

Empathy, social relationship and co-occurrence in young adults with DCD

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ABSTRACT

Empathy is defined as an emotional or cognitive response to another's emotional state. It is considered essential for navigating meaningful social interactions and is closely linked to pro-social behavior. Developmental coordination disorder (DCD) is characterized by an impairment of motor coordination that has a marked impact on both academic and day-to-day living activities. Children and adolescents with DCD have been shown to have less developed social support and friendships. The research linking empathy and DCD is scarce. The aims of this study are to gain an understanding of the relationship between DCD and empathy in young adults with DCD only, and with DCD coupled with other neurodevelopmental disorders, in comparison with typically developing adults.

Methods: The study included 212 young adults aged 18–40 years. The subjects in this study were from mainstream populations in the UK. The study groups included: (a) “DCD only” with 42 individuals; (b) “DCD + ASD” with 21 individuals; (c) “DCD + ADHD” with 45 individuals; (d) “DCD + ASD + ADHD” with 29 individuals; and (e) the control group of 75 individuals.

Results: ANOVA on the Empathy Questionnaire (EQ) showed a statistically significant difference between groups ($F [4,257] = 35.63$; $p < 0.001$; $\eta_p^2 = 0.409$). No significant differences were found between the DCD-only and the control. MANOVA was performed to assess differences in the Socialising and Friendship Questionnaire (SAF-Q) scores. The results showed a statistically significant difference between groups ($F [8,257] = 9.98$; $p < 0.001$; $\eta = 0.162$). Pearson correlation coefficients were performed, revealing significant high correlations between the EQ and the two parts of the SAF-Q (“past” and “currently”).

Conclusion: The results of this study indicate that social difficulties in the DCD-only group are not due to lack of empathy, but may be driven by an accumulation of external factors. In this study we also concluded that DCD does not appear to be the factor that reduces the ability to empathize, but rather the presence of ADHD and/or ASD.

1. Introduction

1.1. Empathy

Empathy is defined as an emotional or cognitive response to another's emotional state (Baron-Cohen & Wheelwright, 2004). Empathy is assisted by other general cognitive abilities, such as executive functions, perception of visual cues, and a theory of mind

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and language shaped by social and cultural contexts (Decety, Norman, Berntson, & Cacioppo, 2012; Dyck, Farrugia, Shochet, & Holmes-Brown, 2004).

There is some discussion on how to conceptualize empathy in more depth. Some have divided it into cognitive and affective components (Singer, 2006) with *affective* empathy being the capacity for an individual to understand someone else's feelings and emotions by sharing these through observation or imagination of the experience (Singer & Lamm, 2009). This aspect of empathy creates compassionate actions (Baron-Cohen & Wheelwright, 2004).

Cognitive empathy has been described as the understanding of what someone else's emotions may be, without being emotionally involved (Shamay-Tsoory, Aharon-Peretz, & Perry, 2009). Cognitive empathy is thought to entail the ability to predict another's behavior or mental state (Eres, Decety, Louis, & Molenberghs, 2015). The cognitive component is attributed to applying a "theory of mind" (Wellman, 2002; Baron-Cohen & Wheelwright, 2004). Cognitive empathy also requires executive functioning (EF) skills, especially in decision-making (whether or not to act on the emotional situation being witnessed).

Some models look on these two types of empathy as different aspects of one construct, in which cognitive empathy is based on affective empathy. Other models see empathy as two separate elements, having different neural origins (Shamay-Tsoory et al., 2009).

Interestingly, differences have been noted in the balance between cognitive and affective empathy, and this has been demonstrated through different approaches. Some researchers have shown via screening questionnaires that children with antisocial behavior were found to have impaired *affective* empathy, but not impaired *cognitive* empathy (Blair, 2005; Schwenck et al., 2012; Zonneveld, Platje, Sonneveld, Van Goozen, & Swaab, 2017).

Neuroscientists have identified the brain regions for the "empathy circuit": 1) the amygdala, responsible for regulating emotional learning and reading emotional expressions; 2) the anterior cingulate cortex (ACC), activated during observed or experienced pain in the self or others; and 3) the anterior insula (AI), which responds to one's pain and the pain of a loved one (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003). In recent years the mirror neuron system (MNS), comprised of the inferior frontal gyrus and inferior parietal cortex, has been suggested to also be involved in empathy (Gazzola, Aziz-Zadeh, & Keysers, 2006; Kaplan & Iacoboni, 2006; Pfeifer, Iacoboni, Mazziotta, & Dapretto, 2008; Baird, Scheffer, & Wilson, 2011). The broad notion that empathy involves "putting oneself in another's shoes" by simulating what others do, think, or feel, has been linked to the properties of mirror neurons (Iacoboni & Mazziotta, 2007).

