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PAPER

More than a matter of getting 'unstuck': flexible thinkers use more abstract representations than perseverators

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Abstract

Why do people perseverate, repeating prior behaviours that are no longer appropriate? Many accounts point to isolated deficits in processes such as inhibition or attention. We instead posit a fundamental difference in rule representations: flexible switchers use active representations that rely on later-developing prefrontal cortical areas and are more abstract, whereas perseverators use latent representations that rely on earlier-developing posterior cortical and subcortical areas and are more stimulus-specific. Thus, although switchers and perseverators should apply the rules they use to familiar stimuli equally reliably, perseverators should show unique limitations in generalizing their rules to novel stimuli, a process that requires abstract representations. Two behavioural experiments confirmed this counterintuitive prediction early in development. Three-year-old children sorted cards by one rule, were asked to switch to another rule, and then were asked simply to continue their behaviour, with novel cards. Perseverators applied the rule they were using (the first rule) just as reliably as switchers applied the rule they were using (the second rule) with familiar cards; however, only switchers generalized their rule to novel cards. This finding supports an early link between active representations that support switching and abstract representations that support generalization. We interpret this synergy in terms of prefrontal cortical development.

Introduction

Even as adults, we sometimes fail to think flexibly and instead repeat behaviours that worked in the past but are no longer applicable (e.g. failing to make a planned detour from a practised driving route or repeatedly searching for keys in the same pocket). Children are even more robust perseverators: infants tend to search for a toy in its previous hiding location even after observing it being hidden in a new place (Diamond, 1985; Piaget, 1954). Three-year-olds continue sorting cards by the first rule they are exposed to (e.g. by colour) even when explicitly and repeatedly told that the rule has changed (e.g. to shape) (Perner & Lang, 2002; Zelazo, Frye & Rapus, 1996).

What processes lead to perseveration versus flexible switching? According to prominent explanations (e.g. Dempster, 1992; Diamond & Kirkham, 2005; Milner, 1963; Norman & Shallice, 1986; Zelazo *et al.*, 1996), perseverators and switchers do not necessarily differ in how they represent the basic rules they use (e.g. to sort cards by colour or by shape), but rather in processes such as inhibition or attention that operate on these rules. For example, according to the Attentional Inertia account, switchers are better than perseverators at overcoming attentional inertia towards continuing to see stimuli according to one dimension, so that they can switch to another dimension (Kirkham, Cruess & Diamond, 2003). Or, according to the Cognitive Complexity & Control (CCC) account, switchers are better at representing higher-order rules that relate the lower-order rules of colour and shape to one another (Zelazo *et al.*, 1996). However, according to an alternative active–latent account, switchers and perseverators use distinct types of competing rule representations (Cohen & Servan-Schreiber, 1992; Munakata, 1998). Specifically, switchers rely more on 'active' representations, which take the form of sustained neuronal firing and serve to maintain and provide top-down support for currently relevant task information, thus leading to flexible switching to a new task. Perseverators rely more on 'latent' representations, which take the form of changes in neuronal connections and build through repeated experiences, leading to biases to repeat prior behaviours, which may lead to perseveration under insufficiently strong competition from active representations.

Active representations are thought to rely on prefrontal cortical regions and develop relatively late, whereas latent representations are thought to rely more on posterior cortical and subcortical regions and develop relatively early (Casey, Durston & Fossella, 2001; Frank, 2005; Jog, Kubota & Graybiel, 1999; Miller, Erickson & Desimone, 1996; Miller & Desimone, 1994; Morton & Munakata, 2002). In addition, active and latent memory systems differ in the type of information they represent: prefrontal active representations are thought to code for more abstract information, whereas posterior latent

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representations code for more stimulus-specific information (Ashby & Maddox, 2005; Bunge, Kahn, Wallis, Miller & Wagner, 2003; Bunge & Zelazo, 2006; Patalano, Smith, Jonides & Koeppe, 2001; Rougier, Noelle, Braver, Cohen & O'Reilly, 2005; Wallis, Anderson & Miller, 2001). For example, prefrontal representations can code for whether any two objects or relationships between any two words are the same or different, regardless of the specific features of the objects or words (Bunge *et al.*, 2003; Bunge, Wendelken, Badre & Wagner, 2005; Wallis *et al.*, 2001). Prefrontal representations support generalization to novel exemplars based on more abstract rules, whereas posterior representations are more tied to the specifics of previously seen exemplars (Patalano *et al.*, 2001).

