Motor dysfunctions in ADHD and DCD: An examination of the error correction mechanisms

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Introduction

The findings in motor behaviour of Attention Deficit Hyperactivity Disorder (ADHD) and Developmental Coordination Disorder (DCD) have led some to suggest that they simply reflect a common childhood developmental disorder (Gillberg, 2003; Kaplan et al., 1998). On the other hand, current concepts in ADHD suggests a response inhibition deficit (Barkley, 1997), whereas DCD deficit lies in the inability to produce efference copy for movement corrections (Katschmarsky et al., 2001; Wilson et al., 2001). Presence of these deficits was investigated through the amplitude transition function (Becker & Jurgens, 1979) by examining the ability of children with ADHD and/or DCD in movement corrections to superceding stimuli in a crossed double-step tracking task.

Aims of this study are to determine:

(1) The patterns of movement response to error correction in children with ADHD and/or DCD.
(2) How is visuo-spatial error information updated?
(3) The nature of the response inhibition and efference copy deficits underlying motor dysfunctions in ADHD and DCD respectively.

Methods

Participants

Children aged between 10 to 12 were recruited from primary schools. The children were divided into: ADHD-PI (Inattentive) (n=6), ADHD-C (Combined) (n=3), ADHD-PI with DCD (n=4), DCD (n=5), and control group (n=8) using the following measures.

Measures

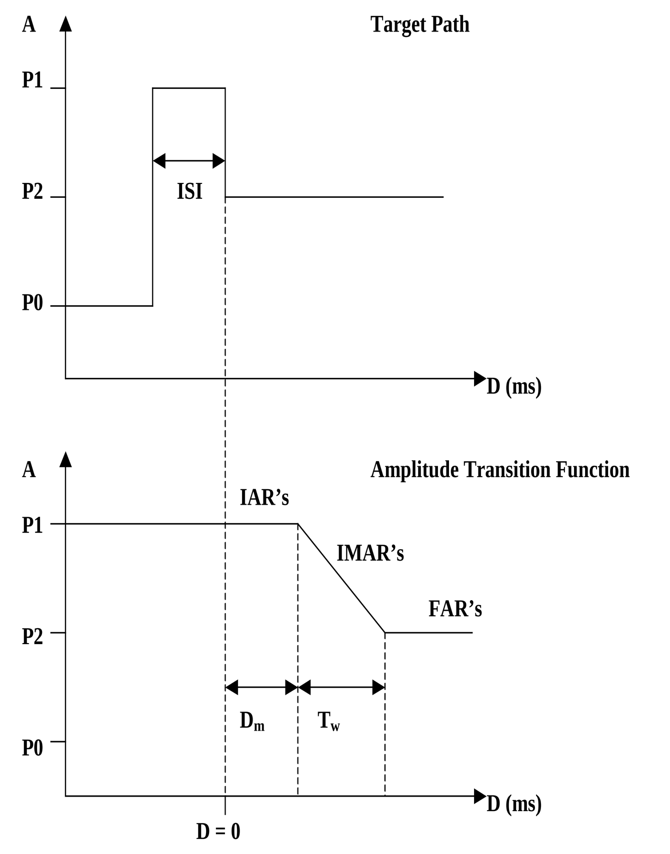
- Australian Twin Disruptive Behaviours Scale (ADBS; Levy & Hay, 2001)
- Conners' Parent Rating Scale (CPRS-R; Conners, 1997)
- Conners' Teacher Rating Scale (CTRS-R; Conners, 1997)
- Developmental Coordination Disorder Questionnaire (DCDQ; Wilson et al., 1998)
- McCarron Assessment of Neuromuscular Development (MAND; McCarron, 1982)

Double-step tracking task

- Participants were required to capture a target that jumped to different locations twice in succession
- The first step served as signal for initiation of a movement response
- The second step indicated new target location and was viewed as an induced movement error where amendment of the initial movement was required
- Two step conditions: single- and double-step
- Four target positions, two on each side of home base (76 cm, 152 cm)
- Six interstimulus intervals of 40, 80, 120, 160, 200 and 240 ms
- A total of 576 randomised trials

Amplitude transition function (ATF)

ATF represents the variations of the amplitudes of the initial response as a function of the determinant time interval (D), which reflects the actual processing time available after the onset of the second target step stimulus (Becker & Jürgens, 1979). Depending on the duration of D, three types of amplitude responses could be obtained (see Fig.1). Deficit in efference copy would affect the ability to produce a corrective response whereas a deficit in response inhibition would affect the ability to cancel the direction of the movement.



P0- Home Base
P1- First Target Position
P2- Second Target Position
S1- First Target Step
A- Amplitude (mm)
IAR's- Initial Amplitude Responses
IMAR's- Intermediate Amplitude Responses
FAR's- Final Amplitude Responses
D_m- Modification Time
T_w- Transition Time
D- Determinant Time interval
S2- Second Target Step
ISI- Interstimulus Interval

Figure 1. The amplitude transition function (ATF) for a family of possible initial response amplitudes to a double-step target, as a function of the delay (determinant time interval, D) between the occurrence of a second target step and the commencement of the initial response (From Glencross & Barrett, 1989).

