Cognition 170 (2018) 270–279

Contents lists available at ScienceDirect

Cognition

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

Original Articles

Young children can overcome their weak inhibitory control, if they conceptualize a task in the right way

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ARTICLE INFO

Keywords:
Executive function
Inhibitory control
Task conceptualisation
Conceptual Knowledge
Development

ABSTRACT

This article investigates the process of task conceptualization, through which participants turn the instructions on a task into a mental representation of that task. We provide the first empirical evidence that this process of conceptualization can directly influence the inhibitory demands of a task. Data from Experiments 1 and 2 (both n = 24) suggested that robust difficulties on inhibitory tasks can be overcome *if* preschoolers conceptualize the tasks in a way that avoids the need for inhibitory control. Experiment 3 (n = 60) demonstrated that even when all other aspects of a task are identical, simply changing how the rules are introduced can influence whether such a conceptualization is adopted – thereby influencing children's performance on the task. An appreciation of the process of conceptualization is essential for our understanding of how inhibitory control and knowledge interact in early development.

1. Introduction

Inhibitory control is the cognitive process used to prevent the execution of behavior that is incompatible with current task goals (Chevalier et al., 2012). Prepotent responses can be incompatible with task goals, because they are triggered without recourse to them (e.g., Isoda & Hikosaka, 2011; Norman & Shallice, 1986; Shiffrin & Schneider, 1977). Whether a task contains a goal-inappropriate prepotent response will depend, among other things, on the way that participants *conceptualize* the task. In other words, it will depend on the contents of the mental representation that participants construct in order to perform the task. The presence of a goal-inappropriate prepotent response will have a significant effect on the performance of young children in particular, because of their weak inhibitory control.

Vygotsky (1962) was the first to propose that the way children represent a task will determine their subsequent performance on it. Indeed, conceptual understanding more broadly may be seen as central to early cognitive development (e.g., Kirkham, Cruess, & Diamond, 2003; Zelazo, Frye, & Rapus, 1996). Specifically in relation to inhibitory task performance, several theorists have suggested that "task conceptualization" affects inhibitory demands (e.g., Apperly & Carroll, 2009; Kloo, Perner, & Giritzer, 2010; Russell, 1996; Simpson & Riggs, 2005a). However, to our knowledge, there have been no attempts to put this idea to the test. The aim of this article, therefore, is to empirically investigate how this conceptualization process affects inhibitory demands.

We start with the assertion that prepotent responses are not the product of the *world*; they are the product of the *mind*. How an individual conceptualizes a task determines whether it contains a prepotent response. Consider, for example, the Day/Night task, which is one of the Stimulus-Response Compatibility tasks used to study inhibitory control in childhood. In this task, preschoolers are instructed to say "night" to a day picture, and "day" to a night picture (Gerstadt, Hong, & Diamond, 1994; Simpson & Riggs, 2005b). The prepotent responses in this task are the more obvious responses of saying "day" to the day picture, and "night" to the night picture. In a limited sense, these prepotent responses are stimulus-driven, since it is the presentation of day and night stimuli that triggers them. However, outside the Day/Night task, the mere presence of these stimuli is not sufficient to make the responses of saying "day" and "night" prepotent. This is obvious: despite their weak inhibitory control, preschoolers do not struggle to resist saying "night" every time they look at the night sky. So there must be something particular about the way that children conceptualize the Day/Night task which means the responses "day" and "night" *become* prepotent in this task.

Once we accept that prepotent responses are the product of the mind, rather than the world, it necessarily follows that the way an individual conceptualizes a task will influence whether or not it contains a goal-inappropriate prepotent response, and therefore whether the task has inhibitory demands. Crucially, it is likely that some tasks will

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http://dx.doi.org/10.1016/j.cognition.2017.10.008
Received 30 March 2017; Received in revised form 4 October 2017; Accepted 16 October 2017

contain a goal-inappropriate prepotent response if conceptualized one way, and will thus require inhibitory control; but they will contain no such response if conceptualized another way, thus avoiding this requirement. We refer to these contrasting types of conceptualization as "IC-requiring" and "IC-avoiding". This distinction is important when studying early cognitive development, because preschoolers have particularly weak inhibitory control (e.g., Garon, Smith, & Bryson, 2014; Wiebe, Sheffield, & Espy, 2012; Willoughby, Wirth, & Blair, 2011). Thus, whether preschoolers use an IC-requiring or IC-avoiding conceptualization is likely to have a dramatic effect on their performance.

While it has been suggested that the way a task is conceptualized is likely to influence its inhibitory demands (e.g., Apperly & Carroll, 2009; Kloo et al., 2010; Russell, 1996; Simpson & Riggs, 2005a), to the best of our knowledge, there is no direct evidence to support this suggestion. Accordingly, in this study we sought the first empirical evidence for this phenomenon. Studying task conceptualization is challenging, because mental representations cannot be observed directly, but must instead be inferred from behavior. It is therefore essential that any tasks used are reliable and well-understood. The present study therefore used Stimulus-Response Compatibility tasks, for two reasons. First, we can be confident that these tasks *have* inhibitory demands. Unlike almost any other developmental measure of inhibitory control, there is clear evidence that Stimulus-Response Compatibility tasks are difficult specifically because of their inhibitory demands (Gerstadt et al., 1994; Simpson & Riggs, 2005b, 2009; Simpson, Riggs, & Ferrand, 2006). The important logical consequence of this, for the experiments reported here, is that if preschoolers perform well on any variant of an Stimulus-Response Compatibility task, then the inhibitory demands of that task must necessarily be low: preschoolers' weak inhibitory control means they could not succeed if inhibitory demands were high. Success on any Stimulus-Response Compatibility task would therefore be consistent with preschoolers having conceptualized it in an IC-avoiding way.