The active–latent account thus leads to a unique and counterintuitive prediction. Despite the fact that switchers and perseverators are equally reliable in applying the sorting rules they are using to familiar cards (with switchers applying the new rule and perseverators applying the old rule), they should differ in their ability to apply their rules to novel cards. Specifically, switchers should generalize their behaviour to novel stimuli more reliably than perseverators. If perseverators sort cards using stimulus-specific rules (red cards in one pile, blue cards in another), they should consistently apply these rules to familiar red and blue cards, but not to new exemplars (e.g. a yellow card).[1] In contrast, if switchers sort cards using more abstract rules (e.g. according to *colour*), they should use these abstract rules in sorting new exemplars. Our prediction is unique, because other accounts posit that switchers and perseverators do not differ in how they represent the basic sorting rules, such that once they are using any given rule, switchers and perseverators should apply it in the same way. Our prediction is also counterintuitive, given that generalization to novel cards requires perseverators simply to extend the single rule they have been using all along. Two experiments test this prediction by comparing switchers (who are reliably using a new rule) and perseverators (who are equally reliably using an old rule) in their ability to apply the rule they are using to sorting novel stimuli.

Experiment 1

To assess whether switchers and perseverators differ in applying their equally reliable sorting rules to novel cards, children were asked to sort familiar cards by one rule, then to switch to sorting the same cards by a new rule, and finally to apply the rule they were using to novel cards.

Method

Participants

Forty-one 39-month-olds ($M = 39.0$ months; range: 38.6–39.3 months; 23 boys) participated. Eighteen participants were in the colour-to-shape condition (first asked to sort cards by colour and then to switch to shape), and 23 were in the shape-to-colour condition.[2] Additional children were excluded from analyses because of fussiness (4), mixed behaviour in post-switch (4), failing pre-switch (1), and experimental error (1). All participants were recruited through a departmental participant pool. Informed consent was obtained for all children. Children received a small prize and their parents were paid $5 for travel expenses.

Design and Procedure

The experiment consisted of four phases (Figure 1). In the *pre-switch* phase, children sorted cards by one rule – either colour or shape, counterbalanced. In the *post-switch* phase, children were asked to sort the same cards by the other rule. In the *novel* phase, generalization ability was assessed by asking children to sort new cards by the same rule as they had been using (post-switch rule for switchers; pre-switch rule for perseverators). In the final *familiar* phase, children were again presented with and asked to sort the original cards used in pre-switch and post-switch. This phase served to assess whether children still remembered their sorting rule, in which case any differences observed in the novel phase could be attributed to generalization abilities, and not to extraneous factors such as forgetting the rule or unwillingness to continue playing the game.

All children were tested individually in a session that lasted approximately five minutes. Each child sat across a table from the experimenter. Two trays were on the table, each with a target card affixed to it. The target cards remained constant throughout the experiment and depicted a red truck and a blue flower. The cards-to-be-sorted included the standard cards (used in the pre-switch, post-switch and familiar phases) and the novel cards (used in the novel phase). The standard cards depicted blue trucks and red flowers (thus exactly matching each target card on one dimension). The novel cards depicted a turquoise TV, an orange ball, an orange-yellow mirror, a teal refrigerator, a green house and a yellow apple. Thus the novel cards only approximately

[1] Some existing results are consistent with this prediction but do not test it directly. For example, children are less likely to perseverate when the features on cards change between the first rule (e.g. to sort red boats and blue rabbits by shape) and the second rule (e.g. to sort yellow cars and green flowers by colour) (Total Change condition of Zelazo *et al.*, 2003). This suggests that perseveration is at least in part stimulus-specific. However, it is not clear how this compares with switching. Moreover, children in these studies were not asked to generalize their behaviour to the novel stimuli (and were in fact asked to switch to a new rule). Thus, it remains to be seen whether switchers and perseverators differ in their abilities to generalize when instructed.

[2] More children were run in the shape-to-color condition to obtain a reasonable number of switchers in this condition: fewer children switched in shape-to-colour (22%) than in colour-to-shape (44%), although this difference was not significant, Yates $\chi^2(1) = 1.5$, $p = .22$.

