Consciousness and Cognition 29 (2014) 171–177

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Examining intention in simulated actions: Are children and young adults different?

Carl Gabbard [a,*], Priscila Caçola [b]

[a] Texas A&M University, United States
[b] University of Texas – Arlington, United States

ARTICLE INFO

Article history:
Received 10 December 2013
Available online 3 October 2014

Keywords:
Motor imagery
Intention
Action processing

ABSTRACT

Previous work with adults provides evidence that 'intention' used in processing simulated actions is similar to that used in planning and processing overt movements. The present study compared young adults and children on their ability to estimate distance reachability using a NOGO/GO paradigm in conditions of imagery only (IO) and imagery with actual execution (IE). Our initial thoughts were that whereas intention is associated with motivation and commitment to act, age-related differences could impact planning. Results indicated no difference in overall accuracy by condition within groups, and as expected adults were more accurate. These findings support an increasing body of evidence suggesting that the neurocognitive processes (in this case, intention) driving motor imagery and overt actions are similar, and as evidenced here, functioning by age 7.

1. Introduction

A search of contemporary literature in prominent journals shows quite clearly that the concept of motor imagery has attraction across a variety of scientific and clinical fields. Arguably, the key feature underlying these interests is the idea that processes involved in simulating a motor action via motor imagery are similar to that used for planning and executing an action (see Grèzes & Decety, 2001; Jeannerod, 2006; Munzert, Lorey, & Zentgraf, 2009). While discussions concerning association and activation of specific brain substructures continue, several reports indicate that at some level there is a functional equivalence between motor imagery and action processing (e.g., Burianová et al., 2013; Kunz, Creem-Regehr, & Thompson, 2009; Lorey et al., 2010; Young, Prat, & Chau, 2009). For example, evidence has been reported showing that motor imagery follows the basic tenets of Fitts' Law (Young et al., 2009; Solodkin, Hlustik, Chen, & Small, 2004; Stevens, 2005). That is, simulated movement duration, like actual movement, decreases with increasing task complexity.

Here, we discuss the issue of *intention* by addressing the question – is intention of completing a simulated motor action equivalent to intention used in processing overt actions? Whereas previous work with adults provides hints of support for equivalence (Gabbard, Cordova, & Lee, 2009), the present study addressed the question from a developmental (age-related) perspective by comparing young adults and children. Several definitions have been applied to the term intention. In the context of action processing, we associate it with 'choice with commitment' (Cohen & Levesque, 1990), and for our interests, 'intention [commitment] to act and the consequences of the action' (Frith, 2002). Searle (1983) also complements the general idea by suggesting that intention initiates a transaction between mind and environment by representing the end or aim of the action before the action is undertaken.

* Corresponding author. Address: TAMU 4243, College Station, TX 77843, United States. Fax: +1 847 8987.
URL: http://motordevelopment.tamu.edu/ (C. Gabbard).

http://dx.doi.org/10.1016/j.concog.2014.08.013
1053-8100/

From one perspective, intention is inherent in motor imagery. For example, Jeannerod (1997) proposed that motor imagery of a specific action is based on the internal representation of *intended*, yet unexecuted actions. Furthermore, it is suggested that motor representations via motor imagery are in fact intentions. Jeannerod (2003) also proposes that simulated action includes everything that is involved in an overt action, except for muscular contractions and joint rotations. Complementing this idea is the notion that planning of simulated and executed movements differ primarily in that at some (currently unknown) point, inhibitory processes suppress motor output (e.g., Decety, 1996; Lotze et al., 1999; Schwoebel, Boronat, & Coslett, 2002). Furthermore, selected propositions of internal model theory suggest that in the case of the specification of an *intended* goal for action (intentional state)— the motor centers generate an appropriate outflow signal so as to perform the planned movement (inverse model) (e.g., Jordan, 1995; Wolpert & Kawato, 1998); this outflow signal has been described as an efference copy also known as an action representation and simulation of action (Choudhury, Charman, Bird, & Blakemore, 2007; Glover, 2004; Jeannerod, 1997; Wilson et al., 2004). In a recent essay by Butterfill and Sinigaglia (2012), the authors state that whereas intention and motor representation play distinct roles in purposive action, the two features 'interlock' for effective action.

