Journal of Experimental Child Psychology 120 (2014) 59–72

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

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

Task structure complexity and goal neglect in typically developing children

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A R T I C L E   I N F O

Article history:
Received 27 November 2012
Revised 4 November 2013
Available online 31 December 2013

Keywords:
Executive function
Fluid intelligence
Goals
Goal neglect
Task complexity
Task instructions
Working memory

A B S T R A C T

Goal neglect is a failure to enact task requirements despite being able to accurately report them. In this study, we introduce a new child-appropriate experimental paradigm to measure goal neglect in children between 7 and 11 years of age and test the hypothesis that the complexity of an action plan, not real-time trial demands, increases goal neglect. A total of 66 children (M_{age} = 9.50 years) were administered a Feature Match task. Half of the children were given four rules for matching, and half were given three rules for matching. After practice, the four-rules group was told to ignore the additional rule, and both groups completed an identical three-rules task. The results showed that the extra rule increased goal neglect and its correlation with fluid intelligence. Although intermittent trial errors were correlated with fluid intelligence for both groups, only in the four-rules group were systematic rule failures (i.e., goal neglect) correlated with fluid intelligence. Task performance improved with chronological age; however, when controlling for the influence of fluid intelligence, the relationship between age and task performance was effectively removed. This suggests that a child's current level of fluid intelligence (and not age) determines task performance. We suggest that the relationship among goal neglect, complex task instructions, and fluid intelligence is linked to the mental preparation for future events, that is, mentally compiling verbal instructions into a set of activated goal representations in working memory that represent what is to be done and under what circumstances.

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http://dx.doi.org/10.1016/j.jecp.2013.11.003

Introduction

Goals are "an intention to accomplish a task, achieve some specific state of the world, or take some mental or physical action" (Altmann & Trafton, 2002, p. 39). Goals are central to the construct of executive functioning, which in turn is related to the construct of fluid intelligence (Friedman et al., 2006). Accordingly, many researchers directly or indirectly conceptualize the term *executive function* as a process of goal activation (Altmann & Trafton, 2002; Duncan, Emslie, Williams, Johnson, & Freer, 1996; Nieuwenhuis, Broerse, Nielen, & De Jong, 2004). In this context, executive functioning can be thought of as goal-directed processes that exert control over thought and behavior in novel and complex situations (Jurado & Rosselli, 2007). When goals are not brought to sufficient awareness, we can suffer from a lapse in intention, whereby nothing is attempted in behavior despite verbal knowledge that an action is required (Duncan et al., 1996). This abulic dissociation, termed *goal neglect*, is similar to that seen in patients with damage to the frontal lobes.

Anecdotal and historical accounts of behavior after damage to the frontal lobes (Bianchi, 1922; Luria, 1966) suggest major defects in planning, coordinating, or controlling a sequence of action. Behavior will often manifest as disorganized and fragmentary, with sequences of action left incomplete and purposeless actions introduced (Duncan, 1986). Intriguingly, the same chaotic behavior can be seen in people with intact frontal functioning when they are faced with novel tasks of high complexity (Duncan et al., 2008). The best predictors of this type of behavior are tests of fluid intelligence such as Raven's Matrices and the Cattell Culture Fair Test of *g*. These tests provide an excellent measure of Spearman's *g* or general intelligence (Carroll, 1993). Spearman's *g* derives from the finding that diverse tests of cognitive ability correlate with one another (Spearman, 1904). To explain the covariance in abilities, Spearman proposed that some general factor (*g*) underlies individual differences in intelligence. Subject to vigorous study for more than a century, *g* is a well-established predictor of social, educational, neurocognitive, and biological factors (Jensen, 1998).

Adult research regarding goal neglect has typically been conducted using two main experimental paradigms: the Letter Monitoring task (Duncan et al., 1996) and the Feature Match task (Duncan et al., 2008). These two experimental paradigms share several important characteristics that make them ideal for eliciting and measuring goal neglect. First, the tasks provide minimal performance feedback to participants. Once the experimental trials have started, participants are not provided with any information regarding their task performance by the experimenter or through the experimental paradigm. Second, the association between task stimuli and the corresponding action requirement is not explicitly stated by the task stimuli, nor is it obvious or intuitive in any way. That is, the task requirements are ambiguous, and hence participants must rely on internal representations to correctly guide behavior. Finally, the collection of task requirements and overall task structure must be novel. Novelty appears to be a key characteristic for both frontal patients and normal individuals in eliciting goal neglect (Duncan et al., 1996), with well-practiced habits and "crystallized" intelligence measures showing resilience against brain damage (Duncan, Burgess, & Emslie, 1995).

Children provide an excellent opportunity to investigate goal neglect due to the changes in executive function (Brydges, Reid, Fox, & Anderson, 2012) and fluid intelligence (Anderson, 1992) that occur throughout the childhood years. These changes are thought to be due to the development of the prefrontal cortex (PFC). Over childhood, the PFC undergoes substantial development (Casey, Giedd, & Thomas, 2000; Giedd & Rapoport, 2010; Giedd et al., 1999; Gogtay et al., 2004), reflected by marked changes in the abilities associated with the PFC between 7 and 11 years of age (McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002). For example, between 7 and 11 years of age, children show an increased ability to hold information in mind and manipulate it (Diamond, 2002), which is a hallmark feature of goal-directed behavior and generally referred to as *working memory* (Baddeley, Sala, Robbins, & Baddeley, 1996). In a standard memory item of the Wechsler Intelligence Scales, the Forward Digit Span task, participants are asked to remember and recall a series of digits in the same order as they were heard. Children show an improvement of 1.5 digits on the task from 7 to 13 years of age. However, when children are required to recall the digits in the opposite order as they were presented, which requires manipulation of the temporarily stored information, there is an improvement of 3 additionally recollected digits (Diamond, 2002).