Children’s Attention to Rules in Sorting Cards: Distinguishing Between Theories of Cognitive Development

The Dimensional Change Card Sort (DCCS) task (Zelazo, Frye, & Rapus, 1996) is a common method for studying children’s redirection of attention. Children are asked to sort cards, once based on the dimension of shape and once on color. Four-year-olds typically perform well on both aspects of the task, but 3-year-olds fail the second aspect. We observed 96 children and modified the DCCS task to examine the effect of novel stimulus cards on 3-year-olds’ performance and test the validity of the Cognitive Complexity and Control (Zelazo et al., 1996) and the Attentional Inertia (AI; Diamond, Kirkham, & Amso, 2002) theories. Results of the modified task showed that 3-year-olds performed as well as 4-year-olds, consistent with the AI theory.

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difficulty in completing rule-related tasks because inhibiting one rule was as hard as inhibiting two rules.

Children were able to respond successfully when the day/night task was modified so that children were asked to assign labels to the moon and sun cards that were not related to the pictures, such as “pig” and “dog.” The researchers concluded that the label given to the stimulus was more important than the individual card itself. Children’s inability to inhibit their initial response to the cards (for example, responding “day” when presented with a picture of a sun) demonstrated that their difficulty resulted from tasks that asked children to pair a stimulus with a contrary label. Tasks that used labels that were not independent of the pictures on the cards allowed the children to inhibit their typical response more easily and thus perform better on the task.

In light of these data, Kirkham and Diamond (2003) developed the Attentional Inertia (AI) theory, proposing that younger children perseverate on the first rule and then cannot attend to a second rule. Children fail the DCCS task because they have trouble (re)focusing their attention to the newly relevant dimension (Kirkham & Diamond, 2003). Three-year-olds, once accustomed to thinking about a stimulus by one dimension, are unable to refocus their attention on another dimension. Munakata et al. (2003) point out that 3-year-olds are able to answer correctly a verbal query about a second dimension, yet are unable to sort by a new rule. It is not certain whether children encode or remember a change in rules, even if they are able to verbalize the rules. Inhibiting the first dimension and focusing on the second dimension requires a greater neural network capacity than that required by the application of a rule with a single dimension (Kirkham & Diamond, 2003; Munakata et al., 2003).

Manipulation of tasks requiring children to inhibit previous knowledge, rules, and perspectives can reduce the need for inhibitory demand. Thus, tasks not requiring children to inhibit natural responses (such as labeling pictures of the sun as “day”) are easier for young children. Success on the DCCS task occurs around age four, which is developmentally around the same age as success on appearance-reality tasks, false belief tasks, tests of spatial perspective, tests of ambiguous figures, conflict tasks, and liquid conservation tasks (Diamond, Carlson, & Beck, 2005).

Zelazo et al. (2003) performed a similar study in which novel stimuli were used in the post-switch task, labeling this variation in the DCCS task the Total Change version. Three- and 4-year-old children were required to sort five cards with red and blue rabbits and boats in the first task, and five cards with yellow and green flowers and cars in the post-switch task. The group performing the Total Change version made more correct responses than the group performing the standard version. Results from both studies show that the new stimuli helped 3-year-old children perform better on the second task. Zelazo et al. (2003) suggest that because children performed well when there were changes in the stimulus dimensions such that different colors and shapes were used in the pre- and post-switch tasks, the majority of 3- to 4-year-olds do not perseverate on a dimension, supporting the theory of CCC. However, according to Rennie, Bull, and Diamond (2004), the complexity of rules remained the same as that of the standard condition for both tasks, because the previously relevant dimensions were no longer present to divert children’s attention from the relevant values of the post-switch task. Rennie et al. (2004) concluded that Zelazo et al.’s (2003) findings are consistent with AI theory rather than CCC theory.

Diamond et al. (2002) also present results that question CCC theory as an explanation for 3-year-olds’ failure to correctly execute the DCCS task. Previous studies demonstrated that manipulations reducing the need for inhibition help children complete the tasks correctly. They write specifically that studies such as Perner and Lang (2002) demonstrated that children can hold in mind multiple rules for the same set of cards if they inhibit the dimensions of sorting. In addition, the absence of target cards (cards used to label the sorting piles) improves performance, and children are able to apply higher-order rules and successfully complete the task because they do not need to inhibit their tendency to match the sorting cards to the target cards (Perner & Lang, 2002).

