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Quiet eye training facilitates visuomotor coordination in children with developmental coordination disorder

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ABSTRACT

Introduction: Quiet eye training (QET) has been shown to be more effective than traditional training (TT) methods for teaching a throw and catch task to typically developing 8–10 yr old children. The current study aimed to apply the technique to children with developmental coordination disorder (DCD).

Method: 30 children with DCD were randomly allocated into TT or QET intervention groups. The TT group were taught how to control their arm movements during the throw and catch phases, while the QET group were also taught to fixate a target location on the wall prior to the throw (quiet eye1; QE1), followed by tracking the ball prior to the catch (quiet eye2; QE2). Performance, gaze and motion analysis data were collected at pre/post-training and 6-week retention.

Results: The QET group significantly increased QE durations from pre-training to delayed retention (QE1 = +247 ms, QE2 = +19%) whereas the TT group experienced a reduction (QE1 = −74 ms, QE2 = −4%). QET participants showed significant improvement in the quality of their catch attempts and increased elbow flexion at catch compared to the TT group (QET = −28°, TT = −1°).

Conclusion: QET changed DCD children's ability to focus on a target on the wall prior to the throw, followed by better anticipation and pursuit tracking on the ball, which in turn led to improved catching technique. QET may be an effective adjunct to traditional instructions, for therapists teaching visuomotor skills to children with DCD.

1. Introduction

Developmental coordination disorder (DCD) affects between 1.7 and 6% of children (depending on the stringency of diagnostic criteria; Hendrix, Prins, & Dekkers, 2014). The condition is characterised by a marked impairment in the performance of motor skills that have a significant, negative impact on daily activities (Sugden, Chambers, & Utley, 2006). Not only does DCD impact all areas of motor performance (Cantin, Ryan, & Polatajko, 2014), but it can influence academic achievement (Liberman, Ratzon, & Bart, 2013; Chen, Tsai, Hsu, Ma, & Lai, 2013), social development (Tseng, Howe, Chuang, & Hsieh, 2007; Chen, Tseng, Hu, and Cermak (2009) and long term physical health (Cairney & Veldhuizen, 2013).

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Whilst uncertainty remains regarding the precise aetiology of DCD (Vaivre-Douret, 2014; Caravale, Baldi, Gasparini, & Wilson, 2014), there is strong evidence to suggest that children with DCD have significant impairments in the processing of visual information relevant to the performance of motor tasks, compared to their typically developing (TD) peers (e.g. Wilson & McKenzie, 1998; Sigmundsson, Hansen, & Talcott, 2003; Piek & Dyck, 2004; Tsai, Wilson, & Wu, 2008). It is well established that predictive eye movements support the planning and control of goal directed movements in natural environments (see Land, 2009 for a review), and such eye movement analyses can differentiate between children with and without DCD (Langaas, Mon-Williams, Wann, Pascal, & Thompson, 1998; Robert, Ingster-Moati, Albuisson, Cabrol, Golse, & Vaivre-Douret, 2014). For example, children with DCD are unable to utilise predictive information to assist with the mapping of required movement patterns (Debrabant, Gheysen, Caeyensberghs, Van Waelvede, & Vigerhoets, 2013; Smits-Engelsman, Wilson, Westenberg, & Duysens, 2003), and cannot make use of advanced (partial) visual cues to support the efficient planning of subsequent movements (Mon-Williams et al., 2005; Wilmut & Wann, 2008).

The resulting paradox is that, despite having impaired eye movements (e.g. Robert et al., 2014), children with DCD rely more on visually guided online control when responding to stimuli (Debrabant et al., 2013). Visual target perturbation studies have demonstrated the significant difficulties children with DCD experience when making predictive online movement adaptations to movement trajectories (Hyde and Wilson, 2011a,b). Importantly, the deficits experienced by children with DCD are most pronounced in complex, interceptive tasks (Bairstow & Laszlo, 1989; Wilmut & Wann, 2008; Mak, 2010), and as such there is a need for research to further examine visuomotor control and motor performance in these less constrained settings using 'real-world' tasks (Wilson, Miles, Vine, & Vickers, 2013).

