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The development of the illusion of control and sense of agency in 7- to-12-year old children and adults

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We would like to dedicate this paper to Joop van der Pligt (1951–2015), as the research it describes reflects the outcomes of his passionate research interest in the illusion of control.

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ABSTRACT

The illusion of control can be defined as the erroneous belief that one's actions cause a specific outcome, whereas sense of agency refers to the subjective feeling of authorship over one's actions. In the present study we investigated the development of illusory control and sense of agency. A novel card-guessing game was developed in which 7- to-12-year old children (Study 1) and adults (Study 2) were required to select a card, and we manipulated the congruence of the outcome with their initial choice (i.e. congruent or incongruent) and the valence of the outcome that was presented (i.e. positive or negative). We found that illusory control and the self-attribution bias (i.e. the bias to attribute positive outcomes to oneself) in the card guessing game decreased, as children get older. In contrast, for both children and adults sense of agency in the task was similarly affected by outcome congruency, suggesting that the ability to relate predicted to observed action outcomes reflects a basic mechanism that helps people to sustain a sense of agency. Thus, while the illusion of control decreases as we get older, the experience of agency as a function of outcome congruency seems to be more stable across development.

1. Introduction

Imagine a seven-year-old boy playing a dice-throwing game. Before throwing he carefully blows the dice in the hope that this will affect the outcome. This is an example of the *illusion of control*; i.e., the erroneous belief that one's actions can cause a certain outcome, even if that outcome is in fact uncontrollable and entirely determined by chance (Langer, 1975). Now imagine a seven-year-old boy who receives a computer racing game for his birthday. After starting the game, the boy may be engaged in driving the car and steering the remote control wheel. As long as the movements displayed on the screen are congruent with the boy's movements, he will experience a strong *sense of agency*, i.e. the belief that one is controlling one's own actions and their outcomes in the world (Wegner, 2003). However, when the movements made by the car do not match the movements made via the remote control wheel (e.g. when the computer is in demo mode), this will result in a reduction of sense of agency.

In this paper we draw parallels between research on the illusion of control and research on sense of agency – two related concepts that have, surprisingly, to a large extent been discussed separately throughout the literature. We will argue that the illusion of control is strongly related to a process of reinforcement learning and the detection of illusory contingencies (for review, see: van Elk, Friston, & Bekkering, 2015). In contrast, sense of agency is primarily related to a predictive process, in which the anticipated outcomes of one's actions are compared with the observed sensory consequences. We present two studies to investigate the development of the illusion of control and sense of agency in young children and adults.

1.1. Illusion of control

Early work on the illusion of control has shown that many people act as if they have control over situations that are actually determined by chance (Langer, 1975; Langer & Roth, 1975). For instance, people indicate having greater control over throwing dice or selecting a lottery ticket when performing the action themselves than if someone else does it for them (Langer, 1975). Based on these findings it has been suggested that the illusion of control is

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especially likely to occur when a game of chance is approached as if it were a game of skill; i.e., when people erroneously attribute potential outcomes to one's abilities rather than to external factors or luck (Langer, 1975; Langer & Roth, 1975; Wohl & Enzle, 2002). Other studies have suggested that the illusion of control is caused by a process of associative or reinforcement learning, in which one's action is accidentally paired with a specific outcome (Blanco & Matute, 2015; Matute, 1996; Matute & Blanco, 2014). For instance, by using a random reinforcement schedule (i.e. sounds or lights were presented at random intervals) it was found that many participants developed a particular strategy for responding (e.g., pressing computer buttons in a specific order), and also reported feelings of control over the outcome (Blanco & Matute, 2015; Matute, 1996; Matute & Blanco, 2014).

Developmental studies have shown that the illusion of control is especially prevalent in young children and decreases with increased age (Heckhausen & Schulz, 1995; Weisz, 1980, 1981; Weisz, Yeates, Robertson, & Beckham, 1982). For instance, when kindergartners were presented with a game of chance (i.e. drawing cards blindly from a shuffled deck), they perceived outcomes as contingent upon competence-related factors (e.g. skills, age, etc.) whereas older children showed an awareness of the non-contingent nature of the game (Weisz, 1980). It has been suggested that this tendency of young children to over-estimate the amount of control that can be exerted over the environment is especially adaptive during early development (Heckhausen & Schulz, 1995). Young children are continuously faced with changes in their bodily and cognitive capacities and need to learn which aspects of their environment they can control, and which are beyond their control. An underestimation of the amount of control that can be exerted is likely to lead to passivity and learned helplessness (Rholes, Blackwell, Jordan, & Walters, 1980). In contrast, an overestimation of control may be adaptive because it helps the person to not miss opportunities to exert control (Haselton & Nettle, 2006; Haselton et al., 2009), as well as through its positive effects on self-esteem (Taylor & Brown, 1988).