1.2. Empathy and social relationships

Empathy is considered essential for navigating meaningful social interactions; it is closely linked to prosocial behavior (Lockwood, 2016; Decety & Jackson, 2004). Empathy may therefore be positively associated with prosocial behavior (Batson et al., 1989). Empathy allows the person to execute positive social actions and predicts responsiveness to others' needs, especially to those in close relationships and in times of stress (Batson, 2011). Morelli, Ongb, Makatia, Jackson, and Zaki (2017) investigated the influences of empathy on social networks among college students. Their results revealed that people with high empathy occupied central positions in networks based on trust, empathic support, and close relationships. Morelli, Lieberman, and Zaki (2015) reviewed the literature exploring the association between positive empathy and prosocial behavior. They suggested that positive empathy uniquely relates to prosocial behavior, as well as to a sense of social connection and subjective well-being.

Positive empathy may enhance social relationships by increasing perceptions of social closeness to relationship resources (Gable, Reis, Impett, & Asher, 2004; Gable, Gonzaga, & Strachman, 2006) and feeling connected. Studies revealed an association between positive empathy and increased social closeness, relationship satisfaction, commitment, intimacy, and trust (Gable et al., 2004; Gable et al., 2006; Gable, Gosnell, Maisel, & Strachman, 2012).

Positive empathy, however, may not come without some challenges. Tone and Tully (2014) described how empathic tendencies can be "risky strengths". They suggested that too much empathy can lead to "empathic personal distress and excessive interpersonal guilt." This could indicate a connection between empathic responses which are too positive and increased risks of internalizing disorders, such as anxiety.

1.3. Developmental coordination disorder (DCD)

DCD, sometimes referred to as *dyspraxia*, is a developmental disorder characterized by an impairment of motor coordination that has a marked impact on both academic and day-to-day living activities (APA, 2013). DCD prevalence rates in schoolchildren have been estimated at 5–6% (Lingam, Hunt, Golding, Jongmans, & Emond, 2012), and it is recognized more often in boys than in girls (APA, 2013). Yet despite the relatively high prevalence, there is less awareness of DCD than of other conditions such as autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD).

1.3.1. DCD and social relationships

Children with DCD have been shown to have less developed social support and friendships (Smyth & Anderson, 2000; Skinner & Piek, 2001), weaker social skills (Kanioglou, Tsorbatzoudis, & Barkoukis, 2005), more social isolation and social problems (Smyth & Anderson, 2000; Chen, Tseng, Hu, & Cermak, 2009), and greater peer victimization/bullying (Campbell, Missiuna, & Vaillancourt, 2012). Lower levels of self-esteem in children with DCD have also been noted (Miyahara & Piek, 2006). There is likewise increasing evidence that the motor and social problems of DCD experienced in childhood often persist into adulthood (Kirby, Williams, Thomas, & Hill, 2013; Tal-Saban, Zarka, Grotto, Ornoy, & Parush, 2012).

In DCD, the opportunities to socialize during adolescence may have been far less frequent than with typically developing (TD)

peers. Young people coping with DCD are likely to have fewer friends and therefore be more socially isolated (Mandich, Polatajko, & Rodger, 2003). Emotional immaturity has been noted in adolescents with DCD; some were functioning at a developmentally younger age level than their TD peers of the same age (Cantell, Smyth, & Ahonen, 1994). The authors concluded that this behavior may be a means of reducing their exposure to comparisons with age-matched peers, potentially delaying the need for them to behave as society expects.

Gagnon-Roy, Jasmin, and Camden (2016), in their scoping study relating to adults with DCD, found an improvement in functional social status and the potential to “catch up” with peers once they become adults. Nevertheless, adults with DCD have also been identified as having raised levels of anxiety and depression, compared to typically developing peers (Hill & Brown, 2013; Kirby et al., 2013).

1.3.2. DCD and empathy

The research linking empathy and DCD is scarce. Cummins, Piek, and Dyck (2005) investigated the empathic skills of children with DCD by measuring the level of empathy and social behavior in children aged 8–13 years, with and without motor coordination problems. They recognized that children with DCD have difficulties with attending to and processing visual information, and they proposed that this may make it harder to attend to and process emotional expressions by other people. Their results indicated significant differences between these two groups in their verbal and perceptual empathy skills; the findings remained intact even when the visual-spatial processing was controlled. Prior to the above work, Gillberg, Gillberg, and Steffenburg (1992) also theorized that children with motor and attention problems have deficits in empathic abilities, and that they would find it harder to detect the emotions of others.

1.3.3. Co-occurrence with DCD

Comorbidity or co-occurrence refers to the presence of two or more disorders in the same individual (Smits-Engelsman, Jover, Green, Ferguson, & Wilson, 2017). DCD frequently co-occurs with a number of other neurodevelopmental disorders, such as ADHD and ASD (Goulardins, Marques, & De Oliveira, 2017; Tal-Saban, Ornoy, & Parush, 2014; Kadesjö, Björn, & Gillberg, 2001). ADHD is the development of inappropriate levels of attention and hyperactivity that impinge on learning and social relationships (DSM-5, 2013; Barkley, 2015).