Second, we can be confident about *why* Stimulus-Response Compatibility tasks have inhibitory demands. The precise mechanism that creates inhibitory demands in these tasks has been extensively studied (Diamond, Kirkham, & Amso, 2002; Hanauer & Brooks, 2005; Montgomery, Anderson, & Uhl, 2008; Montgomery & Koeltzow, 2010; Simpson & Riggs, 2005a, 2007, 2011; Simpson et al., 2012). When participants are told to make two specific responses in these tasks, these two responses become primed (that is, activated to near-threshold levels, such that they can be readily produced). Stimulus-Response Compatibility tasks' "if-A-then-b/if-B-then-a" rule structure means that the incorrect primed response is triggered on each trial. This incorrect response must then be inhibited, so that the goal-appropriate response can be made instead. It is this specific aspect of these tasks that creates their inhibitory demands.

To illustrate this with an example: in the Grass/Snow task, children must point to one of two picture cards in response to verbal cues. In one version of this task (Simpson & Riggs, 2009), participants are shown a picture of a sun and a picture of a moon. They are told that when the experimenter says "moon", they should *point to the sun card*, and when the experimenter says "sun", they should *point to the moon card*. The two responses – *point to sun* and *point to moon* – become primed. The if-A-then-b/if-B-then-a rules mean that when the "sun" cue is presented, the *point to sun* response is inappropriately triggered; and that when the "moon" cue is presented, the *point to moon* response is inappropriately triggered. These inappropriate responses must be inhibited, so that the task rules can be followed correctly. Thus, the inhibitory demands of the Grass/Snow task (and other Stimulus-Response Compatibility tasks) follow on directly from the need to apply these if-A-then-b/if-B-then-a rules.

The developmental literature suggests simply that preschoolers find Stimulus-Response Compatibility tasks difficult because they have weak inhibitory control. However, because of task conceptualization this might not be the whole story. The main hypothesis of the current study is that these tasks *can* be passed by preschoolers, *if* they are able to conceptualize the tasks in an IC-avoiding way. This would be achieved with any conceptualization that allowed children to make task-appropriate responses without having to use if-A-then-b/if-B-then-a rules.

2. Experiment 1

Experiment 1 investigated whether preschoolers can pass otherwise challenging Stimulus-Response Compatibility tasks by conceptualizing them in an IC-avoiding way. To do this, we identified two different ways of presenting the task instructions: one which emphasized the if-A-then-b/if-B-then-a nature of the task rules, and the other which emphasized an alternative way of approaching the task. Importantly, while these ways of instructing the task differed, the task stimuli and responses were otherwise identical.

Stimulus-Response Compatibility tasks are typically introduced using two rules (e.g., "When I say 'moon', point to the sun card", and "When I say 'sun', point to the moon card"). It may be that this two-rule presentation encourages preschoolers to conceptualize the task in a way that uses if-A-then-b/if-B-then-a rules (i.e., to conceptualize the task in an IC-requiring way). In contrast, if the same task were presented with a single rule, such as "Point to the other card", this might encourage children to adopt a different conceptualization. If this conceptualization did not entail using if-A-then-b/if-B-then-a rules, then it would not require inhibitory control. Children would still need to make the same responses (pointing to "sun" when they hear "moon", and pointing to "moon" when they hear "sun"), but they would be doing so in a way that did not rely on their weak inhibitory control, and so they should perform better.

Two points need to be clarified. First, as previously noted, evidence suggests that it is *specifically* the application of if-A-then-b/if-B-then-a rules that makes Stimulus-Response Compatibility tasks inhibitory (Diamond et al., 2002; Hanauer & Brooks, 2005; Montgomery & Koeltzow, 2010; Montgomery et al., 2008; Simpson & Riggs, 2005a, 2007, 2011; Simpson et al., 2012). Conceptualizing them in *any* other way will therefore remove their inhibitory demands. Thus, we don't need to know the precise nature of an alternative conceptualization to know that it will be IC-avoiding: simply knowing that it does not use if-A-then-b/if-B-then-a rules is sufficient. Second, conceptualizing a Stimulus-Response Compatibility task with a single rule rather than with two rules will probably reduce its working memory demands, although not sufficiently to make the task significantly easier. Diamond et al. (2002) tested this possibility using the Day/night task, and found this Stimulus-Response Compatibility task to be no easier when introduced with a single rule.

Experiment 1 used two Stimulus-Response Compatibility tasks, each of which was presented in two ways (a one-rule presentation and a two-rule presentation). We used a version of the Grass/Snow task, referred to here as the "Verbal-cue task", and a new Stimulus-Response Compatibility task which we called the "Box task". These tasks were chosen to provide baselines for both poor performance and good performance: performance on the Verbal-cue task is known to be poor when presented with two rules (Simpson & Riggs, 2009), and performance on the Box task is known to be good when presented with a single rule (Carroll, Apperly, & Riggs, 2007a,b; Simpson, Riggs, & Simon, 2004).

Experiment 1 compared preschoolers' performance on two versions of the Box task and two versions of the Verbal-cue task (see Table 1). In the 2-Rule versions of these tasks, the instructions encouraged children to use an IC-requiring if-A-then-b/if-B-then-a conceptualization. In contrast, the 1-Rule versions encouraged an IC-avoiding conceptualization, which did not use if-A-then-b/if-B-then-a rules. The most parsimonious prediction was that the 1-Rule versions of the tasks would be conceptualized in an IC-avoiding way (so performance would be good), and the 2-Rule versions would be conceptualized in an IC-requiring way (so performance would be poor).

In the Box task, participants were presented with two boxes – one