Results

A 3 x 2 x 2 x 3 x 2 multivariate mixed ANOVA conducted on reaction times and on determinant time intervals shown a main effect for response type, $\underline{F}$ (2, 17) = 74.76, $\underline{p}$ <.05, η^2 = 0.90 and $\underline{F}$ (2, 17) = 238.48, $\underline{p}$ <.05, η^2 = 0.97 respectively. There was no statistically significant interaction effect observed between groups. Simple effects revealed that each response type was statistically different from each other (see Fig. 2 and 3).

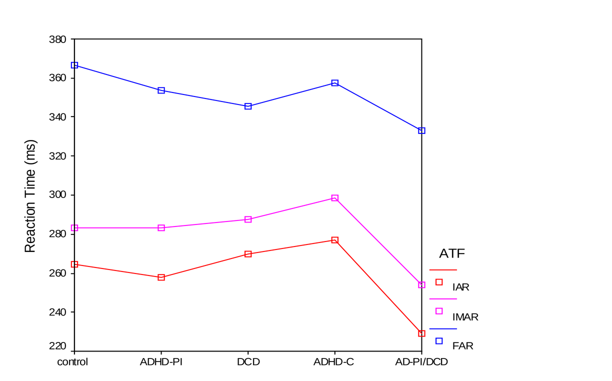


Figure 2. Mean reaction times for IAR, IMAR and FAR for each group.

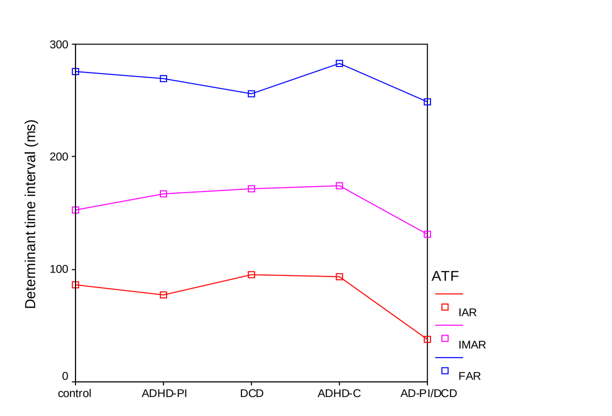


Figure 3. Mean determinant time intervals for IAR, IMAR and FAR for each group.

From the bivariate correlations between initial amplitude and determinant time interval for each participant in each group, the Fisher's combined transformed correlation coefficients indicate that the initial amplitude can be specified in all groups. The results revealed a consistently stronger relationship for the control and ADHD-PI groups to amend their initial amplitudes as a function of the determinant time interval (D) whereas this relationship was found to be weaker and varied across conditions for the ADHD-C and DCD groups (see Fig. 4).

The Fisher's combined transformed correlation coefficients also revealed a strong relationship between initial amplitude and corrective amplitude for all groups (see Fig. 5). Regardless of group membership, all participants were able to produce the corrective response to the second target position.

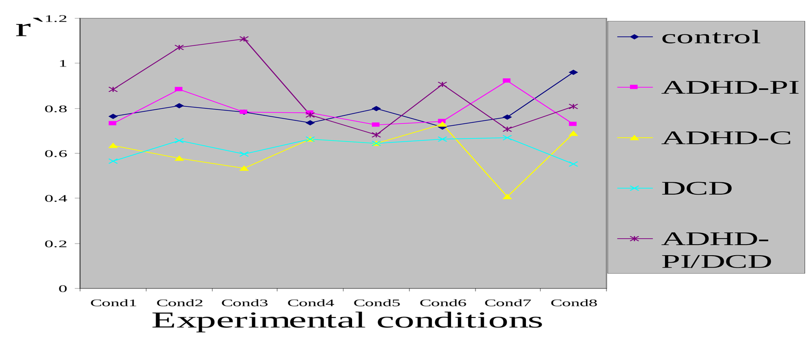


Figure 4. A display of the Fisher's combined transformed correlation coefficients (r`) from the correlations between initial amplitudes and determinant time interval for each group across all experimental conditions.

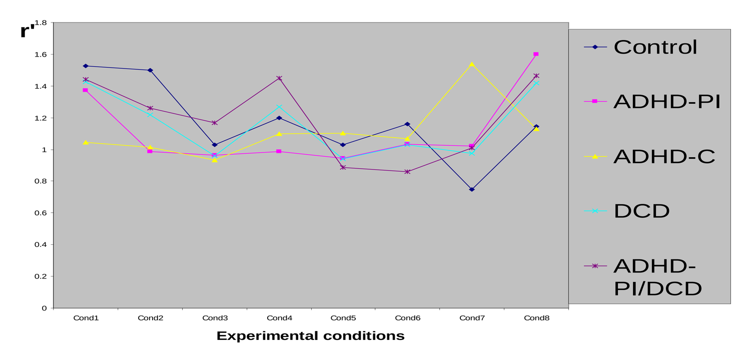


Figure 5. A display of the Fisher's combined transformed correlation coefficients (r`) for the correlations between initial amplitudes and corrective amplitudes in each group across all experimental conditions.

Conclusion

The preliminary findings in this study suggest that the amplitude of an initial double-step response varies as a function of D in all groups. The ADHD subtypes were able to inhibit the initial response when a correction is required but this ability is reduced in ADHD-C. Similarly, the DCD group was able to produce a corrective response that is accurate with respect to the final target position but this ability is also diminished compared to the control and ADHD-PI groups. These results suggest that there may be a ADHD subtype difference in response inhibition and that efference copy is operating in DCD but is not as effective. A larger sample size is required for more conclusive findings.

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