Gillberg and colleagues coined the acronym *DAMP* – deficits in attention, motor control, and perception; their model described a 40% overlap of ADHD and DCD (Gillberg & Rasmussen, 1982; Hellgren, Gillberg, & Gillberg, 1994). Evidence from a number of researchers has shown that 23% of children show signs of DCD, with 8% of these also meeting the criteria for ADHD (Kirby & Sugden, 2007). Another study reported that 25% of the DCD-diagnosed children were found to have ADHD and dyslexia, while 10% had both ADHD and DCD (Kirby & Sugden, 2007). In young adults with DCD, 75% were found to also have ADHD (Tal-Saban et al., 2014).

A few studies indicated lower scores in empathy questionnaires and tasks, in comparison with TD children (Braaten & Rosen, 2000; Marton, Wiener, Rogers, Moore, & Tannock, 2009). Barkley, Fischer, Smallish, and Fletcher (2006) predicted that children with ADHD would show less empathy and a reduced ability to adopt the perspective of another person, because of their deficiency in inhibitory control. Children with ADHD had statistically significant lower scores in the areas of affective and cognitive empathy, in comparison with TD children (Ozyurt, Ozturk, & Akay, 2017).

ASD, also known as autism spectrum conditions (ASC), is a spectrum of disorders that cause difficulty in socialization and communication, along with a pattern of restrictive, repetitive behaviors (DSM-5, 2013).

Due to recent changes in the Diagnostic and Static Manual for Mental Disorders–Fifth Edition (DSM-5, 2013), ASD and DCD can be diagnosed as co-occurring in certain individuals (Caçola, Miller, & Williamson, 2017). Impaired empathy is considered a marked feature of ASD (Baron-Cohen & Wheelwright, 2004). Recent studies indicated that individuals with ASD do not exhibit a complete loss of empathy, but rather a greatly reduced cognitive empathic ability (Baron-Cohen, 2017).

In one study (Montgomery et al., 2016), individuals with ASC self-reported whether they had “dyspraxia” as well; these were compared with a population without ASC. This study reported that those with dyspraxia had lower empathy levels than the general population, and that 6.9% of those with ASC reported having dyspraxia as well, compared to 0.8% of the general population. There were some limitations in this study, since the term *dyspraxia* was used instead of *DCD*. Dyspraxia is sometimes a diagnosis given by educational professionals without the person having a formal diagnosis of DCD and confirmed motor difficulties. The term has also been used sometimes as a default diagnosis for someone who has learning challenges but doesn’t fit the dyslexia category. In addition, the study’s reported incidence of motor-skill dyspraxia was much lower than that noted from previous research, which has shown motor difficulties present in 80% of individuals with ASD (Green et al., 2009; Ming, Brimacombe, & Wagner, 2007). Montgomery et al. provided no confirmation of actual motor-skill deficits or functional impairments.

In summary, a review of the literature underlines the importance of empathy for social relationships and prosocial behavior (Lockwood, 2016; Decety & Jackson, 2004). Studies demonstrated that children and adolescents with DCD have poorer social relationships and friendships, in comparison to typically developing populations (Gagnon-Roy et al., 2016). Furthermore, researchers and clinicians have observed a high prevalence of DCD co-occurring with other neurodevelopmental disorders, such as ADHD and ASD (Goulardins et al., 2017).

1.4. Aims of this study

Our aims were to gain an understanding of the relationship between empathy and DCD in young adults, and to consider if there is any relationship between empathy and their past and current social experiences. We examined adults with DCD only, DCD + ADHD,

DCD + ASD, and DCD + ADHD + ASD, in comparison to typically developing adults.

2. Method

2.1. Participants

The study included 212 young adults between the ages 18–40 years (Mean age = 22.37 SD = 8.94; males: 34%). The subjects were from mainstream populations in the UK, representing a mix of students, employed, and unemployed adults. The subjects were recruited based on a convenience sample, using advertisements within the university setting and workplaces, from notices posted on Facebook/Twitter, and from the Discovery Centre clinic (University of South Wales). Exclusion criteria stated that the participants had no known birth complications or known psychiatric, physical, or neurological deficits. This information was obtained by the participants themselves, who answered questions about their health condition and previous diagnoses. Participants who answered that they had birth complications or known psychiatric, physical, or neurological deficits were not recruited for the study.

