Research Report

ALL TOGETHER NOW: When Dissociations Between Knowledge and Action Disappear

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Abstract—*Why do people sometimes seem to know things but fail to act appropriately on the basis of this knowledge? Such dissociations between knowledge and action often occur in infants and children, and in adults following brain damage. These dissociations have supported inferences about the organization of cognitive processes (e.g., separable knowledge and action systems) and their development (e.g., knowledge systems develop before action systems). The current study tested the basis for knowledge-action dissociations in a card-sorting task in which children typically correctly answer questions about sorting rules while sorting cards incorrectly. When questions and sorting measures were more closely equated for the amount of conflict that needed to be resolved for a correct response, children showed no systematic dissociation between knowledge and action. The results challenge standard interpretations of knowledge-action dissociations and support an alternative account based on graded knowledge representations.*

People can appear to know things but fail to act appropriately on the basis of this knowledge. For example, adults with prefrontal damage and children can verbally report new rules they have learned for sorting cards (e.g., sort according to the color of the objects on the cards), but incorrectly sort the cards according to previously learned rules (e.g., sort according to the shape of the objects on the cards; Milner, 1963; Zelazo, Frye, & Rapus, 1996). Similarly, infants can look to a new location where they have watched a toy being hidden, but incorrectly reach back to an old location where the toy was previously hidden (Diamond, 1985; Hofstadter & Reznick, 1996; Piaget, 1954). Such compelling dissociations have suggested that knowledge and action are neurally and psychologically separated, so that action systems may be impaired or underdeveloped while knowledge systems are fully functioning (Diamond, 1991; Goodale & Milner, 1992; Hofstadter & Reznick, 1996).

However, in some cases the dissociations between knowledge and action may result in part from artifactual differences in how knowledge and action are measured, rather than from inherent differences between knowledge and action systems. In the card-sorting example (Zelazo et al., 1996), the action measure may be more difficult than the knowledge measure because it involves conflicting cues whereas the knowledge measure does not. Specifically, children first learn to sort cards according to one rule (e.g., by color, with blue objects in a tray on the left and red objects in a tray on the right). Then they are asked to sort according to a new rule (e.g., by shape, with trucks in the left tray and flowers in the right tray). The two rules always conflict, so that the cards (e.g., red trucks, blue flowers) get sorted differently according to the first rule (red trucks in the right tray, blue flowers in the left tray) versus the second rule (red trucks in the left tray, blue flowers in the right tray). Thus, the action measure has inherent conflict; children must sort a card with conflicting cues of color and shape. In contrast, traditional knowledge measures have no corresponding conflict; children have simply been asked, for example, "Where do trucks go in the shape game?" There is no conflicting cue of color to process in this case. Children's simultaneous success on knowledge measures and failure in sorting cards might thus reflect their general difficulty with resolving conflicting cues, rather than reflecting a fully functioning knowledge system with an underdeveloped action system.

The current study tested the role of conflict in dissociations between knowledge and action in the card-sorting task. We presented children with the standard version of the task, with its nonconflict questions, and also asked conflict questions (e.g., "Where do the red trucks go in the shape game?"). Poor sorting but correct answers to the conflict questions would provide evidence for a dissociation between knowledge and action. In contrast, poor sorting and incorrect answers to the conflict questions (and correct answers to the standard nonconflict questions) would suggest a more general difficulty with resolving conflict, and that the apparent dissociation between knowledge and action in the standard version of the card-sorting task is an artifact of differences in conflict between the measures for knowledge and action.

METHOD

Participants

Sixteen 3-year-olds participated in the experiment. There were 6 males and 10 females in the group. Participants were recruited through the University of Denver Developmental Participant Pool. Parents received a junior scientist degree (a certificate resembling a diploma) or small gift for their child's participation and $5 to cover travel costs. Three additional participants were excluded from the analyses (1 because of fussiness, 1 because of experimental error, and 1 because of color blindness reported by the parent).

