Journal of Experimental Child Psychology 118 (2014) 143–151

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Brief Report

One of these things is not like the other: Distinctiveness and executive function in preschoolers

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ARTICLE INFO

Article history:
Received 19 June 2013
Revised 28 September 2013
Available online 7 November 2013

Keywords:
Cognitive flexibility
Distinctiveness in memory
Executive function
Isolation effect
Organizational processing
Working memory

ABSTRACT

There is scant evidence that children younger than 7 years show a memory advantage for distinct information, a memory phenomenon termed the isolation effect (*Journal of Experimental Psychology: Learning, Memory, and Cognition*, 2001, Vol. 27, pp. 1359–1366). We investigated whether 4-, 5-, and 6-year-olds' developing organizational processing and executive function contributed to the isolation effect, demonstrated when recall was better for a semantically unique target (e.g., sheep, pig, *watermelon*, duck) rather than a semantically common target (e.g., apple, banana, *watermelon*, strawberry). To encourage organizational processing, children were asked to categorize each item presented. Children also completed working memory and cognitive flexibility tasks, and only children who scored high in cognitive flexibility demonstrated the isolation effect.

Introduction

Memory advantages for distinct information are clearly demonstrated in the isolation paradigm, where adults remember items better when unique in context (e.g., apple, watermelon, *elephant*, strawberry) rather than common in context (e.g., dog, horse, *elephant*, cat). This robust effect in adults is termed the isolation or the von Restorff effect (see Hunt, 1995), and it occurs regardless of the type of isolated item (e.g., perceptually or numerically distinct), location of the isolate (e.g., early or late in the list), or delay between presentation and recall (Hunt, 1995, 2009). In children, however, the

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0022-0965/$ - see front matter
http://dx.doi.org/10.1016/j.jecp.2013.09.012

effect is mercurial. Howe, Courage, Vernescu, and Hunt (2000) demonstrated that 7-year-olds displayed an isolation effect for numerical isolates (i.e., number in a list of words), whereas 5-year-olds showed no memory advantage for distinct numerical information. In a study examining a semantic isolation effect in preschoolers (i.e., item from a different category in a categorized list), 5- and 6-year-olds failed to show an isolation effect, whereas 4-year-olds actually showed impaired memory for semantically isolated items (Miller, Marcovitch, & McConnell Rogers, 2011). Furthermore, when perceptual, semantic, and numeric isolates were presented in a list, 7-year-olds had better memory for perceptual and semantic isolates, whereas 5-year-olds primarily showed a memory benefit for perceptual isolates (Howe et al., 2000). These inconsistencies suggest that the isolation effect for conceptually distinct information is emerging during preschool. The purpose of the current study was to examine what developing cognitive processes contribute to this memory phenomenon.

Hunt and Lamb (2001) hypothesized that organizational processes related to encoding similarities between items (e.g., forming categories) are necessary to set the context for distinctive processing (e.g., considering differences) against this background of similarity. A unique item is better remembered because it benefits from both organizational and distinctive processing, whereas the same item results in inferior memory when typical in context because it would be processed like other background items (e.g., only organizationally; Hunt & Lamb, 2001). Although adults typically organize and process category information spontaneously for list items (e.g., Mandler, 1967), recognizing and clustering items by category is effortful in young children. Schwenck, Bjorklund, and Schneider (2009) provided evidence for development in 4- to 8-year-olds' clustering (i.e., recalling items together by category) and sorting strategies (i.e., arranging items by category). Although 4-, 5-, and 6-year-olds typically failed to use sorting strategies during study and displayed below-chance performance of clustering, children used more organizational strategies when they were trained. Schwenck and colleagues suggested that this pattern was indicative of a production deficiency—failure to produce the strategy even though capable of using it. Production deficiencies in organizational strategies likely impede an isolation effect in preschoolers because they would be unable to appreciate the similarity between background items necessary to process the isolate's distinctiveness. Thus, encouraging organizational processing may elicit the isolation effect in younger preschoolers.