All participants completed the Adolescents & Adults Coordination Questionnaire (AAC-Q; Tal-Saban, Ornoy, Grotto, and Parush, 2012) and were only included in the DCD group if they fell below the 5th percentile. Thereafter, the sample consisted of two cohorts of adults:

- (a) A DCD group, self-reported having been diagnosed with DCD by qualified medical professionals including neurologists, occupational therapists, and physical therapists. This group was comprised of 137 individuals (Mean age = 28.19 years, SD = 9.50. Males: 31%).
- (b) A control group comprised of adults with no diagnosis of DCD. This group contained 97 individuals (Mean age = 24.93 years, SD = 7.62. Males: 27%).

The relatively larger sample of adults with DCD was due to the specific method of recruitment, which included the Discovery Centre clinic and special dyspraxia groups among Facebook/Twitter's population, who showed apparent interest in this study.

Furthermore, in order to ensure the exclusion criteria, all participants completed the Adult ADHD Self-Report Scale (ASRS-v.1.1; Kessler et al., 2005) and the Autism Spectrum Quotient (AQ; Allison, Auyeung, & Baron-Cohen, 2012), two recognized screening tools for ADHD and ASD. Participants who met the screening criteria for ADHD or ASD were excluded from the final cohort. This procedure resulted in the exclusion of 20 participants from the control group.

This screening process created five groups:

- (a) "DCD only" group of 42 individuals (Mean age = 28.31 years, SD = 11.72. Males: 22%);
- (b) "DCD + ASD" group of 21 individuals (Mean age = 24.25 years, SD = 7.64. Males: 38%);
- (c) "DCD + ADHD" group of 45 individuals (Mean age = 28.27 years, SD = 7.46. Males: 42%);
- (d) "DCD + ASD + ADHD" group of 29 individuals (Mean age = 30.48 years, SD = 8.91. Males: 21%);
- (e) Control group of 75 individuals (Mean age = 23.11 years, SD = 6.76. Males: 32%).

No differences between the study groups were found in age: χ^2 (94, N = 228) = 204.57, p = 0.17; or in gender: χ^2 (6, N = 226) = 7.29, p = 0.30.

2.2. Instruments

2.2.1. Socialising and Friendship questionnaire (SAF-Q; Tal-Saban & Kirby, 2018)

The SAF-Q is a self-report questionnaire focusing on both present (as an adult) and past social functioning (in late teens) to broadly examine the concepts of social participation, relationships, and friendships. The SAF-Q focuses on two age ranges: 15–17 years and 18–40 years. The SAF-Q has 23 questions divided into three sections:

(Section 1) "Relationships and socialising in the past" (age 15–17), which contains 9 multiple-choice questions (e.g. *How many friends did you have? How often were you invited to friends' houses?*).

(Section 2) "Current relationships and socialising," comprised of 14 multiple-choice questions (e.g. *How often do you spend your leisure time engaged in social activities? How would you rate your current dating life?*).

The questions in Sections 1 and 2 are rated on a Likert scale ranging between 1 and 5 points, with a final score in the first section ranging from 9 to 45, and in the second section ranging from 14 to 70. Higher scores indicate better friendships and socializing in young adults.

(Section 3) Five social scenarios are included, with multiple options for each (e.g. *A student is taking a number of courses together with another student he/she is attracted to. If you were in his/her position, what you would do?*). In addition, seven general questions about socializing are asked (e.g. *The most important thing about friendships is...*) with options to choose from; and one open-ended question (*What or who has helped you most in making relationships or friendships?*).

The SAF-Q is a reliable and valid questionnaire (Tal-Saban & Kirby, 2018). In the present study we used only the two first sections of the SAF-Q.

2.2.2. Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004)

The EQ is a psychological self-report measure of empathy. The items include questions about both affective and cognitive empathy, with no categorization; in most instances of empathy, the affective and cognitive components co-occur and cannot be easily disentangled (Baron-Cohen & Wheelwright, 2004).

The EQ is a valid and reliable screening tool designed for clinical application, and sensitive to measuring lack of empathy. The EQ has 60 questions, broken down into 40 questions tapping empathy, and 20 filler-questions (to distract the participant from a relentless focus on empathy). Each item scores 1 point if the respondent records mild empathic behavior, or 2 points for strong behavior. Higher scores indicate better empathy. The EQ was shown to reliably distinguish between clinical groups (e.g. between ASD and TD). Females have higher scores than males (Baron-Cohen & Wheelwright, 2004).

In this study we also used three screening tools for DCD, ADHD, and ASD.

2.2.3. Adolescents & adults coordination questionnaire (AAC-Q; Tal-Saban et al., 2012)

The AAC-Q is a self-report questionnaire for ages 16 years and above, which includes 12 questions assessing coordination problems, based on the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR). It is a valid and reliable screening tool with high internal consistency (0.88) and high construct validity (Tal-Saban et al., 2012). The AAC-Q has cut-off scores for borderline DCD (lower 15% score) and probable DCD (lower 5% score). The lower 5th percentile was used for inclusion criteria in the DCD study group.