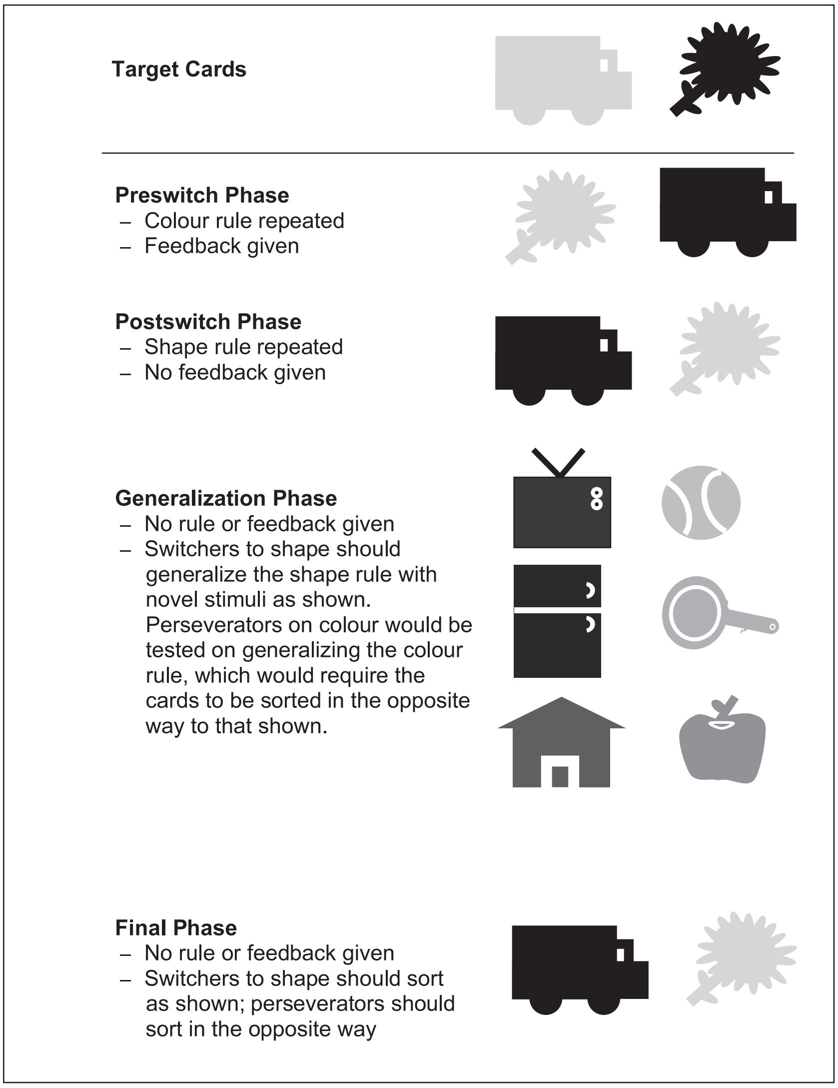

Figure 1 *Experiment 1: Cards to-be-sorted are shown under their corresponding target cards, for sample pre-switch, post-switch, generalization and final phases. Colours are converted into greyscale, such that red = the lightest grey, and blue = black. For novel generalization cards, the darkening of light greys corresponds to shifting away from red (to orange, orange-yellow and yellow) and the lightening of dark greys corresponds to shifting away from blue (to turquoise, teal and green). Novel cards were designed so that generalization would be difficult without a representation of the appropriate abstract rule.*

matched each dimension of the target cards. These stimuli were designed so that the novel stimuli became increasingly dissimilar to the standard stimuli across trials, and generalization would be difficult without an abstract representation of the appropriate rule.

Only one condition (shape-to-colour) is described here for simplicity. The pre-switch phase started with the experimenter first naming the game and explaining the rule ('Today we are going to play a game called the shape game. In the shape game, trucks go here and flowers go here.'). The experimenter then demonstrated the game by sorting two cards facedown into the appropriate trays. The child was then invited to participate ('Now it's your turn to play!'), and for each of the subsequent six pre-switch trials, the rule was reiterated ('Remember, in the shape game, trucks go here and flowers go here') and feedback was given ('Good job!' if correct or 'No, trucks go here in the shape game' if incorrect).

The post-switch phase started with the experimenter strongly emphasizing the change of the game: 'Now we are going to switch and play a new game, called the colour game. We are not going to play the shape game anymore. No way! We are going to play the colour game and the colour game is different. In the colour game, red ones go here and blue ones go here.' During the post-switch phase, the rule was repeated for each of the six trials ('Remember, in the colour game, red ones go here and blue ones go here'). However, in post-switch no feedback was given – the experimenter neutrally said 'OK' after the child placed each card into a tray.