Executive function (EF), the processes involved in the conscious control of thought and behavior, develops dramatically during the preschool years (Garon, Bryson, & Smith, 2008; Jacques & Marcovitch, 2010). EF abilities are hypothesized to play a role in encoding and retrieving information from long-term memory (e.g., Baddeley, 1996), and several researchers have demonstrated that individual differences in EF contribute to age-related changes in memory (e.g., Picard, Cousin, Guillery-Girard, Eustache, & Piolino, 2012). A popular conceptualization of EF is that several components contribute to EF (e.g., Garon et al., 2008): working memory (i.e., holding and manipulating information in mind), inhibition (i.e., suppressing prepotent responses), and cognitive flexibility (i.e., modifying thought and behavior according to changes in situational context). Furthermore, EF components differentially contribute to memory. For instance, Ruffman, Rustin, Garnham, and Parkin (2001) demonstrated that reduced inhibition was related to false memory and poor source monitoring, whereas better working memory was related to all types of memory measured (i.e., less false memory, better source monitoring, and higher accuracy). Given EF's role in memory and the dramatic improvements during preschool, it is likely that this developing cognitive function is associated with the isolation effect. Cognitive flexibility may be particularly important because remembering distinctive information requires one to consider information in multiple contexts (e.g., the isolate of a different context relative to the background context).

In the current study, we examined the emerging isolation effect for semantically distinct information. Although preschoolers may better remember salient information at the perceptual level (Howe et al., 2000), it is likely that preschoolers' inability to produce a robust semantic isolation effect is related to a production deficiency in organizational processing (Schwenck et al., 2009). Therefore, we provided preschoolers with cues for organization (i.e., naming the category of each list item) to elicit an early isolation effect. We also examined how individual differences in EF were related to distinctiveness and total list recall, with a specific emphasis on cognitive flexibility (because the isolation effect requires flexibly switching between categories) and working memory (because of its central role in memory).

Method

Participants

The sample consisted of 24 4-year-olds (*M* = 4.80 years, *SD* = 0.27, 12 girls and 12 boys), 24 5-year-olds (*M* = 5.32 years, *SD* = 0.24, 12 girls and 12 boys), and 24 6-year-olds (*M* = 6.49 years, *SD* = 0.31, 12 girls and 12 boys) from a mid-sized southeastern U.S. city. More than half (57%) of parents reported household earnings over $60,000, 21% reported earnings under $60,000, and 22% did not respond. Fully 68% of parents self-reported as White, 17% as African American, 7% as biracial, and 3% as other, with 5% not responding.

Procedure

Children completed an isolation task, a working memory task (i.e., Auditory Backward Digit Span), and a cognitive flexibility task (i.e., Dimensional Change Card Sort, DCCS) presented in the following fixed order: (a) List 1 of the isolation task (either isolate or control), (b) Auditory Backward Digit Span, (c) DCCS, and (d) List 2 of the isolation task (either control or isolate).

Isolation task

In the isolation task, one isolate list and one control list were presented to each participant. Each list consisted of eight pictures from categories rated highly familiar to young children (i.e., animals, foods, and clothes; Bjorklund & Bernholtz, 1986) on individual cards. List items were randomly ordered for each child, with the exception that the target item (i.e., elephant, pants, or watermelon) was always presented in the sixth position. In the isolate list, all items were from the same category except for the conceptually different target item (e.g., strawberry, ice cream, banana, lollipop, apple, *elephant*, cupcake, carrot). In the control list, all items were from the same category, and the target item was another child's isolated item (e.g., deer, bird, duck, turtle, dog, *elephant*, pig, sheep). The control list allowed us to examine memory for a target item, where list effects were equated (e.g., recency, list length) and the only difference was the item's relation to background items. There were six possible list compositions for the isolate list (i.e., food with clothes isolate, food with animal isolate, clothes with animal isolate, clothes with food isolate, animals with food isolate, and animals with clothes isolate) and three list compositions for the control lists (i.e., food, clothes, and animals).

Each list was presented by a different stuffed animal (i.e., Tigger or Pooh) to differentiate the lists during presentation and recall. To encourage organizational processing, the experimenter told children that they would play a memory game where they would see cards that could belong to one of two categories. Children were presented with cards one at a time, asked to name each picture, and asked to decide the category to which the item belonged. For example, in the isolation list, the experimenter would say, "Do you know what this is? [*Child's response*] That's right, it's a strawberry, and is a strawberry an animal [background item category] or a food [isolate category]? [*Child's response*]." The control list consisted of items that were all from the same category, so children were given a distracter category to ensure categorization (e.g., is a strawberry furniture or a food?). If the initial response was incorrect, children were prompted to name the item with the correct label and category name. Each card was turned over and placed beneath the stuffed animal after the item was named and categorized appropriately. After list presentation, there was a 5-min delay during which children completed a distracter task (i.e., coloring or Tic-Tac-Toe). The experimenter then asked children to recall the cards on the character's list. Once children indicated that they were unable to name any more items, the experimenter gave them a final memory prompt and verbal free recall was terminated (~40 s after the final prompt).