2.2.4. The short Autism Spectrum Quotient (AQ; Allison et al., 2012)

The AQ is a self-report questionnaire for ages 16 and above, containing 10 questions with a total score of 10. This is a valid and reliable tool for screening suspected autism spectrum disorder. The AQ was shown to reliably distinguish between clinical groups (e.g. between ASD and TD). Its internal consistency is high (0.85), with high construct validity (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). The AQ has defined cut-off points of six and above. However, to increase the sensitivity for exclusion, we used a score of seven or higher.

2.2.5. Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005)

This is a valid and reliable screening tool for suspected ADHD in adults aged 18 years and above. The ASRS is a self-report questionnaire containing six questions, based on the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR). The ASRS was shown to reliably distinguish between ADHD and TD populations. Internal consistency was high (0.88), with significant kappa coefficients for all items ($p < 0.001$) (Adler et al., 2006). The ASRS has a cut-off point for screening attention problems of four or more. However, to increase the sensitivity for exclusion in this study, it was decided that a score of five or more would be used.

2.3. Procedure

The study was approved by the University of South Wales Ethics Committee.

The participants were based on a convenience sample, using advertisements within the university setting and workplaces, as well as postings on Facebook and Twitter. The questionnaires were completed by the participants online, which required 30 min to do so. All subjects were offered support if they indicated difficulty responding to the questionnaire items.

2.4. Statistical procedures

A type-I error rate of 0.05 was set for all statistical analyses, using the Statistical Package for Social Sciences for Windows (version 21; SPSS Inc., Chicago, IL, USA). Descriptive statistics were performed for describing the study population. Group differences in the score of the EQ were analyzed using Univariate ANOVA (Analysis of Variance). On the SAF-Q they were analyzed using MANOVA. Differences between gender were analyzed by t test. Pearson correlations were performed to examine the relationships between the SAF-Q and EQ questionnaires.

3. Results

The ANOVA results on the EQ questionnaire showed a statistically significant difference between groups ($F [4,257] = 35.63$; $p < 0.001$; $\eta_p^2 = 0.409$). Scheffé post-hoc analyses revealed significant differences between the DCD and the DCD + ASD groups, between the DCD + ASD + ADHD and DCD groups, and between the DCD + ADHD group and the control group (see Table 1).

One-way ANOVA was conducted with Gender and Group as between-subject factors on the EQ scores. The results revealed a non-significant main effect of gender ($F [3,257] = 1.79$; $p = 1.51$), a significant main effect of groups ($F [4,257] = 27.68$; $p < 0.001$; $\eta_p^2 = 0.359$), and a non-significant interaction between them ($F [4,257] = 1.90$; $p = 0.112$). A series of planned contrasts, comparing each of the groups to the control group, revealed no significant difference between the DCD group and the control group ($F [4,257] = -2.19$; $p = 0.297$), but did reveal significant differences between all study groups and the control group ($p < 0.001$).

Based on the literature showing gender differences in the EQ results within the typically developing population (Baron-Cohen & Wheelwright, 2004), and the contrasting results between the DCD and control groups, a t test was performed on these two groups.

Table 1

Mean scores (SD) ANOVA and Scheffé post-hoc results investigating group differences on the EQ questionnaire score.

	DCD (A) (n = 42)	DCD + ASD (B) (n = 21)	DCD + ADHD (C) (n = 45)	DCD + ASD + ADHD (D) (n = 29)	Control (E) (n = 75)	Group differences
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
EQ*	42.71 (12.52)	22.95 (9.24)	38.64 (10.90)	25.72 (7.30)	44.44 (7.63)	A > B, D** B < A, C, E** C > B, D** C < E* D < A, C, E** E > B, C*, D*

Notes: *EQ: Empathy quotient. *p < .05; **p < .01; ***p < .001.

Results indicated a significant difference between the genders in the DCD group (M male = 39.6; SD = 7.28, M female = 44.73; SD = 13.83; $t(37) = -2.58$, $p = 0.014$), and a significant difference between the genders in the control group (M male = 37.22; SD = 4.89, M female = 46.69; SD = 6.76; $t(73) = -4.09$, $p < 0.001$).

Next, MANOVA was performed to assess differences in the SAF-Q scores. The results showed a statistically significant difference ($F[8,257] = 9.98$; $p < 0.001$; $\eta = 0.162$) between groups.

In order to examine the source of this difference, the data from each part of the questionnaire (SAF-Q “past”; SAF-Q “currently”) were subjected to ANOVAs. The results are presented in Table 2. Scheffé post-hoc analyses revealed significant differences in the SAF-Q “past” between all the groups and the control group. In the SAF-Q “currently” section, no difference was found between the DCD group and control group, while differences were found between all other groups and the control group (see Table 3).