In the novel phase, the experimenter simply asked the children to continue their behaviour: 'You are doing great! Just keep doing what you are doing!' Children were presented with six novel cards and asked, 'Where do you think this goes?'

The familiar phase started with the experimenter stating, 'You are almost done!' Children were presented with six standard cards again (blue trucks and red flowers) and asked, 'Where do you think this goes?' The rule was not repeated and feedback was not provided for either the novel or the familiar phase.

Results

Initial descriptive analyses indicated that the data were non-normal in the pre-switch, post-switch and familiar phases.[3] Thus, as in previous studies (Kirkham *et al.*, 2003), children were classified within each of these phases based on whether they sorted at least five out of six cards according to a consistent rule. Because the contrast of interest concerned switchers versus perseverators, children had to pass pre-switch, and then either clearly switch (sort at least 5/6 cards correctly, $N = 13$) or clearly perseverate (sort at least 5/6 cards incorrectly, $N = 28$) in post-switch to be included in the study. Reliability during post-switch and generalization phases was measured as the number of consecutive cards, starting with the first card, sorted according to the rule used in post-switch (the new rule for switchers and the old rule for perseverators).[4] Chance performance for generalization was 0.98 cards. This number was computed across all 64 permutations of how the six novel cards could be sorted, and represents the average number of consecutive novel cards sorted according to the rule used in post-switch across these permutations.

The key prediction for this study was confirmed: switchers applied their post-switch sorting rule to more consecutive novel cards ($M = 3.1$, $SD = 2.4$) than did perseverators ($M = 1.4$, $SD = 1.6$), $F(1, 40) = 10.3$, $p = .003$ (Figure 2), controlling for age and post-switch reliability. During post-switch, perseverators were actually marginally more reliable than switchers in applying the rule they were using (perseverators: $M = 5.9$, $SD = 0.4$ vs. switchers: $M = 5.1$, $SD = 2.3$, $t(39) = 1.9$, $p = .07$). Switchers generalized their rule to novel cards better than expected by chance ($t(12) = 3.2$, $p = .008$), whereas perseverators' generalization did not differ from chance ($t(27) = 1.4$, $p = .2$). Similar results were obtained when the rule children were told to use in post-switch was included as a factor instead of the rule they actually used. In addition, colour ($M = 2.7$, $SD = 2.1$) was marginally easier to generalize than shape ($M = 1.5$, $SD = 1.8$), $F(1, 40) = 3.2$, $p = .08$.

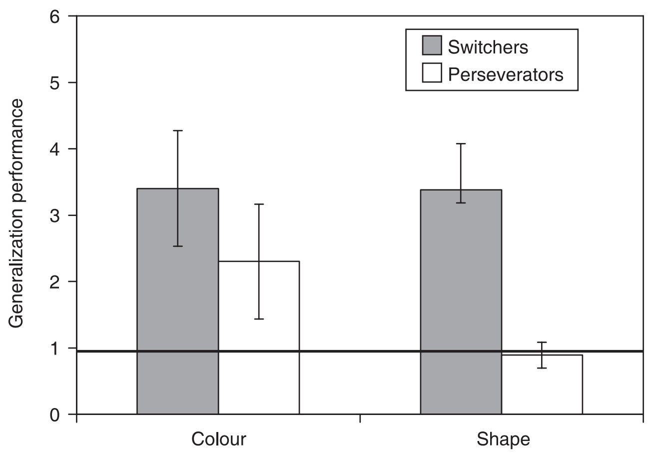

Figure 2 *Experiment 1: Switchers generalized their sorting rule to more novel cards than did peservorators. Only switchers performed better than chance, indicated by the horizontal line.*

Finally, performance in the familiar phase was highly consistent with the rule used in post-switch, with no significant difference between the percentage of perseverators (96%) and switchers (77%) passing the familiar phase (Yates $\chi^2(1) = 1.9$, $p = .2$). Perseverators' excellent performance with familiar cards indicates that their poor performance with novel cards reflected difficulty generalizing their sorting rule, rather than extraneous factors, such as an inability to remember the rule or unwillingness to continue with the task.

