

Research Report

When Actions Speak Louder Than Words

Improving Children's Flexibility in a Card-Sorting Task

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ABSTRACT—*People often perseverate, or repeat habitual behaviors when they are no longer appropriate. For example, after sorting cards by one rule, children will reliably perseverate with this rule even when they are clearly and repeatedly instructed to switch to a new rule. Such perseveration may result from limitations in working memory abilities for holding instructions actively in mind. If so, children may switch more readily to a new rule following experiences that are less demanding on working memory, such as guided practice with the new rule. In a study testing this prediction, 3-year-old children received direct instructions to switch to a new rule, guided practice with the new rule, or both. Providing children with guided practice was much more effective than telling them what to do. These findings support theories of perseveration based on competing memory systems, challenge alternative theories, and suggest effective methods for countering prepotent behaviors.*

People perseverate in many ways. Infants will repeatedly search for an object in a previous hiding location, even after seeing it hidden in a new location (Marcovitch & Zelazo, 1999; Piaget, 1954). Children will perseverate in sorting cards according to an old rule (e.g., according to their shape), even when they are told repeatedly that the rule has changed (e.g., the cards should be sorted according to color; Zelazo, Frye, & Rapus, 1996). Adults with prefrontal damage show similar behaviors (Milner, 1963; Stuss & Benson, 1984). And all adults engage in more subtle forms of perseveration, such as searching for keys in a location they have already checked, or driving a familiar route instead of stopping for an intended errand.

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Although these examples may be mundane, the universality and robustness of perseverative behaviors highlight fundamental aspects of human cognitive abilities, limitations, and development. Understanding why people perseverate and how to overcome such tendencies may also help to inform education, training, and remediation. The current study tested the effectiveness of a somewhat counterintuitive method for reducing perseveration; this method was motivated by a theory of perseveration based on competing memory systems.

Memory relies on multiple specialized systems (e.g., Gabrieli, 1998; Schacter & Tulving, 1994), which can interact in supportive (McClelland, McNaughton, & O'Reilly, 1995; Pasupathy & Miller, 2005) or competitive (Poldrack & Packard, 2003) ways. According to competing-memory-systems accounts of perseveration (Cohen, Dunbar, & McClelland, 1990; Diamond, 1985; Morton & Munakata, 2002), perseveration—and ultimate success in switching flexibly to new tasks—reflects a competition between two distinct memory systems. One system builds up memories in posterior cortical and subcortical regions as a behavior (e.g., sorting cards by shape) is repeated, leading to a bias to repeat that behavior. This system has been referred to as a “latent” memory system, because memories take the form of changes in connections rather than sustained activity; connection changes are inaccessible to other brain regions and are evidenced only as biases during subsequent information processing (Munakata, 1998). A separate working memory system actively maintains information (e.g., a new rule for sorting cards by their color), providing top-down support for task-relevant information. When currently relevant information conflicts with previously relevant information, the working memory and latent memory systems may compete. Perseveration occurs when latent memories win this competition, whereas flexible switching occurs when working memories win. Working memory relies heavily on prefrontal cortical regions (Miller & Cohen, 2001), which may explain why perseveration is particularly evident in patients with prefrontal damage and, given the

protracted development of prefrontal regions (Casey, Giedd, & Thomas, 2000; Chugani, Phelps, & Mazziotta, 1987), in children.

This competing-memory-systems perspective suggests that the most effective methods for reducing perseveration may not be the most obvious or direct. For example, in the card-sorting task described earlier, children hear the new rule ("in the color game, red ones go here, and blue ones go here") with each card they are asked to sort. Direct instruction would seem an obvious means of eliciting appropriate behaviors. However, from the competing-memory-systems perspective, direct instruction may be relatively ineffective in this situation because it requires children with underdeveloped working memory systems to actively hold instructions in mind. It may be more effective to guide children toward the target behavior in a way that builds up latent memories for this behavior. For example, if the target behavior is to sort cards by color, children could be guided toward this behavior by sorting cards that display only color information (e.g., a completely blue card), without any conflicting shape information. Shape information could gradually be brought back into the cards, so that children are scaffolded toward the target behavior in the face of conflicting information (see also Vygotsky, 1978). Sorting such cards by color would build latent memories, making children more likely to subsequently sort the original cards by color.