DCCS

In the DCCS (Zelazo, Frye, & Rapus, 1996), the experimenter told children that they would play a sorting game where they would match cards to target cards that could be identified by two dimensions (i.e., a yellow flower and a green car). The experimental cards (i.e., yellow cars and green flowers) could be sorted to match the targets based on color or shape. During the preswitch phase, children were asked to sort six experimental cards on one dimension (color or shape, counterbalanced) to target cards affixed to two white boxes with slits cut into the lids. All children sorted at least five of the six cards correctly during the preswitch phase. During the postswitch phase, children were asked to switch rules (e.g., if they sorted by shape in the preswitch phase, they were asked to sort by color). Because most children (78%) performed perfectly or entirely incorrect across the six postswitch trials, performance was coded as pass (at least five postswitch trials correct) or fail (4 or fewer postswitch trials correct) (Zelazo et al., 1996).

Auditory Backward Digit Span

During the training phase of the Auditory Backward Digit Span (Carlson, Moses, & Breton, 2002), children were introduced to "Leo," a silly lion puppet who says everything backward. Children were presented with two-digit lists (e.g., 6, 4) and were instructed on how Leo would say the list (e.g., 4, 6). Children then needed to repeat the correct response to the experimenter. If children passed training by correctly repeating two two-digit training lists backward, they moved to the testing phase. During the testing phase, the experimenter gave three two-digit lists before increasing to a three-digit list and continued to give three trials at each list length before increasing the length of the list by one digit. Children were presented with trials until they responded incorrectly on three consecutive trials. Children were assigned a working memory span (WM Span) based on the longest list they could reproduce backward (Carlson et al., 2002). They were assigned a score of 0 if they did not pass training and were assigned a score of 1 if they passed training but were unable to complete a two-digit list during testing.

Results

For all analyses, age and WM Span were analyzed as continuous and centered variables unless otherwise noted. One 5-year-old had WM Span data that were removed from analyses due to experimenter error. Preliminary analyses failed to reveal any main effects or interactions with sex, so sex was not included in subsequent analyses. Age, DCCS performance (fail = 0, pass = 1), and WM Span were all correlated (all rs > .40, ps < .001). Table 1 presents descriptive statistics by age.

Total word recall in isolation task

A mixed general linear model was conducted to analyze the effects of age, WM Span, DCCS performance, list type (within participants: isolate vs. control), and within-participant interactions (i.e., list type by each between-participant predictor and three-way interactions with age) on total words recalled. No within-participant effect was significant (Fs < 1.49, ps > .22, η^2s < .03), suggesting that total recall did not differ for the isolate and control lists. A significant effect of WM Span, $F(1, 65) = 4.32$, $p = .04$, $\beta = .69$, $\eta^2 = .06$, revealed that higher WM Span was related to better recall across both isolate and control lists. Furthermore, a marginal effect of age, $F(1, 65) = 3.03$, $p = .09$, $\beta = .59$, $\eta^2 = .04$, suggested that total recall across both lists improved with age.

Table 1
Descriptive statistics by age.

Measure	Age											
	4-year-olds				5-year-olds				6-year-olds			
	M	(*SD*)	Range	*n*	*M*	(*SD*)	Range	*n*	*M*	(*SD*)	Range	*n*
Total list recall												
Isolation list	2.63	(2.08)	0–6	24	3.92	(1.77)	0–7	24	4.46	(1.91)	0–8	24
Control list	2.54	(1.96)	0–7	24	3.17	(1.55)	0–6	24	3.79	(1.62)	0–7	24
DCCS	0.25	(0.44)	0–1	24	0.71	(0.46)	0–1	24	0.83	(0.38)	0–1	24
WM Span	0.92	(0.88)	0–3	24	1.83	(1.23)	0–4	23	2.67	(1.13)	0–5	24

Table 2
Logistic regression analysis on recall of the target item.