Pearson correlation coefficients were performed on all participants ($N = 212$). The results revealed significant high correlations between the EQ and the two parts of the SAF-Q (SAF-Q “past”: $r = 0.50$, $p < 0.001$; SAF-Q “currently”: $r = 0.54$, $p < 0.001$). This procedure was also performed separately for the five study groups (see Table 4).

4. Discussion

This is the first study considering empathy and socializing skills in adults presenting with DCD only, compared to those with other common developmental disorders co-occurring with DCD. Comparison of these groups with the control group of TD adults enabled us to consider (a) the relationship between the conditions and empathy levels, and (b) the possibility of a relationship between empathy and the past/current social experiences in these differing groups.

The results of this preliminary study showed some interesting initial findings. Individuals with only DCD showed scores on the EQ similar to those in the control group. Interestingly, the standard deviation in the DCD-only group was high, with some participants actually scoring higher in empathy than the control group. For most individuals, empathy was linked throughout their lives with positive interpersonal and intrapsychic outcomes, including better relationships with friends and partners, increased social engagement, and resilience (Chow, Ruhl, & Buhrmester, 2013; Shiner & Masten, 2012).

Despite the high EQ scores in the DCD-only group, when comparing the SAF-Q “past” and “currently”, we see that all the study groups (DCD; DCD + ADHD; DCD + ASD; DCD + ASD + ADHD) had significantly lower scores in the SAF-Q “past” in comparison to the control group. However, when we examined how they were performing socially in the “currently” section, no differences emerged between the DCD-only group and the control group. We can assume from these results that the problem of social relationships in the DCD-only group is not due to inherent factors like low levels of empathy (as in the other study groups). The social difficulties of the DCD-only group may be explained by external factors, such as lack of social opportunities and low social participation, rather than lack of social skills (Gagnon-Roy et al., 2016; Tal-Saban & Kirby, 2018).

As mentioned, some participants in the DCD-only group scored higher in the EQ questionnaire (expressed higher levels of empathy) than the control group (see Table 1). From this we can argue that perhaps too much empathy, especially affective empathy, is a “risky strength”. This could lead to a heightened sensitivity to self and others, resulting in greater concern for potential social rejection. Interestingly, thirty years ago Zahn-Waxler, Klimes-Dougan, and Kendziora (1998) described such a model based on girls, where they examined potential difficulties arising from higher levels of empathy. Tone and Tully (2014), in their review about

Table 2

Mean scores (SD) and ANOVA results investigating group differences on the SAF-Q questionnaire score.

SAF-Q	DCD (n = 42)	DCD + ASD (n = 21)	DCD + ADHD (n = 45)	DCD + ASD + ADHD (n = 29)	Control (n = 75)	ANOVA		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	F	p	eta
SAF-Q ‘past’	22.81 (7.70)	17.67 (7.51)	20.49 (7.54)	17 (5.17)	27.81 (6.98)	18.11	$p < .001$	0.259
SAF-Q ‘currently’	39.40 (8.88)	31.62 (9.72)	37.22 (9.22)	31.52 (9.57)	42.80 (9.22)	11.37	$p < .001$	0.180

Notes: *SAF-Q: The Socialising and Friendship Questionnaire.

Table 3

Post-hoc analyses (Scheffé multiple comparisons) investigating group differences on the SAF-Q scores (only significant differences).

Questionnaire	Group ^a	Mean difference	p
SAF-Q 'past'	DCD vs. Control	−5.0038	0.011
	DCD + ASD vs. Control	−10.1467	< 0.001
	DCD + ADHD vs. Control	−7.3244	< 0.001
	DCD + ADHD + ASD vs. Control	−10.8133	< 0.001
	DCD vs. DCD + ADHD + ASD	5.8095	0.024
SAF-Q 'currently'	DCD vs. DCD + ASD	7.7857	0.045
	DCD vs. DCD + ADHD + ASD	7.8875	0.016
	DCD + ASD vs. Control	−11.1810	< 0.001
	DCD + ADHD vs. Control	−5.5778	0.040
	DCD + ADHD + ASD vs. Control	−11.2828	< 0.001

Notes: ^a SAF-Q: The Socialising and Friendship Questionnaire.**Table 4**

Pearson correlations between the study groups.

	EQ				
	DCD (n = 42)	DCD + ASD (n = 21)	DCD + ADHD (n = 45)	DCD + ASD + ADHD (n = 29)	Control (n = 75)
SAF-Q 'past'	0.445**	0.016	0.282	0.286	0.457**
SAF-Q 'currently'	0.595**	0.439*	0.348*	0.465*	0.369**

SAF-Q: The Socialising and Friendship Questionnaire; EQ: Empathy Quotient.