The current study tested these predictions by assessing the effectiveness of telling children a new card-sorting rule, providing them with guided practice with the new rule, or combining instruction and guided practice. According to the competing-memory-systems account, children should be more likely to switch to a new rule through scaffolding (without ever being told what to do) than through direct instruction.

METHOD

Participants

Forty-eight 39-month-olds ($M = 38$ months 30 days; range = 38 months 22 days to 39 months 8 days) participated in the experiment, with 16 children (8 males and 8 females) in each condition. Participants were recruited through the participant pool of the Department of Psychology at the University of Colorado, Boulder. Parents received a small gift for their child's participation and \$5 to cover travel costs. Thirteen additional participants were excluded from the analyses, because an error occurred during the experimental procedure ($n = 6$), they failed the preswitch phase ($n = 2$), their parent interfered with the procedure ($n = 2$), they had disabilities reported by the parent ($n = 2$), or they picked up and looked at previously sorted cards¹ ($n = 1$).

¹Previously sorted cards are typically set facedown into the trays. If the cards are set faceup so that they remain visible, children show less flexibility in switching to a new rule (Kirkham, Cruess, & Diamond, 2003).

Design and Procedure

Children sorted cards into trays according to one rule in a pre-switch phase. Their ability to sort cards according to a new rule was assessed in a postswitch phase, following direct instruction with the new rule (instruction condition), guided practice with the new rule (scaffolding condition), or direct instruction and guided practice (scaffolding-plus-instruction condition). Children in the instruction condition sorted unrelated cards between the preswitch and postswitch phases, so that the card-sorting process between these phases would be equated across the three conditions. The ordering of the rules and the target-card locations were counterbalanced across participants; one specific condition is described here for simplicity (Fig. 1).

The procedure was adapted from Experiment 1 in Zelazo et al. (1996) and from Munakata and Yerys (2001). Each child sat across a table from the experimenter. On the table were two trays, each with a target card fastened above it (e.g., a red flower on one tray and a blue truck on the other). In the preswitch phase, the experimenter provided a rule to sort by one dimension (e.g., "in the shape game, the trucks go here, and the flowers go there") before sorting two cards (e.g., a blue flower and a red truck) into the appropriate trays facedown. On each of the following two trials,² the experimenter reminded the child of the rule, labeled a card by the relevant dimension (e.g., "here's a truck"), and asked, "Where does this go in the shape game?" The experimenter provided feedback on the child's sorting and corrected the sort if it was incorrect.

In the intermediate phase, children were presented with new cards to sort. In the scaffolding and scaffolding-plus-instruction conditions, the children were first presented with *one-dimensional* cards. These cards displayed information relevant to the dimension that would be used for sorting in the subsequent postswitch phase (e.g., the color blue), without any conflicting information relevant to the previous rule (e.g., no shape). For these children, the intermediate phase began with two one-dimensional imitation trials, on which the experimenter handed the child a one-dimensional card, used a copy of the same card to demonstrate how to sort it in the new game, and asked the child to sort his or her card. The imitation trials were followed by trials on which the experimenter handed the child a one-dimensional card to sort without guidance. This unguided sorting continued until the child sorted correctly on two consecutive trials or had been given five one-dimensional cards (1 child in the scaffolding condition and 1 child in the scaffolding-plus-instruction condition). Then, the experimenter said, "Let's keep playing this new game." The children were presented with six *morph* cards, which displayed an increasing amount of information relevant to the dimension that had been used for sorting in the preswitch phase (e.g., a shape that looked increasingly like a flower;

²Studies often use five or more preswitch trials, but two demonstration trials and two preswitch trials are sufficient for establishing perseverative tendencies (Zelazo et al., 1996); to simplify the procedure, this is the number we used.