Discussion

Despite switchers and perseverators both showing highly reliable performances in applying the rule they were using to familiar cards, the groups differed strikingly in applying their rule to novel cards. Specifically, children who flexibly switched from one sorting rule to a second sorting rule with familiar cards consistently applied that second rule to sorting novel cards. In contrast, children who reliably sorted familiar cards by the first rule throughout were unable to apply this rule to novel stimuli. This counterintuitive finding suggests an early synergy between two abilities supported by prefrontal cortical regions in adults: flexibility and generalization.

However, switchers and perseverators also differed in how often they had used the rule they were asked to generalize. Because perseverators did not switch away from the first rule they were exposed to, they sorted up to 12 cards in a row (six trials of pre-switch and six trials of post-switch) by the rule that they were later asked to generalize. In contrast, switchers sorted up to only six cards in a row (during post-switch) by the rule that they were asked to generalize. This difference might make the findings from Experiment 1 even more striking: perseverators

[3] Prior to excluding data from children who failed pre-switch or who showed mixed behaviour in post-switch, 80% of children sorted all six pre-switch cards correctly, 80% sorted all six cards correctly or all six cards incorrectly in post-switch, and 83% sorted all six familiar cards consistently with the rule they used in post-switch.

[4] Results are similar across other measures of reliability (e.g. overall number of cards sorted consistently with the rule used in post-switch), but number-of-consecutive-cards is used as a potentially more sensitive measure, owing to its greater differentiability from chance and the increasing difficulty of cards across the generalization phase.

had twice as many opportunities as switchers to practise and learn the rule they were asked to generalize, but they nonetheless failed to apply this rule to novel cards. However, it is also possible that perseverators' representations of their sorting rule *became* more entrenched or stimulus-specific as a result of the repeated rule exposure that they experienced in Experiment 1, thus precluding generalization. Experiment 2 tests this possibility.

Experiment 2

To assess whether perseverators' prolonged use of a single rule led to the formation of representations that were more stimulus-specific, switchers received an extra block of six post-switch trials, thus equating rule use among switchers and perseverators before generalization.

Method

Participants

Forty-nine 3.5-year-old children ($M = 44.7$ months; range: 43.1–45.3 months; 15 boys) participated. Additional children were dropped from the analyses because of experimental error (3), fussiness (1), and mixed behaviour in the post-switch phase (1). These participants were recruited through the same departmental participant pool as in Experiment 1.

Design, Procedure and Analyses

This experiment was almost identical to Experiment 1, except that switchers received 12 post-switch trials instead of six. Perseverators experienced the same number of trials (i.e. 12) as in Experiment 1. This equated the number of cards that switchers and perseverators sorted by the rule they were asked to generalize.

Results

Perseverators were just as reliable as switchers in applying the rule they were using to familiar cards (perseverators ($N = 17$): $M = 10.8$, $SD = 2.5$, across six trials of pre-switch and six trials of post-switch; switchers ($N = 32$): $M = 11.3$, $SD = 2.4$, across 12 trials of post-switch, $t(47) = .8$, $p = .5$). Differences between switchers' and perseverators' ability to generalize their rule to novel cards depended on the post-switch rule used, $F(1, 48) = 7.8$, $p = .008$ (Figure 3), controlling for age and post-switch reliability. When the post-switch rule used was colour, the key prediction for the study was confirmed: switchers generalized to more consecutive novel cards ($M = 4.2$, $SD = 2.0$) than did perseverators ($M = 1.9$, $SD = 1.5$), $t(20) = 2.9$, $p = .007$. Furthermore, switchers generalized their rule to novel colours better than expected by chance ($t(12) = 6.0$, $p < .001$), whereas perseverators' generalization with novel colours did not differ from chance ($t(8) = 1.8$, $p = .11$). These findings are consistent with the results of Experiment 1. However, when the post-switch rule used was shape, switchers ($M = 1.4$, $SD = 1.6$) and perseverators ($M = 2.3$, $SD = 2.3$) did not differ in their generalization to novel cards, $t(25) = 1.1$, $p = .3$, and neither group generalized better than expected by chance, all p's $> .2$. As in Experiment 1, colour generalization ($M = 3.3$, $SD = 2.1$) was easier than shape generalization ($M = 1.7$, $SD = 1.8$), $F(1, 48) = 6.5$, $p = .01$. Performance during the familiar phase was again consistent with post-switch behaviour, with no differences between groups: 75% of switchers and 75% of perseverators passed the familiar phase (Yates $\chi^2(1) = 1$, $p = .7$).