Design and Procedure

The children were asked to sort cards into trays according to one rule in a preswitch phase and according to a different rule in a postswitch phase. They were then asked standard and conflict questions about the postswitch rule. The ordering of the rules, the target cards, and the ordering of blocks of standard and conflict questions were counterbalanced across participants; one specific condition is described here for simplicity.

The procedure was adapted from Experiment 1 in Zelazo et al. (1996). Each child sat across a table from the experimenter. Two trays were on the table, each with a target card fastened above it (e.g., a red flower above one tray, a blue truck above the other). The cards to be sorted (red truck, blue flower) matched each target card on one dimension. In the preswitch phase, the experimenter provided the rules to sort by one dimension (e.g., "In the color game, all the red ones go

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Table 1. *Numbers of children (*N *= 16) passing and failing postswitch sorting and the standard questions*

	Postswitch sorting	
	Pass	Fail
Standard questions		
Pass	6	**7**
Fail	**0**	3

Note. Critical cells for comparison are in boldface. This comparison showed a significant effect, $p < .05$.

Table 2. *Numbers of children (*N *= 16) passing and failing postswitch sorting and the conflict questions*

	Postswitch sorting	
	Pass	Fail
Conflict questions		
Pass	3	**4**
Fail	**3**	6

Note. Critical cells for comparison are in boldface.

here, but only the blue ones go there") and proceeded to sort one card (a blue flower or red truck) into each tray face down. On the following six trials, the experimenter reminded the child of the rules, labeled a card by the relevant dimension (e.g., "Here's a red one") and asked, "Where does this go in the color game?" The experimenter provided feedback on whether the child had sorted the card correctly, and corrected the sort if it was incorrect. In the postswitch phase, the experimenter said, "Okay, now we're going to switch and play a new game, the shape game. We're not going to play the color game any more. No way. We're going to play the shape game, and the shape game is different." Then, the experimenter provided the rules to sort by the other dimension (e.g., "In the shape game, all the flowers go here, but only the trucks go there"). On the following six trials, the experimenter reminded the child of the postswitch rules, labeled a card by the relevant dimension (e.g., "Here's a flower") and asked, "Where does this go in the shape game?" In this phase, the children did not receive feedback on whether they sorted cards correctly.

The children then were asked eight questions about the postswitch rule. These questions included a block of four standard questions and a block of four conflict questions.[1] The questions in the standard block alternated between the two possibilities regarding the postswitch rule (e.g., "Where do the trucks go in the shape game?" and "Where do the flowers go in the shape game?"), so that each question was asked twice. Similarly, the questions in the conflict block alternated between the two possibilities regarding the postswitch rule (e.g., "Where do the red trucks go in the shape game?" and "Where do the blue flowers go in the shape game?"), so that each question was asked twice.

ANALYSES AND RESULTS

Initial descriptive analyses indicated that the data were nonnormal. In the preswitch phase, most children (87.5%) sorted all of the cards correctly. In the postswitch phase, most children (68.75%) either sorted all of the cards incorrectly or sorted all of the cards correctly. Similarly, in the question phase, for all of the questions of a given type (conflict or standard), most children (75%) either answered every question correctly or every question incorrectly. 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 were classified as passing the sorting task if they sorted at least four out of the six cards correctly, and as passing the question task if they answered at least three out of the four questions correctly. Tables 1 through 3 show the number of children in each classification for the three comparisons of interest.

