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Developing control over the execution of scripts: The role of maintained hierarchical goal representations



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ABSTRACT

The execution of a script often requires detecting and resolving conflict with a goal, particularly in nonroutine situations. To take the example of taking a bus daily to work, if someone's usual bus is delayed and a bus for another destination comes first, the person must inhibit taking it and wait for the usual one. Young children can gradually acquire the ability to control the execution of scripts in such nonroutine situations, but few studies have explored the control process involved. In two experiments, we investigated the role of developments in the maintenance of hierarchical goal representations and in executive functions. We measured the ability to control the execution of scripts using a task in which children helped a doll select items to wear; clothing options were presented in an unexpected order in the nonroutine situations. The younger children (4-year-olds) could not flexibly control their execution of scripts in nonroutine situations, although they could exogenously detect and resolve conflict if they were prompted to maintain a subgoal. The older children (5-year-olds) endogenously controlled script execution based on a main goal, whereas subgoal maintenance led them to rigidly control their performance. In addition, children's inhibition abilities were associated with their

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control of script execution. These findings indicate that the development of the control process underlying the execution of scripts in nonroutine situations is partially dependent on the ability to maintain hierarchical goal representations.

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Introduction

In daily life, we are familiar with many scenarios in which we conduct action sequences to achieve short- and long-term goals. For example, individuals who go out to eat in a restaurant proceed through a stereotyped action sequence of events; they enter the restaurant, order food, eat, pay, and then leave. Similarly, in everyday life, we all acquire *scripts*, that is, event knowledge made up of action sequences (Nelson, 1986; Schank & Abelson, 1977). According to Schank and Abelson (1977), scripts are goal-directed and organized in a temporal-causal order. Moreover, scripts contain hierarchical structures in which both main goals and subgoals are represented. Previous developmental studies (e.g., Fivush, 1984; Nelson, 1986) have demonstrated that 3- to 4-year-olds are capable of reporting well-organized scripts that play a fundamental role in their cognitive activities such as imitation (e.g., Bekkering, Wohlschläger, & Gattis, 2000), pretend play (Furman & Walden, 1990), and text processing (Hudson & Slackman, 1990). In addition, it is notable that scripts guide goal-directed behavior over a relatively long period of time; even 3- to 4-year-olds may plan and enact natural action sequences based on their own scripts (Freier, Cooper, & Mareschal, 2015; Hudson & Fivush, 1991; Hudson, Shapiro, & Sosa, 1995; Loucks & Meltzoff, 2013; Shapiro & Hudson, 2004; Yanaoka, 2014).

However, the performance of natural action sequences, which is referred to as “script execution” in this article, is frequently disrupted by unpredicted events or distractions unrelated to the goal. Little is known about preschoolers’ abilities to control script execution endogenously in such nonroutine situations. Yet, some recent studies have tackled this issue. For example, when observing a misleading demonstration of familiar action sequences that included irrelevant actions, 5-year-olds avoided overimitating the irrelevant actions, but 3-year-olds tended not to (Freier et al., 2015). In addition, 5-year-olds can modify familiar scripts when necessary. Yanaoka (2014) developed a “doll task” that measures the ability to execute a script for changing clothes. When presented with a doll wearing clothing items incorrectly, 5-year-olds could remove them until the familiar script can be followed. Thus, young children not only acquire event knowledge but also can gradually acquire the ability to control script execution; however, the control processes underlying script executions in such nonroutine situations have yet to be fully understood.

To date, several previous studies have demonstrated many models of controlling script execution in nonroutine situations (e.g., Cooper, Ruh, & Mareschal, 2014; Cooper & Shallice, 2006; Trafton, Altmann, & Ratwani, 2011; Wood & Neal, 2007). In these models, the goal concept is central to the control of script execution. For example, Cooper et al. (2014) recently developed a “goal circuit model” that is based on the dual systems framework (Norman & Shallice, 1986). In the model, the activation of goal units supports the function of the supervisory system,¹ which helps us to add top-down control for cases in which action is not fully routinized. Consistent with this theory, most of studies regarding executive functions have focused on goal maintenance and demonstrated its role in top-down control (e.g., Miyake & Friedman, 2012; Munakata et al., 2011). Moreover, it is important to note that scripts consist of both main goals and subgoals set up hierarchically. Indeed, script execution is controlled at the multiple goal level (Cooper et al., 2014). Based on this theoretical framework (e.g., Cooper et al., 2014), it has been hypothesized that in controlling script execution in nonroutine situations young children maintain their hierarchical goal representations, detect the conflict with their goals, and resolve it. Thus, the

¹ The supervisory system is like an executive system in that its function consists of several elements such as goal generation, error monitoring, and strategy generation (e.g., Shallice & Cooper, 2011).

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