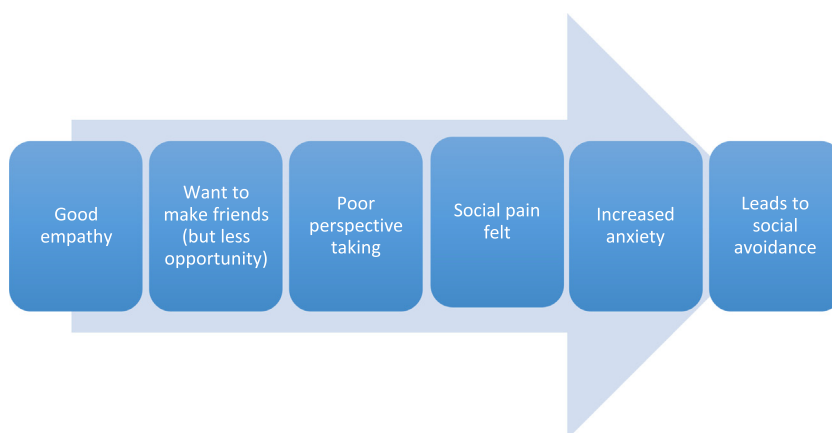
*p < .05; **p < .01; ***p < .001.

empathy, proposed a model in which a high tendency toward empathy can result in vulnerability to psychological disorders, internalizing problems, and particularly fear-arousal symptoms (see Fig. 1). It is this type of response that particularly interests us in the context of adults with DCD – an issue that calls for further research.

Another explanation for the above-mentioned result in the DCD-only group is the link between mirror neuron systems (MNS) and empathy, as well as the proposed association between MNS and motor imagery (Reynolds et al., 2015; Rizzolatti & Craighero, 2004). There is some evidence of a link between MNS and DCD (Wilson, Smits-Engelsman, Caeyenberghs, & Steenbergen, 2017; Wilson et al., 2017; Werner, Cermak, & Aziz-Zadeh, 2012). In light of these findings, perhaps individuals with DCD can understand the feelings of others, but cannot imitate appropriate actions in social situations. Interestingly, Xavier et al. (2016) described the role of imitation as a prerequisite for understanding the emotions and intentions of others. They went on to propose that because some individuals with DCD have a problem with motor imitation, their emotional and social difficulties may actually be a lack of in-trapersonal-interpersonal synchrony.

In light of what has been said so far, it appears that lack of experience, practice, and/or opportunity for social interaction creates a cycle of increasing or cumulative adversity, with less experience in interaction producing less opportunity to interact.

Once those who are coping with DCD (only) become adults, they have more control over their environment and choices. This reduces anxiety levels and allows for better and more appropriate social engagement, since they can choose friends and where to live, study, socialize, and work (Missiuna, Moll, King, Stewart, & Macdonald, 2008). The external factors that contributed to the lower

**Fig. 1.** The interaction between empathy and socialising in adolescents with DCD.

scores in the SAF-Q in their teens (SAF-Q “past”) change as they become adults (SAF-Q “currently”); this stands in contrast to the other study groups, whose difficulties in social relationships and friendships remained low in comparison to the control group.

Interesting results were also seen in the DCD + ADHD group, whose EQ results showed no significant difference in comparison to the DCD-only group, but who were significantly different from the control group. These results coincided with other studies that indicated lower empathy scores in children and adolescents with ADHD (Gumustas, Yilmaz, Yulaf, Gokce, & Sabuncuoglu, 2017; Ozyurt et al., 2017; Gambin & Sharp, 2016). Other studies revealed improvement in empathy following methylphenidate treatment (Golubchik & Weizman, 2017; Gumustas et al., 2017). The lower scores in empathy continued also in young adults with ADHD (Kis et al., 2017).

In the SAF-Q results, no significant differences were found between the DCD-only group and the DCD + ADHD group; but similar to the EQ results, the DCD + ADHD group was significantly different from the control in both parts of the SAF-Q (“past” and “currently”). From these results, we can conclude that both DCD and ADHD have similar social relationship difficulties in adolescence, although in the adult period they are different from the control group in their socializing and friendships. Hence, the social problems seen with DCD + ADHD are not due only to lack of social opportunities, but also because of internal factors. Therefore, methylphenidate treatment improves their empathy abilities; but this may not be appropriate treatment for the DCD-only group.

Finally, the results suggest the unique contribution of different patterns of neurodevelopmental co-occurrence with DCD in empathy ability, as each pattern impacts social relationships and friendships in adulthood. This should be taken into consideration during assessment and intervention for adolescents and young adults with DCD (Smits-Engelsman et al., 2017). The intervention within social relationships and friendships will be different for individuals with DCD only (e.g. creating opportunities and strategies for social relationships), for individuals with DCD + ADHD (need to consider medication treatment in addition to social relationship strategies and adaptation), and for individuals with DCD + ASD + ADHD (lower level of empathy seen as the main problem and the focus of the intervention).