The results replicated previous findings (Zelazo et al., 1996; Zelazo & Reznick, 1991; Zelazo, Reznick, & Pinon, 1995) in that many children appeared to know the sorting rules (as assessed by the standard questions) but not to use them. Specifically, 7 children passed the standard questions but failed postswitch sorting, whereas no children showed the reverse pattern of failing the standard questions while passing postswitch sorting, $\chi^2(1, N = 16) = 5.1$, $p < .05$. In contrast, when knowledge was assessed by conflict questions more analogous to the sorting task, the children showed no evidence of a systematic dissociation between knowledge and action, $\chi^2(1, N = 16) = 0$, n.s. Specifically, the number of children who passed the conflict questions but failed postswitch sorting (4) was similar to the number who showed the reverse pattern of failing the conflict questions while passing postswitch sorting (3). The remaining children showed similar behavior on the conflict questions and postswitch sorting, either passing both tasks (3) or failing both tasks (6). Finally, in a direct comparison between the standard and conflict questions, the children performed better on the standard questions, with 6 children passing the standard questions but failing the conflict questions, and no children showing the opposite pattern, $\chi^2(1, N = 16) = 4.2$, $p < .05$.

DISCUSSION

Apparent dissociations between knowledge and action may be based in part on disparities in how knowledge and action are measured. In the case of children's card-sorting performance, knowledge

Table 3. *Numbers of children (*N *= 16) passing and failing the standard and conflict questions*

	Standard questions	
	Pass	Fail
Conflict questions		
Pass	7	**0**
Fail	**6**	3

Note. Critical cells for comparison are in boldface. This comparison showed a significant effect, $p < .05$.

1. The children also sorted cards between every set of two questions, but this behavior paralleled their performance during the postswitch phase and so is not discussed further.

questions in previous studies had no conflicting information (e.g., "Where do trucks go in the shape game?"), whereas action measures involved two conflicting cues (e.g., the card to be sorted was both a truck and red). When the knowledge and action measures were equated on the conflict dimension in the present study (with conflict questions such as "Where do red trucks go in the shape game?"), children showed significantly worse performance on such conflict questions than on the standard questions, and showed no systematic difference in their sorting behavior and their answers to the conflict questions. These findings demonstrate that observed dissociations between knowledge and action can be more apparent than real.

The current findings thus challenge the idea that dissociations in children's card sorting reflect separable knowledge and action systems, with development in the knowledge system preceding development in the action system. The findings are instead more consistent with theoretical frameworks that emphasize the embedded, interactive nature of cognitive processing, such as neural networks (Elman et al., 1996; McClelland, Rumelhart, & PDP Research Group, 1986; O'Reilly & Munakata, 2000) and dynamic systems (Smith & Thelen, 1993; Thelen & Smith, 1994). Within these frameworks, knowledge is viewed as emerging from, and embedded within, the interactions of multiple endogenous and environmental components (including the details of motor systems, as emphasized by dynamic systems accounts). As a result, knowledge can be graded in nature, with underlying representations varying in strength with the degree of support from multiple interacting components. From this perspective, dissociations between knowledge and action may reflect relatively weak representations that suffice for some tasks but not others. For example, a weak representation of a new card-sorting rule might support the ability to answer nonconflict questions about the rule, whereas stronger representations of the rule might be required to sort cards when faced with the conflicting features present in them, and to answer conflict questions about the rule.

Similar theories based on graded representations have been put forth to account for dissociations observed across a variety of domains, including infants' memory for hidden objects (Munakata, 1998; Munakata, McClelland, Johnson, & Siegler, 1997), children's strategy use (Siegler, 1996), prosopagnosics' recognition of faces (Farah, O'Reilly, & Vecera, 1993), and neurologically intact and frontally impaired adults' abilities to inhibit prepotent responses (Cohen, Dunbar, & McClelland, 1990; Cohen & Servan-Schreiber, 1992). In all of these cases, no single measure is viewed as revealing full knowledge, and measures that reveal limitations are not explained away in terms of deficits solely in other systems. Instead, a range of behaviors is viewed as revealing some degree of knowledge, with the strengths of underlying representations contributing to dissociations observed across measures. The current study addresses one such dissociation in the context of children's card sorting. The results suggest that stronger representations are required in the face of conflicting cues and challenge the claim that knowledge-action dissociations in this task result from knowing rules but failing to use them.

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