Kloo and Perner (2005) proposed that target cards provoke 3-year-old children to use a general rule, for example: “Put each card with the target that has the same thing on it.” The results of their study indicate that cognitive flexibility in the ability to think about one object in different ways is crucial for correctly completing the DCCS task. Kloo and Perner (2005) also point out that if novel stimulus cards are used for the post-switch task, children are able to successfully complete the post-switch task, even though they are still required to use higher-order rules. If the experimenter labels the relevant dimension while handing the child the card to sort, the child will demonstrate marked improvement, yet this change in procedure does not change the need for the child’s understanding of the necessary rule structures (Kirkham et al., 2003). Finally, they point out that when dimensions are separated (not pertaining to the same object), such as boats and cats rather than moons and stars, children are able to correctly sort in the post-switch task even though CCC theory proposes that the separate dimensions would not change performance (Kloo & Perner, 2005; Zelazo et al., 2003).
CC theory and AI theory differ in their explanation of the mechanisms that invoke perseveration in 3-year-olds, but they converge in the assumption that the primary reason for perseveration is that 3-year-olds do not shift attention away from previously relevant stimuli. In support of this contention, Zelazo, Muller, Frye, and Marcovitch (2003) found that children perseverate on a partial change version of the DCCS task. This occurred when the values of the dimensions that were important in the pre-switch phase were retained during the post-switch phase. Red and blue rabbits and boats were sorted by shape in the pre-switch phase, and yellow and green rabbits and boats were sorted by color in the post-switch phase (Muller, Dick, Gela, Overton, & Zelazo, 2006). See Figure 1 for a diagram of the CCC and AI theories.

The goals of the present study were to expand the previous literature concerning the DCCS task and to examine which theory (CCC or AI) best explains the difference in the cognitive function between 3- and 4-year-olds, using a modified DCCS task and the standard DCCS task. We modified the DCCS so that children were asked to sort by the dimensions of color and shape with sets of cards that depicted different shapes in different colors, providing novel stimuli. Although this is a similar procedure to Zelazo et al.’s (2003) Total Change manipulation, we used cards with simple shapes while Zelazo et al. (2003) used cards with complex pictures. In addition, our scoring was more rigid in that we required all 4 responses to be correctly classified for the task to be considered successful; Zelazo et al. (2003) defined a correct trial as being at least 4 correct responses out of 5.

The present study requires children to attend to different dimensions in the pre- and post-switch tasks and a new set of cards with different colors and different shapes is provided for the post-switch task. If 3-year-olds are able to refocus their attention on the second task and complete the post-switch card sorting task correctly in the modified version of the task, the results will support the AI theory. If the new set of cards does not aid children in distinguishing between the old rule and the new rule, however, and 3-year-olds fail as they would in the standard DCCS second task (Kirkham & Diamond, 2003), the results will support the CCC theory. We expect that the novel stimuli in the modified version of the task will allow both 3-year-olds and 4-year-olds to successfully complete the second task.

Method

Participants
Participants were 96 3- and 4-year-old children recruited from three different preschools in Pennsylvania. Fifty-five children were 4 years old and 41 children were 3 years old. Forty-seven of the children were girls, and 49 were boys. There were 34 children in the standard group, (presented with the original DCCS procedure), and 62 children in the modified group (presented with the modified procedure). Preschool teachers distributed letters explaining the study and an informed consent form to the parents of all 3- and 4-year-olds. Children whose parents returned their consent forms were included in the study. We did not include three children’s data in our results because they incorrectly answered pre-screening questions. We randomly selected children from one of the three preschools for the standard condition.

Materials
The materials consisted of 8 white cards, each with one of the following stimuli on it: (a) green triangle, (b) green square, (c) red triangle, (d) red square, (e) orange star, (f) orange circle, (g) blue star, or (h) blue circle. We used extra red triangle and green square cards as example cards in the shape game to indicate the box in which the cards should be placed, and extra blue star and orange circle cards as the examples in the color game.

Procedure
In both the standard and modified conditions, children were tested individually in a quiet room apart from their peers. Participants were brought into the room by the classroom teacher and seated on the floor next to the experimenters. Each test took approximately 5 min. Each child sat in front of two small boxes with an example card attached to each, so that they faced the
Children. Two experimenters were present: one to record the correct or incorrect sorting responses and one to explain the rules of each game and to hand the children the cards. After the child was comfortably situated, the experimenter introduced the card task by saying

What we will be doing today is sorting these cards into two piles. The first game we will play is the shape (color) game. In the shape (color) game we will sort the cards by their shape (color). All of the squares (blue) go in this pile (point to the square/blue card). All of the triangles (orange) will go in this pile (point to the triangle/orange card). Now, can you show me where the squares (blue) go… and where the triangles (orange) go?

We used the final questions of the introduction as a pretest to ensure that the child understood the rules. After children completed this pretest the experimenter handed them four cards, randomly-ordered, one at a time, and asked the children to place each one into the correct pile. We used the orange and blue cards as a set when we asked children to sort by color and the red and green cards as a set when we asked children to sort by shape. The experimenter did not give the children any feedback regarding their performance. In our modified version of the DCCS task, the set of four cards was switched after the first task and replaced with a novel set of four cards with different shapes and colors, and the children were asked to sort the cards using a new dimension. The example cards were also switched to correspond to the second set of cards. In the standard version of the DCCS task, the same four-card set and labels were used in both the pre- and post-switch tasks. Each child’s performance on the second task was calculated by adding the number of cards sorted correctly. The highest possible score on each task was a 4, signifying that the child had correctly categorized all four cards.