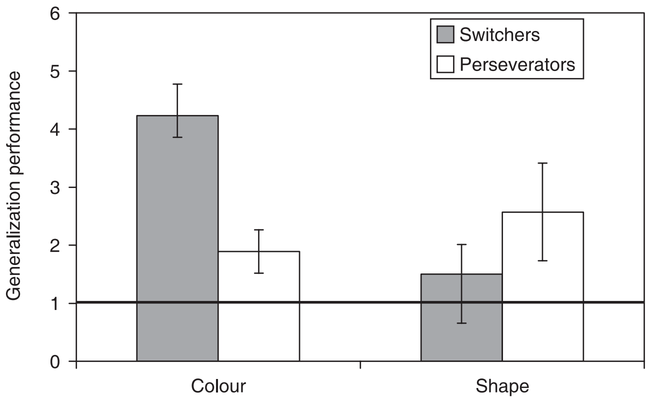

Figure 3 *Experiment 2: Switchers again generalized their sorting rules to more novel colour cards than did perseverators. Switchers and perseverators did not differ in generalizing by shape. Only switchers to colour performed better than chance, indicated by the horizontal line.*

Discussion

Switchers generalized the colour rule to more novel cards than did perseverators, even when the groups were equated for rule use before generalization. Thus, repeated rule use cannot explain why only switchers generalized the colour rule to novel stimuli. This finding demonstrates that the synergy between adaptive responding and generalization is genuine.

The finding that switchers did not differ from perseverators in generalization to shape is consistent with two existing accounts. First, repeated rule use may lead to representations of shape that are more stimulus-specific relative to other dimensions (Gelman & Bloom, 2000; Prasada, Ferenz & Haskell, 2002). Second, repeated emphasis on shape may lead to the formation of stronger semantic representations (Damian, Vigliocco & Levelt, 2001). Semantics may constitute another conflicting dimension by which to sort the novel cards (e.g. 'man-made' items, such as TV and mirror go with the red truck target, and 'natural' items, such as apple, go with the blue flower target). Given that shape generalization was more difficult than colour generalization across the two studies, repeated exposure to shape in Experiment 2 might thus have exacerbated the already more difficult task. Thus, generalization by shape may become selectively jeopardized after repeated shape exposure.

General Discussion

Taken together, the results from these two experiments provide insight into common mechanisms that support flexible behaviour and generalization. Our findings offer the first demonstration of a striking qualitative distinction between switchers' and perseverators' representations of rules, which affect not only the ability to update flexibly when rules change, but also the ability to generalize behaviour to new stimuli. Despite the fact that switchers and perseverators were equally consistent in applying their respective sorting rules to familiar cards, only switchers were able to generalize their behaviour to sorting novel cards. This finding supports the active–latent account that explains switching and perseverating in terms of the differential use of active, abstract, prefrontal representations and latent, stimulus-specific, posterior representations, respectively. More generally, this finding is consistent with accounts that emphasize the importance of abstract representations in cognitive flexibility and other domains of higher-order cognition (Gentner, 2003; Jacques & Zelazo, 2005; Premack, 1984; Rougier *et al.*, 2005; Vygotsky, 1962; Wallis *et al.*, 2001).

Our results pose more of a challenge for alternative accounts of perseveration, which posit that perseverators and switchers represent the basic rules they use in the same way, but differ in other processes that operate on these rules (Dempster, 1992; Diamond & Kirkham, 2005; Milner, 1963; Norman & Shallice, 1986). For example, if perseverators are simply 'stuck' on one dimension whereas switchers have moved on to a new dimension, as the Attentional Inertia account posits (Kirkham *et al.*, 2003), there is no reason for the groups to differ in their generalization to new features within that same dimension. Similarly, the CCC account should not predict perseverators to be worse than switchers at generalizing within a single card-sorting rule, if perseverators 'are capable of either description' (in terms of colour or shape) and simply 'have difficulty switching flexibly between them', and 'a higher order rule will not be required . . . within a dimension' (Zelazo, Muller, Frye & Marcovitch, 2003, pp. 101–102). However, our findings may be compatible with other descriptions of the CCC account, which suggest that 'increases in reflection on lower order rules are logically required for increases in embedding to occur' (Zelazo *et al.*, 2003, p. 9). That is, reflection on lower-order rules (which may support a more abstract understanding of sorting dimensions) may be a precursor to embedding of rules (which supports switching). Our account may provide a lower-level explanation of such theories.