Predictor	Parameter estimates					Goodness-of-fit statistic
	β	*SE* β	Wald χ^2	*df*	*p*	*QICC*
Model 1						
Intercept	−0.39	0.24	2.69	1	0.10	195.26
List (0 = control)	0.96	0.37	6.86	1	0.01	
Model 2						189.06
Intercept	−0.39	0.24	2.69	1	0.10	
List (0 = control)	1.06	0.39	7.43	1	0.01	
Age	0.07	0.28	0.06	1	0.80	
List*Age	0.87	0.47	3.44	1	0.06	
Model 3						186.82
Intercept	0.13	0.43	0.10	1	0.75	
List	−0.34	0.69	0.24	1	0.63	
Age	0.25	0.36	0.47	1	0.49	
DCCS (0 = fail)	−0.86	0.60	2.05	1	0.15	
WM Span	0.10	0.24	0.19	1	0.67	
List*Age	0.23	0.56	0.17	1	0.68	
List*DCCS	2.35	1.01	5.44	1	0.02	
List*WM Span	−0.04	0.42	0.01	1	0.92	
Model 4						187.88
Intercept	0.14	0.43	0.10	1	0.75	
List	−0.32	0.70	0.21	1	0.65	
Age	0.25	0.36	0.47	1	0.49	
DCCS (0 = fail)	−0.87	0.60	2.07	1	0.15	
WM Span	0.10	0.24	0.19	1	0.66	
List*Age	−0.23	0.65	0.12	1	0.73	
List*DCCS	2.41	0.97	6.15	1	0.01	
List*WM Span	−0.02	0.42	0.00	1	0.96	
List*DCCS*Age	1.00	0.64	2.50	1	0.11	
List*WM Span*Age	−0.31	0.26	1.42	1	0.23	

Target recall in isolation task

Of primary interest was target recall on the isolate and control lists. Logistic regressions (Kleinbaum & Klein, 2010) were conducted on the dichotomous dependent variable of target recall (0 = not recalled, 1 = recalled) to determine how age, WM Span, and DCCS performance influence the isolation effect. Characteristics of each model are displayed in Table 2.

QICC was used as our measure of fit regarding variable selection as recommended for non-likelihood-based general estimated equation models (Pan, 2001). Model 1 (*QICC* = 195.26) tested the presence of the isolation effect and revealed a significant effect of list type (within participants) on recall of the target item, $\beta = .96$, Wald $\chi^2(1) = 6.86$, $p = .01$, such that children were more likely to recall a target item in the isolation list (64%) compared with the control list (40%). The second model included age and provided a better fit to the data (*QICC* = 189.06). List type, $\beta = 1.06$, Wald $\chi^2(1) = 7.43$, $p = .01$, was qualified by a marginally significant list type by age interaction, $\beta = .87$, Wald $\chi^2(1) = 3.44$, $p = .06$. Analyses at each age group revealed the isolation effect in 6-year-olds, McNemar $\chi^2(1, N = 24) = 5.79$, $p = .01$ ($M_{\text{isolate}} = .83$, $M_{\text{control}} = .42$), marginally in 5-year-olds, McNemar $\chi^2(1, N = 24) = 3.50$, $p = .057$ ($M_{\text{isolate}} = .67$, $M_{\text{control}} = .33$), but not in 4-year-olds, McNemar $\chi^2(1, N = 24) = 0.00$, $p = 1.00$ ($M_{\text{isolate}} = .42$, $M_{\text{control}} = .46$). Model 3, including DCCS performance and WM Span, provided the best fit for the data (*QICC* = 186.82) and demonstrated that when age, DCCS, and WM Span were included as predictors, only a DCCS by list type interaction emerged, $\beta = 2.35$, Wald $\chi^2(1) = 5.44$, $p = .02$.[1] Fig. 1A displays this interaction, depicting that children who passed the DCCS

[1] This DCCS by list interaction remained significant when DCCS was analyzed as a continuous variable (i.e., number of correct postswitch trials), $\beta = .50$, Wald $\chi^2(1) = 5.93$, $p = .02$. Furthermore, even when WM Span was included as the sole EF predictor, it was not a significant predictor of the isolation effect, $\beta = .14$, Wald $\chi^2(1) = 0.16$, $p = .69$, suggesting that the null effect of WM Span is not due to overlap between performance on the DCCS and WM Span.