Ball catching is a complex dynamic task that requires modifications to planned movement responses based on visual information about the flight of the ball (Williams, 1992; Olivier, Ripoll, & Audiffren, 1997). Children with DCD find this task difficult (e.g. Van Waelvelde, De Weerdt, De Cock, Smits-Engelsman, & Peersman, 2004; Utley, Steenbergen, & Astill, 2007; Przysucha & Maraj, 2013) and use a different technique to TD children; extending their arms out in front of them and 'freezing' their elbow angles in this position throughout the catch in an attempt to reduce the degrees of freedom they have to coordinate in the movement (Utley et al., 2007; Astill, 2007). In this study we investigated whether this freezing strategy is driven by deficits in perception of ball flight characteristics that can be corrected through the use of QET.

The departure point for the current study is Wilson et al.'s (2013) examination of the visuomotor processes underpinning throwing and catching in children. This study found a specific gaze behaviour termed the quiet eye (QE) could distinguish between the motor coordination skill and throwing and catching performance of children. The QE was defined by Vickers (1996, 2007) as the final fixation or tracking gaze on an object (for >100 ms to within 3° of visual angle) before the onset of a critical movement and has been found to be a key predictor of perceptual-cognitive skill in a wide range of movement tasks (see review by Vine, Moore, and Wilson (2014). QE durations of experts in a wide range of motor tasks are typically longer suggesting additional time is needed to organize the neural networks underlying the planning and control of motor skills.

The study by Wilson et al. (2013) was the first to examine the QE in children, and found that those with low motor coordination ability (<20th percentile of MABC-2; Henderson, Sugden, & Barnett, 2007) had significantly shorter QE durations during both the throwing (QE1) and catching (QE2) phase of the task compared to highly coordinated children (>70th percentile of MABC-2; Henderson et al., 2007). It was suggested that the longer QE fixation prior to the throw (held on a virtual target on the blank wall; QE1) of the more skilled children helped to guide a more accurate throw which in turn helped them to locate the ball more quickly as it bounced off the wall. This subsequently helped them to initiate an earlier onset of a QE prior to the catch (the tracking gaze on the ball; QE2), providing earlier information about the ball flight, which could be used to plan the catch attempt (Wilson et al., 2013).

As well as being a key marker of proficient performance, the QE has been shown to be trainable (Vine et al., 2014). The objective of QE training (QET) is to help performer's adopt the QE of a highly skilled prototype so they know where and when to fixate their gaze when executing a motor skill in order to process the most relevant information guiding the planning and control of the action (Vine et al., 2014). Initial studies of QET in the sporting domain have been successful in accelerating the skill acquisition of novice performers when compared to traditional training instructions (e.g., Vine & Wilson, 2011). Miles, Vine, Wood, Vickers, and Wilson (2014) performed the first QET study in children, assessing the effectiveness of a QET intervention in improving performance in a throwing and catching task. Miles and colleagues found that their video-based QET intervention significantly increased the duration of QE1 and QE2, and improved catching performance by 23% in comparison to traditional training instructions, which produced no significant training effects. Although the authors did not assess the longer-term effects of QET in this population (i.e. at a delayed, as opposed to immediately post-training retention test), the findings represented a step forward in determining the transferability of QET to children suffering from DCD in complex, real-world movement skills that underpin many sport and playground games.

The aim of the current study was to extend the work of Miles et al. (2014) to assess the effectiveness of a QET intervention for a throw and catch task in children with DCD. We propose that such a study has both a strong scientific and practical rationale. First, based on Land's (2009) model of predictive eye movements and Vickers' (1996) conceptualisation of the QE, it is important to understand how training children with DCD to adopt more effective gaze and attention can improve their ability to make accurate online predictions to guide and adapt movement patterns, in real-world tasks. Second, there are significant health implications for interventions that can improve ball skills in children with DCD. Magalhães, Cardoso, and Missiuna (2011) identified poor ball skills as an important limiting factor in activity participation for children with DCD, and longitudinal work by Barnett, Van Beurden, Morgan, Brooks, and Beard (2008, 2009) has linked childhood object control proficiency with adolescent physical activity levels and fitness.