spatial representation/imagery						[Blue]
Musical ability			[Yellow]		[Green]	
Adventurousness						
Resilience	[Yellow]	[Yellow]	[Yellow]	[Yellow]		
Risk averse			[Green]			
Phonemic awareness					[Green]	
Entrepreneurship				[Blue]		
Sales/persuasive skills				[Yellow]		
Advanced vocabulary use		[Yellow]			[Green]	
Analytical abilities	[Yellow]	[Green]				
Problem solving skills		[Blue]				
High Energy	[Yellow]			[Blue]		
Face and Emotion Processing					[Green]	

Evidence reported in this paper

[Yellow]	Anecdotal
[Green]	Single Study
[Blue]	Multiple Study
[Black]	Meta Analysis

Table 1. Strengths, talents and abilities exhibited in people with neurodevelopmental disorders/differences. Some of the most common skills appear to be humour, resilience, empathy, hyperfocus, interest in STEM subjects, creativity and problem solving. Yellow shaded segments indicate what we consider 'anecdotal' evidence (identified in case studies, opinion pieces, phenomenological accounts, hypotheses in papers & books), green indicates evidence from a single empirical study based on a group, blue indicates multiple sources of empirical evidence, black indicates evidence based on meta-analyses.

To fully understand strengths in neurodevelopmentally different groups, individual differences should also be considered when studying each group. This is because every person with a neurodevelopmental difference will have a somewhat unique profile (Licari et al., 2019), just as we find in the general population. It is also crucial to consider that comorbidity (i.e., multiple diagnoses) across neurodevelopmental disorders (Licari et al., 2019) is more common than a single neurodevelopmental diagnosis (Smits-Engelsman et al., 2017). Therefore a reflection of the impact that these interacting difficulties and experiences have on the development or visibility of strengths and skills discussed is critical. For example, DCD overlaps with dyslexia and ADHD in 35% to 50% of cases (Kirby et al., 2008). Similarly, ASD often demonstrates motor challenges or poor motor planning as is characteristic of someone with DCD (Bo et al., 2016; Licari et al., 2020). It is currently unknown what impact such comorbidities may have on strengths discussed here at a group level. However, early diagnosis, supportive interventions (Koegel et al., 2014; Lee & Zwicker, 2021), person-centred planning and empowerment (Browder et al., 1997) are important to identify individual comorbidity, personal strengths and weaknesses. This support can enable people with neurodevelopmental disorders to identify and develop their own unique talents and skills, enhancing quality of life (Browder et al., 1997).

Some employers (e.g., Hewlett Packard and Microsoft; Ballesteros-Sola et al., 2018) have begun to see the specific benefits of the skills provided by a neurodiverse workforce, including attention to detail (Dupuis et al., 2022), preference for repetitive tasks (Bury et al., 2021) and a structured environment (Bury et al., 2020; Patel et al., 2021; Scott et al., 2015), introversion (Brinzea, 2019; Hutson, 2022) and optimism (Griffiths, 2012; Verheul et al., 2016). These traits and skills are particularly useful in areas of the technology industry where companies have been founded with goals of inclusivity, i.e., hiring people with ASD for their technical talent (Ballesteros-Sola et al., 2018). Despite this, unemployment and unfavourable job prospects are currently common for many people with neurodiversity (Dobusch, 2021; Krzeminska & Hawse, 2020; LeFevre-Levy et al., 2023). However, with support, the repetitive special interests that people with ASD demonstrate could form a strong motivator for work, and employers could benefit from the specific expertise and attributes of people with ASD (Goldfarb et al., 2019). The relationship between these special interests and skills and employment opportunities in people with neurodiversity remains a relatively under-studied area. Further research to balance historical deficit-based investigations, could be very beneficial in helping to improve employment statistics, and for generating more fulfilling employment experiences within the neurodiverse population (Goldfarb et al., 2019). Additionally, it has been suggested that in 2025, the most valued skills for employment will include analytical thinking and innovation, complex problem-solving, critical thinking and analysis, and creativity (Carter et al., 2023; World Economic Forum, 2020). Drawing attention to the natural ability that some people with neurodevelopmental conditions have in these key areas should enhance their employability and increase personal fulfilment and quality of life (Austin et al., 2019).

Whilst research has traditionally focused on profiles of difficulties in individual conditions, our current paper posits that collective and individual strengths across the range of neurodevelopmental disorders is equally key in supporting people with these conditions (Lavy, 2020; Schutte & Malouff, 2019). Whilst it is important not to generalise and stereotype based on condition, it is hoped that such a re-focus towards signature strengths (Schutte & Malouff, 2019) will aid individuals with neurodevelopmental differences in understanding their value to society. This should increase their self-esteem, and improve their mental health, employment and life satisfaction outcomes (Schutte & Malouff, 2019).

It is vital for wider society, including the media, educators, and employers to understand that people with neurodevelopmental differences have numerous skills and competences, and in many cases, *even enhanced* skills and competences in a number of domains. Reducing stigma attached to the various conditions should reduce some of the familial and educational barriers to early diagnosis and appropriate intervention. Whilst people with neurodevelopmental differences do have significant challenges, these individuals also possess unique talents and valuable skills which need to be shared with wider society in pursuit of our common and goals.

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