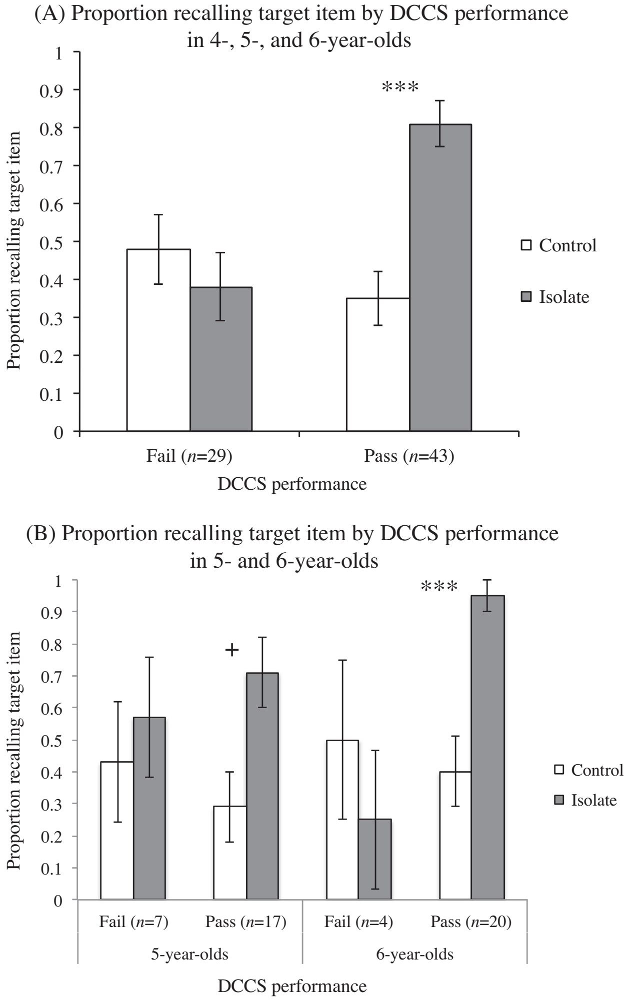

Fig. 1. Proportions recalling target item by DCCS performance. In panel A, 4-, 5-, and 6-year-olds passing the DCCS task demonstrated the isolation effect. In panel B, 6-year olds (and to a lesser extent 5-year-olds) passing the DCCS demonstrated the isolation effect. Standard errors are represented in the figure by error bars attached to each column. $^{***}p < .001$; $^{+}p < .10$.

showed an isolation effect, McNemar $\chi^2(1, N = 43) = 13.88$, $p < .001$, whereas those who did not pass the DCCS did not, McNemar $\chi^2(1, N = 29) = 0.24$, $p = .63$. Finally, Model 4 did not improve model fit to the data (*QICC* = 187.88), suggesting that age did not significantly moderate the effects of EF on the isolation effect because there were no significant three-way interactions among age, list, and EF performance.

Order effects

We also examined whether list order (i.e., isolate list first vs. control list first) influenced recall. A full factorial mixed logistic regression was conducted on target item recall with list type (within participants), age, and list order (between participants) as predictors. This analysis revealed a three-way interaction among list type, age, and list order, $\beta = -2.27$, Wald $\chi^2(1) = 4.18$, $p = .04$. Follow-up logistic regressions at each age group revealed that only 4-year-olds displayed order effects with a marginally significant list type by list order interaction, $\beta = 2.47$, Wald $\chi^2(1) = 3.34$, $p = .07$, suggesting better target recall in whichever list was presented first (58% isolate target recall, 58% control target recall) compared with second (33% control target recall, 25% isolate target recall). Furthermore, 4-year-olds had better overall recall in the first list ($M = 3.42$, $SD = 1.73$) compared with the second list ($M = 1.75$, $SD = 1.96$), $F(1, 22) = 21.21$, $p < .001$, $\eta^2 = .49$, regardless of list type.