**Results**

A 2 (Age) x 2 (Group) analysis of variance showed a main effect of age for number of cards correctly sorted, $F(1, 93) = 5.24, p = .02$, such that 4-year-olds, $M = 3.24$, $SD = .96$, gave more correct responses than 3-year-olds, $M = 2.83$, $SD = .95$. The age x group interaction was marginally significant, $F(1, 93) = 2.85, p = .05$. Figure 2 shows the mean number of correct responses on the post-switch task organized by age and group. Three-year-olds in the standard group performed markedly lower than the 4-year-olds in the standard group, and there was little difference between the performance of 3-year-olds and 4-year-olds in the modified group.

Because we were differentiation between two similar theories, we used a Tukey HSD ($p = .05$) test, a widely-used post hoc test (Aron, Aron, & Coups, 2006), to examine the means for the post-switch task as the Age x Group interaction (see Figure 2) were nearly significant. Post hoc comparisons using the Tukey HSD test indicated that the mean score for the control condition of the 3-year-olds ($M = 2.56$, $SD = 0.89$) was significantly different than that of the 4-year-olds in the control condition ($M = 3.44$, $SD = 0.92$). However, the 3-year-olds in the modified condition ($M = 3.00$, $SD = 0.96$) did not significantly differ from the 4-year-olds in the modified condition ($M = 3.14$, $SD = 0.98$). Thus, it appears that the significant main effect for age was primarily attributable to the difference between the 3- and 4-year-olds in the standard condition.

**Discussion**

Although the interaction between age and group was only marginally significant, the Tukey HSD test indicated a significant difference on the post-switch task between the 3- and 4-year-old age groups in the standard group, but no significant difference in the performance of the 3- and 4-year-old age groups in the modified group. These findings signify that the differences on the modified task, the novel stimuli, allowed the 3-year-olds to perform comparably to the 4-year-olds.

According to the theory of Attentional Inertia, children perseverate on a particular dimension of information and are unable to effectively switch to new rules. After using a set of rules focused on a single dimension of the cards, 3-year-olds are generally unable to inhibit
the rules regarding the original dimension in order to sort by a new dimension. Our results are consistent with AI theory. CCC theory predicts that changing the cards would not affect 3-year-olds’ performance, because the task still requires the use of multiple rules. CCC theory holds that 3-year-olds are unable to complete tasks using multiple rules. In the modified condition, the 3-year-olds were able to sort comparably to the 4-year olds, according to the new rule pertaining to a new dimension. Thus, changing the colors and shapes of the cards reduced the 3-year-olds’ tendency to perseverate. Our results were similar to those of others (Rennie et al., 2004; Zelazo et al., 2003), because the children in the modified condition made more correct responses than the children in the standard condition.

Zelazo et al. (2003) also found that 3- and 4-year-olds performed better in the modified DCCS procedure. They discussed the issue of children’s’ perseveration of attention to previous rules in the DCCS and subsequent success on the Total Change task (similar to our modified procedure) as being consistent with AI theory. They concluded, however, that CCC theory best explains the phenomenon as it more specifically addresses which children are likely to fail the DCCS task. The authors of this study point out that participants in our modified condition had no need to create a higher order rule or system (as indicated by CCC theory); the second aspect of the modified DCCS task was introduced as “a new game” with no suggestion that the rules of the first aspect would be used again. Without a necessity for higher order rules, the children’s perseveration on the first set of rules is still the most immediate reason for failure of the second aspect of the DCCS task.

Many studies (Kirkham et al., 2003; Kloo & Perner, 2005; Perner & Lang, 2002), including the current one, demonstrate that CCC theory does not adequately explain the greater phenomenon of children’s preservation. Whereas the primary focus of the study was the explanation of children’s perseveration on the DCCS task, taking these related tasks that manipulate the need for children’s attention and use of rules into account (e.g., appearance-reality tasks, false belief tasks, tests of spatial perspective, ambiguous figures, conflict tasks, the day/night task), helps to better differentiate between CCC theory and AI theory.

The present study effectively contributed to the current literature pertaining to young children’s performance on the DCCS task. The results of the modified task were consistent with previous research and support the theory of Attentional Inertia, because it improved 3-year-old’s ability to correctly perform the post-switch task. It is unclear why 4-year-old participants did not score higher on the card sort tasks as suggested by the literature, or why they failed to improve on the post-switch in the experimental condition. Future researchers should have the children sort more cards for each task in order to avoid a ceiling effect and expand the range of the measure, because a restriction of the range increases the likelihood of Type II error. The additional information from future studies should continue to build on these findings and previous literature in order to better understand processes involved in children’s ability to complete the DCCS task. Information gained from this study is meaningful in the general discussion of cognitive development, because updated theories guide effective interventions and instructional methods. Based on this study, interventions consistent with AI theory that help children refocus their attention with new material, either through self-monitoring or adult-direction, deserve further consideration.

References