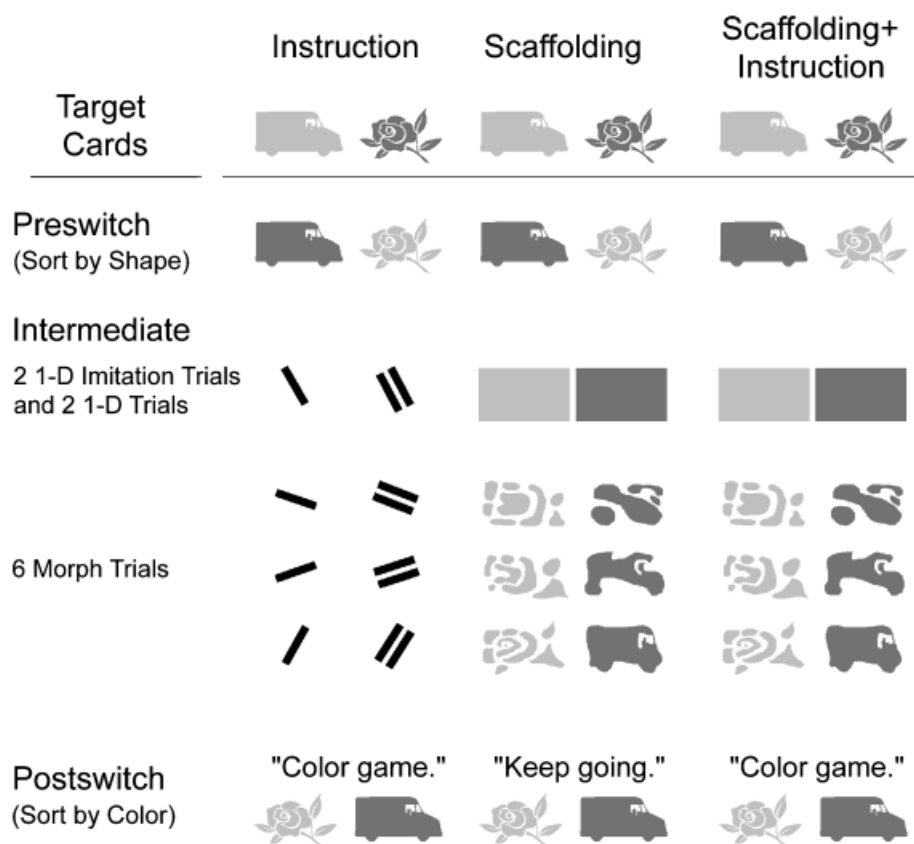


Fig. 1. Sample stimuli and illustration of the procedure in the instruction, scaffolding, and scaffolding-plus-instruction conditions. Each example card is shown below the target card to which it corresponds. In preswitch and postswitch trials, each card to be sorted matched each target card on one dimension. Light gray and dark gray shading correspond to blue and red, respectively. Not shown are target cards with one or two vertical lines, used for the intermediate phase in the instruction condition.

Fig. 1). On each of the six morph trials, the experimenter handed the child a morph card and asked, “Where does this card go?”

Children in the instruction condition completed a similar series of trials in the intermediate phase, except that the cards were unrelated to the main task (Fig. 1). In all conditions, the trials in this phase were administered in the absence of labels or direct instructions about the new game, and with feedback, as in the preswitch phase.

Between the intermediate and postswitch phases in all conditions, the experimenter said, “You’re doing great.” The experimenter continued, “Now we’re going to play the color game” (instruction condition), “Let’s keep going with the color game” (scaffolding-plus-instruction condition), or “Let’s keep going with this game” (scaffolding condition). In the conditions with direct instruction (instruction and scaffolding-plus-instruction), on the following six trials, the experimenter said, “In the color game, the blue ones go here, and the red ones go here.” The experimenter labeled a card by the relevant dimension (e.g., “here’s a red one”) and asked, “Where does it go in the color game?” In the scaffolding condition, on each trial the experi-

menter handed a card to the child and asked, “Where does this card go?” In all conditions, children received no feedback during this phase.

ANALYSES AND RESULTS

All children in the final sample passed the preswitch phase by sorting both cards correctly, as this was a prerequisite for inclusion in the study. Initial descriptive analyses indicated that the data in the other phases of the study were nonnormal. In each part of the intermediate phase, most children sorted all of the cards correctly: Seventy-three percent sorted both of the cards correctly on the one-dimensional imitation trials, 94% sorted the next two cards correctly on the one-dimensional trials, and 71% sorted all of the cards correctly on the morph trials. In the postswitch phase, most children (79%) either sorted all of the cards incorrectly or sorted all of the cards correctly. Because of the nonnormal nature of the data, we used the McNemar chi-square (with the Yates correction for small cell entries) to analyze the data. Children had to sort two cards correctly to pass the imitation part of the intermediate phase, two cards correctly

to pass the subsequent one-dimensional part of the intermediate phase, and at least four out of six cards correctly to pass the morph trials. To pass the postswitch phase, children had to sort at least four out of the six cards correctly, as in previous experiments (e.g., Munakata & Yerys, 2001).³