5. Conclusions

In a number of studies of children with DCD, it has been shown that the presence of other overlapping developmental disorders degrades the functional outcome, compared to those with DCD only (Hill & Brown, 2013; Kirby et al., 2013). In this study we concluded that DCD does not appear to be the factor that reduces the ability to empathize, but rather the presence of ADHD and/or ASD.

The results of this study indicate that social difficulties may be driven more by an accumulation of varying factors, a conclusion that fits with the environmental stress hypothesis (ESH; Mancini, Rigoli, Roberts, Heritage, & Piek, 2017). Individuals with DCD are more likely to experience a number of interpersonal difficulties from early years onward, including decreased self-competence, lower physical activity, higher risk of obesity, and the presence of internalizing problems such as anxiety and depression (Cairney, Rigoli, & Piek, 2013). A key approach of the ESH theoretical framework proposes that the relationship between motor skills and internalizing symptoms is predominantly indirect: poor motor skills lead to various psychosocial consequences in the individual’s surrounding environment, such as lower social support and lower interaction with others because of lack of participation. This then gives rise to increased internalizing symptoms (Cairney et al., 2013). The ESH model proposes that the greatest influence is the environment rather than biological factors, a different perspective compared to the Xavier hypothesis. We view our findings to be in line with ESH theory (see Fig. 2).

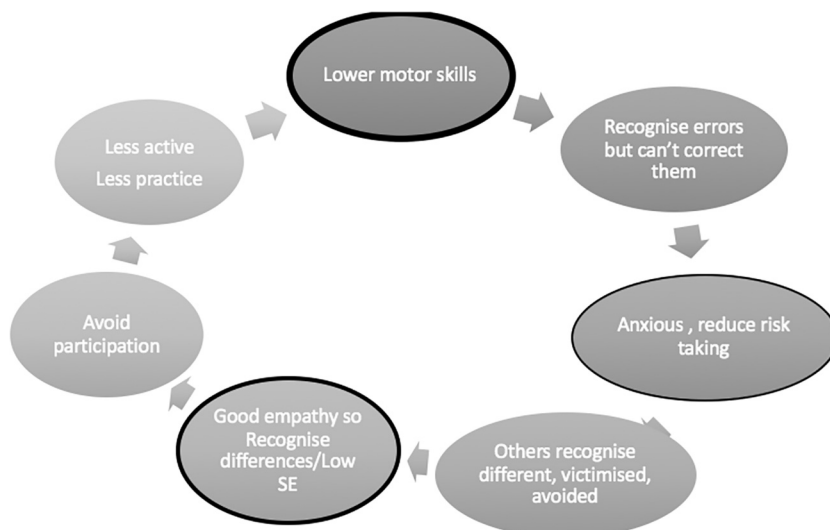


Fig. 2. The Environmental Stress Hypothesis (ESH; Mancini et al., 2017) within social relationships.

5.1. Limitations and future study

In this research all the study groups exhibited DCD or co-occurrence with DCD; there is a need to repeat the study with ADHD-only and ASD-only participants. The numbers of people with DCD + ASD and DCD + ADHD + ASD are relatively small.

In addition, the study employed only self-report questionnaires in screening for DCD, ADHD, and ASD. But it is important to note that all participants in the study groups reported past diagnosis that confirmed the screening results.

The construct of empathy has been vigorously discussed in philosophy, theology, developmental psychology, and neuroscience – including the question of whether it should be (or can be) separated into component parts. For this study we required a practical measure that has been used in the field of developmental disorders, which could be delivered to a large cohort. We concluded that using the EQ was both practical and appropriate within the constraints of the study. However, this tool did not allow for separation of empathy into potentially different cognitive and affective aspects. Similarly, it is important to study the correlation linking empathy, social relationships, and executive functions.

Future studies may be worthwhile using the Interpersonal Reactivity Index (IRI; Davis, 1980) or the Multidimensional Emotional Empathy Scale (Alloway et al., 2016). However, neither of these has been specifically designed for, or tested on, cohorts with developmental disorders.

Anxiety measures were also not taken in this study, which would have allowed the interesting consideration of high empathy scores relating to higher or lower anxiety levels, compared with past or current social interaction. Future research steps would include considering the potential association between anxiety and empathy in individuals with DCD. One particularly interesting aspect is the phenomenon of vicarious anxiety and its underlying mechanisms. In individuals with DCD, their engagement with both their environment and with other people may not always have predictable results. Planned movements may have unplanned outcomes: a child moving to catch a ball misses it again and again. This unpredictability in actions and consequences could be a driver for raising anxiety levels.

Finally, there is a need to develop an intervention program to gain more social opportunities and relationships for adolescents with DCD.

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