From another standpoint, it may be argued that with simulated movements, there is no real intent to actually move; therefore the association between simulated and executed movements is questionable. To illustrate the suggestion, studies of third-person simulation are worth a note; i.e., simulated actions via observation of others. In such a condition, Decety and Grèzes (1999) contend that the neural substrate for action planning (in observers) is activated during perception of action '*only when the intention*' is to imitate that action at some point in the future; hence, resulting in an 'intentional effect' (Badets, Blandin, Bouquet, & Shea, 2006; Gallese & Goldman, 1998; Grèzes & Decety, 2001; Jeannerod, 1999). Complementing the intentional effect hypothesis is the idea that intention exists in both simulated actions and the planning and execution of movement, but at different levels (intentional states) (Coello & Delevoye-Turrell, 2007; Johnson & Haggard, 2002). This notion suggests that level of motor awareness (via motor imagery) and subsequent performance is dependent on the participants' "intentional state." Therefore, we could speculate that different levels of intention may underscore the 'depth' of association between motor imagery and executed actions.

In 2009, Gabbard and colleagues examined the general premise of equivalence by testing adult ability to estimate distance reachability via use of motor imagery in two conditions: one involved use of imagery only and the other imagery plus execution arranged in a NOGO/GO paradigm. That is, with imagery only (red target), a verbal estimate of whether the target was within reach or out of reach was given. With imagery-execution (green target) participants knew that they would actually reach after giving a verbal estimate and be judged on accuracy. The assumption was that this condition would prompt greater intention. Half of the targets were randomly presented within actual reach (peripersonal space) and half out of reach (extrapersonal space). Results indicated no statistical difference in overall accuracy by condition, a finding that supports at least in part, the equivalence idea that motor simulation and planning with execution have similar intentional characteristics.

The present study used a NOGO/GO paradigm comparing children and adults on reach estimation via use of motor imagery only (IO) and imagery with execution (IE) conditions. Our aim was to test the hypothesis that children's behavior with imagery would approximate that shown with young adults. That is, there would be no difference between conditions, a finding that would give additional support for the equivalence hypothesis. Furthermore, this outcome would also suggest that this aspect of mental representation and motor planning (intention in motor imagery) is functionally similar to adults.

On the other hand, there was the plausible hypothesis that children would perform better in the imagery and 'execution' (IE) condition. We based that expectation on the assumption that an intentional effect was more likely. That is, by anticipating that actual reach follows, the child is more likely to increase movement awareness and subsequently intention level, resulting in more accurate performance. There are hints in the literature supporting this hypothesis. One is the observation that children, especially young children, need to engage more motor processes when simulating action, whereas older children and adults are more reliant on visual information to solve imagery tasks (Frick, Daum, Wilson, & Wilkening, 2009; Funk, Brugger, & Wilkening, 2005). Another possible account for non-equivalence with children is that the relationship between simulated actions and executed movements follow a developmental course; i.e., the relationship becomes stronger with increasing age through adolescence (Caeyenberghs, Tsoupas, Wilson, & Smits-Engelsman, 2009; Choudhury et al., 2007; Gabbard, 2009; Skoura, Vinter, & Papaxanthis, 2009). And finally, as a general developmental assumption, whereas intention is associated with motivation and commitment to act, age-related differences could impact imagery behavior. For example, children could possibly be more motivated to attend to the task goal with knowledge that execution follows.

Another expectation based on earlier work comparing children and adults in a NO/GO just imagery accuracy condition, was that children would be less accurate overall and more so in extrapersonal space (Gabbard, Cordova, & Ammar, 2007; Gabbard et al., 2009); an observation that would apply to both conditions in the present study.

2. Method

2.1. Participants

The sample consisted of 15 children aged 7–11 years (mean 8.82) and 15 university student volunteers aged 18–23 years (mean 19.8); all right-handed as determined by results of the Lateral Preference Inventory (Coren, 1993). All participants