One might ask whether perseverators experienced increased conflict during failed post-switch trials, such that their poor generalization reflected carry-over effects from post-switch rather than how abstractly they represented the rules. This possibility seems unlikely for several reasons. First, perseverators' excellent performance in the final familiar phase suggests that their failure on generalization cards is not a result of high conflict experienced in the post-switch phase, as they had no trouble applying the rule they used in post-switch to familiar cards at the very end of the game. Second, we know of no evidence to support the idea that perseverators experience more conflict than switchers. In fact, the active–latent account and associated models predict that children should experience maximal conflict near the transition from perseverating to switching, when the competition between representations is closest (Stedron, Sahni & Munakata, 2005); this peak in conflict occurs both before and after the transition to switching, and is not limited to perseverators. Third, in our sample, perseverators showed no signs of experiencing more conflict than switchers during post-switch. We tested for such conflict by recoding videotapes for reaction-time data. Perseverators responded just as quickly as switchers across all post-switch trials (2.4 and 2.5 s, respectively, $t < .1$) and on the first post-switch trial (3.4 and 4.1 s, respectively, $t = 1.0$). Thus, perseverators' difficulties with generalization do not seem to be driven by greater conflict.

Nonetheless, other forms of this idea, that the process of switching to a new sorting rule influences subsequent generalization performance, are possible and consistent with the active–latent account. For example, the act of switching may activate prefrontal representations that aid in the generalization of a rule to novel exemplars. Further studies are needed to test this possibility.

Alternatively, one might ask whether switchers are simply smarter and thus perform better than perseverators on all tasks, making the relationship between flexibility and generalization seem trivial. Indeed, the use of more active and abstract representations may be an important component of general intelligence (Conway, Kane & Engle, 2003; Duncan *et al.*, 2000; Gray, Chabris & Braver, 2003). However, the reported synergy between switching and generalization seems unlikely to be trivially characterizable in terms of general smarts or better verbal ability, for several reasons. First, evidence for the role of general intelligence in cognitive flexibility is mixed. Correlations between verbal ability and executive function in children have been reported (Carlson, 2005; Carlson & Moses, 2001; Hongwanishkul *et al.*, 2005; Hughes, 1998). However, some of these studies included a measure of switching only as part of a large battery of tasks that contributed to a composite executive function score and did not report specific correlations between switching and general intelligence (Carlson, 2005; Carlson & Moses, 2001; Hughes, 1998). The one study that reported a link between receptive vocabulary scores and card-sorting performance (Hongwanishkul, Happaney, Lee & Zelazo, 2005) relied on invalid analyses, treating categorical switching data as if it were continuous. Other evidence suggests that general intelligence only weakly predicts whether children switch or perseverate (Deák, Narasimham, Cepeda & Legare, submitted), and children show age-related improvements in executive function that are not related to verbal ability (Carlson, 2005). Second, switchers do not perform better than perseverators on implicit memory tasks, thought to tap posterior rather than prefrontal cortical areas (Snyder & Munakata, 2009; Kharitonova, Hulings & Munakata, 2009). Finally, in the current study, perseverators had no trouble applying the first rule to the standard cards at both the start and the end of the session, suggesting that their poor generalization performance does not stem from general difficulties with all tasks or from limitations in all components of intelligence. Instead, we argue that perseverators' difficulty with the novel cards specifically reflects the use of less active and less abstract representations.

Why do flexibility and generalization go hand-in-hand early in development? This early synergy may reflect their reliance on common neural properties supported by prefrontal cortical regions. For example, active representations (supporting flexibility) and abstract representations (supporting generalization) may both rely on distance from posterior cortical regions responsible for veridically representing the perceptual details of the changing environment. The observed synergy might also reflect a more inherent functional dependence between active and abstract representations: active maintenance may serve as a critical component in the development of abstract representations (Rougier *et al.*, 2005). A third factor, such as language development, may also contribute to the early synergy between flexibility and generalization. For example, language could serve to coordinate distinct facets of human intelligence (Spelke, 2003), or support developing abilities to both actively maintain information (Jacques & Zelazo, 2005; Vygotsky, 1962) and form abstract representations (Deacon, 1997; Gentner, 2003). Further developmental work is needed to establish the precise trajectory of the reported synergy, and consequently to advance the understanding of the origins of these fundamental facets of human intelligence.

Acknowledgments

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