Children in the three conditions did not differ in their performance in the intermediate phase, all χ^2 's < 0.7. In the postswitch phase, children were much more successful in the scaffolding and scaffolding-plus-instruction conditions than in the instruction condition. Only 4 of 16 children (25%) passed the postswitch phase in the instruction condition, compared with 13 of 16 children (81%) in the scaffolding condition, $\chi^2(1, N = 32) = 8.0, p < .005$, and 15 of 16 children (94%) in the scaffolding-plus-instruction condition, $\chi^2(1, N = 32) = 13.0, p < .0005$. Children were equally successful in the scaffolding and scaffolding-plus-instruction conditions, $\chi^2(1, N = 32) = 0.3, n.s.$

DISCUSSION

Providing children with guided practice using a new rule was much more effective than directly instructing them to use the new rule. This finding may run counter to assumptions about the most effective methods for eliciting specific behaviors, but it is consistent with Vygotsky's (1978) ideas about the importance of scaffolding. Moreover, this finding was predicted by a theory of perseveration based on competing memory systems. Specifically, if a working memory system for holding currently relevant information actively in mind is underdeveloped relative to a latent memory system that builds up memories with repeated experiences, experiences that tap the latent memory system (e.g., guided practice) will be more effective than those that require the working memory system (e.g., direct instruction).

One might try to explain the current results using alternative theories of perseveration, but there is no a priori reason to predict these results from those theories. They could just as easily explain the opposite pattern of results. For example, cognitive complexity and control theory posits that perseveration results from an inability to consciously reflect on tasks and recognize higher-order rules (Zelazo et al., 1996; Zelazo, Mueller, Frye, & Marcovitch, 2003). One might argue that guided practice facilitates recognition of higher-order rules, or removes the need for them. However, this theory lacks mechanisms to explain why guided practice would have this effect but direct instruction would not. Other theories have the same problem explaining the results. Attentional-inertia theory posits that perseveration results from a difficulty inhibiting the pull to attend to previously relevant information that has become irrelevant (Kirkham, Cruess, & Diamond, 2003). Redescription

theory posits that perseveration results from a conceptual difficulty in understanding that objects can be redescribed (e.g., no longer described as a car, but now described as a red thing; Kloo & Perner, 2005). One might argue that guided practice helps to inhibit pulls toward irrelevant information, or increases the understanding that objects can be redescribed as being of a different kind. However, again, these theories cannot explain why guided practice, but not direct instruction, has these effects.

These findings are consistent with the benefits of scaffolding that have been demonstrated in other domains (e.g., Kotovsky & Gentner, 1996; Morton, Trehub, & Zelazo, 2003; Reese, 1963), including task switching in adults (Rogers & Monsell, 1995). Studies like these can shed light on and inform practices in education, training, and remediation. For example, in math learning, repeated experience with certain types of challenging problems encourages advanced strategy use that is not typically taught (Siegler & Jenkins, 1989). For older adults learning new health behaviors, repeatedly visualizing the behaviors is more effective than mentally rehearsing verbal instructions (Liu & Park, 2004). From the competing-memory-systems perspective, these repeated experiences that are closely related to target behaviors build latent memories for those behaviors. Such scaffolding can be effective in many situations, but the benefits may be most apparent when people need to overcome perseverative tendencies and have limited working memory resources. The current study demonstrates that in such situations, the accuracy of performance on even simple tasks, carried out immediately, improves more with scaffolding than with direct and repeated instruction. A promising avenue for future work will be to specify the mechanisms that resolve the conflict between competing memory systems and that translate this resolution into action, a process that likely taps frontostriatal circuitry (Casey, Durston, & Fossella, 2001; Frank, 2005).

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³Other studies have used a stricter criterion of sorting at least five out of the six cards correctly (Kirkham, Cruess, & Diamond, 2003). The pattern of results in the current study was similar regardless of which criterion was used; the classification of only 3 of the 48 children changed with the stricter criterion.

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