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Driving skills of young adults with developmental coordination disorder: Regulating speed and coping with distraction

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ABSTRACT

In two experiments, we used an automatic car simulator to examine the steering control, speed regulation and response to hazards of young adults with developmental coordination disorder (DCD) and limited driving experience. In Experiment 1 participants either used the accelerator pedal to regulate their speed, or used the brake pedal when they needed to slow down from a pre-set speed. In Experiment 2, we introduced an auditory distraction condition that shared similarities with maintaining a conversation. Overall, the DCD group produced a larger variance in heading and needed more steering adjustments on straight roads, compared to age-matched controls. When turning bends, the DCD group showed greater difficulty in controlling steering while regulating their speed with the accelerator pedal but this was less problematic when using the brake. The DCD group also responded slower than the control group to pedestrians who walked towards their path. The auditory distraction in Experiment 2 had no visible effects on steering control but increased the reaction times to pedestrians in both groups. We discuss the results in terms of the visuomotor control in steering and the learning of optimal mappings between optic flow and vehicle control.

1. Introduction

Driving is an important skill learned in late adolescence and early adulthood that contributes substantially to feelings of independence. It facilitates interactions with peers and can be instrumental in securing employment and in pursuing further education. For the small portion of people who suffer from developmental coordination disorder (DCD), however, driving a car may appear to be a considerable challenge. According to the diagnostic criteria set by international organisations, individuals with DCD show impaired control of voluntary motor activity in the absence of a known medical condition or pervasive developmental disorder, which impacts negatively on their activities of daily living (APA, 1994; WHO, 1993). Much research has been dedicated to the identification of children with DCD and to therapeutic programmes aimed at ameliorating their symptoms (e.g., Gibbs, Appleton, & Appleton, 2007; Schoemaker, Hijlkema, & Kalverboer, 1994), but there is far less research into the specific difficulties these individuals present when reaching adulthood (Cantell, Smyth, & Ahonen, 2003; Losse et al., 1991).

Difficulties in learning to drive have been linked with general coordination problems (Cousins & Smyth, 2003; Missiuna, Moll, King, Stewart, & Macdonald, 2008) so it is not surprising that young adults with coordination difficulties mention learning to drive as one major source of concern (Losse et al., 1991). The sparse existing studies that mention driving, show that

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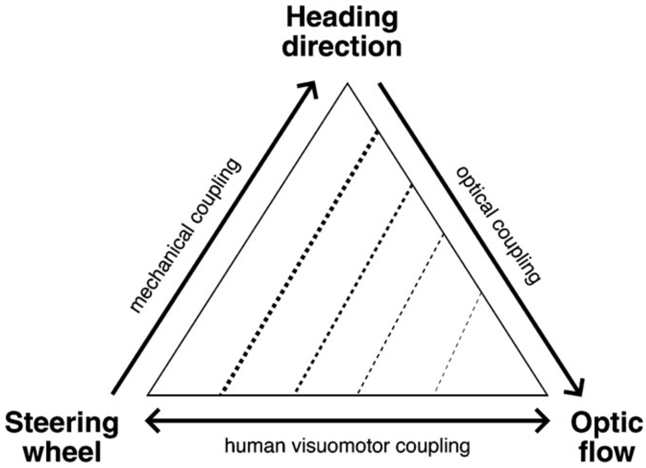

Fig. 1. Schematic illustration of the couplings involved in vehicle control. Mechanical and optical couplings control two of the interactions and the human operator establishes the mapping between the steering actions and optic flow including speed regulation. The two-way arrow at the bottom of the figure illustrates the bidirectional mapping between steering and optic flow. The diagonal broken lines illustrate that the system may operate across different dynamic timescales, so this could be a small triangle representing short iterative adjustments, or operate over a longer time frame with less frequent adjustments. There is evidence to suggest that individuals adopt their own dynamic timescales for steering control and errors can occur when they are forced to operate under a different timescale (Fajen, 2008; Wilkie, Wann, & Allison, 2008).

individuals with DCD are less likely to learn to drive than their age-matched control peers, or drive fewer miles per week (Kirby, Sugden, & Edwards, in press), and perceive themselves to be less competent drivers (Missiuna et al., 2008). Learning to drive may be particularly difficult for individuals with DCD for two reasons. First, spatial perception, sequencing and dual-tasking, are all crucial to driving and previous research on individuals with DCD has pointed out general difficulties on all these abilities (e.g., Wilmut & Wann, 2008; Wilmut, Wann, & Brown, 2006; Wilson & McKenzie, 1998). Such abilities are required for instance in perceiving the approach speed to an upcoming bend or selectively allocating attention to road hazards. Secondly, driving is a complex skill and one that does not lend itself to break-up into simpler sub-components that might facilitate learning. For instance, it requires the simultaneous control of both steering and speed. In Fig. 1 we offer a schematic representation of the three mechanisms involved in vehicle control. There is a mechanical coupling linking steering wheel and heading direction, which depends on the vehicle's characteristics (e.g., wheel base and turning arc). There is an optical coupling linking heading direction and the visual information available to the driver, or optic flow, which depends on the laws of optics and include travelling speed (Gibson, 1958). Finally there is a visuomotor link between optic flow and steering control, which depends on the human's ability to detect the relevant properties from optic flow and to implement an action that corrects any undesirable state and brings about a desired optic flow pattern (Wann & Wilkie, 2004). Importantly, the mapping between the steering actions and the optic flow pattern is bidirectional and dependent on speed control (de Oliveira et al., 2009). While driving on a straight road, one mainly needs to maintain heading direction using small steering adjustments and speed is adjusted on a less frequent basis, but in preparing for an upcoming bend one must regulate the speed to enable the effective execution of steering actions that will change direction in a timely manner. We were interested in the ability of individuals to exercise control over steering and speed, while at the same time, selectively attend to road hazards.

Thus, in the present study we examine the skills of young adults with DCD in the context of driving along straight roads and also when turning bends. In the first experiment we manipulate the mechanism for speed regulation by having participants use only the accelerator pedal to control their speed or by having participants use only the brake pedal to decelerate from a pre-set speed when they deem it necessary. In the second experiment we maintain the use of the brake pedal and manipulate the existence of an auditory distraction that shares similarities to conversing while driving. The dependent measures we adopted were, within steering control, the ability to keep to a straight path (i.e., heading variance) and the amount of iterative corrections to heading (i.e., number of steering adjustments), within speed regulation, the preferred travelling speed and the moment when participants started decelerating before entering a bend, and within responses to hazards, the time to react to pedestrians who walked towards the path of the driver. To study these factors we created a virtual environment with a set of city roads where we could record measures of vehicle control, as well as the responses to pedestrians. The main aim of this study was to assess the driving skills of young adults with DCD and examine specific contexts and conditions that may facilitate or hamper their performance.

2. General methods

2.1. Participants

Participants were 23 young adults aged between 16 and 22 years (*M* = 18.6 years, *SD* = 1.9). There were 11 participants in the DCD group, 6 male and 5 female, aged 18.6 years (*SD* = 2.3). Table 2 of supplementary material includes the full