The illusion of control may be considered a specific instance of 'magical thinking', which refers to a broader phenomenon where people tend to infer causal relationships (either real or illusory) between specific events in the world (e.g. as observed in belief in the laws of contagion and similarity in sympathetic magic; cf. Eckblad & Chapman, 1983; Nemeroff & Rozin, 2000). Illusory control is at the heart of different forms of magical thinking that involve personal action, such as the belief in sympathetic magic (e.g. belief in Voodoo, whereby a specific action is believed to have a distant effect; cf. Nemeroff & Rozin, 2000), and various superstitious beliefs and behaviors (Foster & Kokko, 2009). In line with the observed decline in illusory control with increased age, developmental studies on magical thinking have shown that younger children are more prone to magical thinking (i.e., perceiving illusory contingencies between two unrelated events), and are also more likely to accept magical explanations for anomalous events than older children (Rosengren & Hickling, 1994; Rosengren, Kalish, Hickling, & Gelman, 1994; Subbotsky, 2004). For instance, 4-year old children found it more difficult to distinguish between possible and impossible events than 5-year old children and they were more likely to give magical explanations, whereas older children explained anomalous events in terms of 'tricks' (Rosengren & Hickling, 1994; Rosengren et al., 1994).

The decline in magical thinking with increased age is typically interpreted as reflecting a transition from a cognitive processing style that is characterized by 'pre-causal explanations' (e.g. animistic or artificialistic), to causal or physical explanations (Laurendeau & Pinard, 1962; Rosengren et al., 1994). It is suggested that younger children do not yet have a model enabling them to distinguish what can be explained in terms of everyday causal principles and what not (Woolley, 2000). Piaget already noted that throughout development children have to learn when causal efficacy can be attributed to the self or to external factors (Piaget, 1960). Younger children may have specific difficulties with distinguishing non-contingent (e.g. chance) from contingent (e.g. skills) events (Weisz, 1980, 1981; Weisz et al., 1982). Interestingly, it has also been pointed out that magical and natural explanations for events may actually co-exist throughout development (Legare, Evans, Rosengren, & Harris, 2012), as children may be particularly motivated by a need for discovery, seeking and providing explanations for events that are novel or unexpected (Legare, 2015).

1.2. Sense of agency and the illusion of control

Whereas illusory control reflects a motivated tendency to believe that outcomes that are in fact determined by chance can be controlled (i.e. either by oneself, or through a process of vicarious control; Rothbaum, Weisz, & Snyder, 1982), 'sense of agency' refers to the basic feeling of authorship over specific actions and outcomes. In many cases illusory control and sense of agency are strongly related (e.g. in a game of chance one may develop a strong illusion of control and an accompanying strong sense of agency), but both concepts can also be disentangled. For instance, when driving a car in a computer racing game sense of agency may be quite high, while there is no illusory control (as the depicted car is in fact controlled by the driver).

A large number of studies have investigated the functional and neural mechanisms underlying sense of agency (for review, see: David, Newen, & Vogeley, 2008; de Vignemont & Fourneret, 2004; Kuhn, Brass, & Haggard, 2012), for instance by using experimental manipulations in which the congruency between intended and observed action consequences is systematically manipulated by introducing visuo-spatial or temporal deviations (Fourneret & Jeannerod, 1998; Franck et al., 2001; van den Bos & Jeannerod, 2002). Small deviations between performed and observed movements often remain unnoticed (e.g. Fourneret & Jeannerod, 1998), but with an increased mismatch between intended and observed action outcomes, sense of agency typically decreases and participants are more likely to attribute the observed movements to an external source (Fourneret & Jeannerod, 1998; Franck et al., 2001; van den Bos & Jeannerod, 2002).

An important model to account for these findings proposes that sense of agency depends on the successful integration of predicted and observed action effects, by using an internal forward model (Frith, 2012; however, for alternative theoretical models, see: Metcalfe, Eich, & Castel, 2010). Internal forward models of motor control propose that efferent signals from motor-related areas are used to anticipate the sensory consequences of one's movements (Wolpert, 1997). A mismatch between predicted and observed outcomes results in a 'prediction error signal' and a subsequent updating of one's forward model, resulting in the attribution of an outcome to an external cause for instance.

With respect to the development of sense of agency, several studies have shown that young children are characterized by a reduced awareness about the extent to which specific actions and outcomes can be controlled. For instance, pre-school aged children tend to confuse intended with accidental outcomes (cf. Metcalfe et al., 2010; Shultz & Wells, 1985; Shultz, Wells, & Sarda, 1980) and they tend to change their retrospective awareness and verbal reporting of their prior intentions based on the outcome of an action (e.g. 'Did you intend to hit the green or the red ball?'; cf. Astington, 2001; Phillips, Baron-Cohen, & Rutter, 1998; Shultz & Wells, 1985). In contrast, 5-year old children are well aware of the distinction between intentional and accidental actions and their outcomes (Lang & Perner, 2002; Shultz et al., 1980). Two recent studies that more directly assessed sense of agency in 10-year