The observed order effects make it difficult to determine whether target recall was due to list type or list order in 4-year-olds. Thus, we conducted the same four logistic regression models depicted in Table 2 on 5- and 6-year-olds to determine whether DCCS performance remained the best predictor of the isolation effect when list order was not an issue. Model 4 provided the best fit for the data ($QICC = 120.03$), suggesting that age may moderate the effects of the DCCS,[2] $\beta = 2.37$, Wald $\chi^2(1) = 3.22$, $p = .07$, and WM Span on the isolation effect, $\beta = -.86$, Wald $\chi^2(1) = 3.54$, $p = .06$. Regarding the DCCS, Fig. 1B shows that although passing the DCCS is related to the isolation effect, the effect for 6-year-olds, McNemar $\chi^2(1, N = 20) = 9.09$, $p = .001$, is stronger than the marginal effect for 5-year-olds, McNemar $\chi^2(1, N = 17) = 3.27$, $p = .065$. The 5- and 6-year-olds who failed the DCCS did not show an isolation effect, McNemar χ^2s$(1) = 0.00$, $ps = 1.0$. Regarding WM Span, post hoc analyses indicate that 5-year-olds do not show a relationship between WM Span and isolate or control target recall, $rs(23) < .28$, $p < .22$. However, in 6-year-olds, better WM Span may be related to deficits in the isolation effect because higher WM Span is positively related to control target recall, $r(24) = .41$, $p = .05$, and is not significantly related to isolate target recall, $r(24) = -.34$, $p = .11$.

Discussion

In the current study, we cued preschoolers with categorical processing during a traditional isolation paradigm to elicit a semantically based isolation effect in children younger than 7 years. Categorization cues assisted children with organizational processing necessary to contextualize the isolation effect (Hunt & Lamb, 2001). This likely freed up resources related to this typically effortful strategy in preschoolers (e.g., Schwenck et al., 2009) and provided children with a context of similarity for which they could process the distinctiveness of the isolate. However, not all children exhibited the isolation effect, and individual differences in cognitive flexibility best predicted memory for distinctive information.

Initially, it appeared that younger children exhibited a mediational deficiency, in which they engaged in organizational processing when prompted (i.e., they named the correct category of each item) but failed to translate it into a benefit on the task (see Bjorklund, Miller, Coyle, & Slawinski, 1997). By including measures of EF, we were able to determine that deficits in cognitive flexibility (typically observed in younger children) better accounted for this deficiency. This aligns with EF theory. According to the cognitive complexity and control theory (Zelazo, Müller, Frye, & Marcovitch, 2003), children who fail the DCCS can typically sort items according to rules (e.g., sort by color) but do not appreciate that rules can be embedded under a hierarchical structure (e.g., in one setting sort by color, in another setting sort by shape). Applied to the isolation paradigm, children limited in cognitive flexibility could process items according to one strategy (i.e., organizationally) but exhibit a mediational deficiency because they fail to appreciate a context appropriate for an additional strategy (i.e., distinctive processing). Furthermore, the marginal order effect, in which 4-year-olds were less likely to display the isolation effect when the isolate list was presented later, is also consistent with EF theory, suggesting that a habit built toward organizational processing will initially make it difficult for children to switch to distinctive processing (see Marcovitch & Zelazo, 2009). Finally, the relationship between cognitive flexibility and the isolation effect contributes to representational theories of EF, suggesting that improvements in EF are related to children's ability to form and reflect on representations of their environment (e.g., Marcovitch & Zelazo, 2009; Snyder & Munakata, 2010). Consequently, better cognitive flexibility should be related to the appreciation of list items' abstract category membership (e.g., Snyder and Munakata, 2010), facilitating organization, distinctive processing, and the isolation effect.

[2] This marginal DCCS by list by age interaction remained when DCCS was analyzed as a continuous variable, $\beta = .50$, Wald $\chi^2(1) = 2.65$, $p = .10$.

The current study also provides evidence for EF's differential contribution to memory. Cognitive flexibility appears to be a specific mental resource (see Bjorklund et al., 1997) critical to the isolation effect. This is compatible with the definition of cognitive flexibility, defined as the ability to consider multiple representations of a single item (e.g., Jacques and Marcovitch, 2010). More specifically, the isolation effect requires the target item to be considered both organizationally (i.e., item category) and distinctively (i.e., differences between the item and the background category). Interestingly, WM was not related to superior memory for distinctive information, but it appeared to most strongly influence total list recall. This replicates previous work (Ruffman et al., 2001) and provides additional evidence that EF components contribute to memory differently. Furthermore, the fact that superior WM in 6-year-olds was positively related to recall of the control target (and not the isolate target) might even be suggestive of a trade-off in this particular paradigm. More specifically, older children with higher WM Spans could be focused on total recall to the extent that it is difficult to disengage from the necessary organizational processing and distinctively process the isolated target.

In conclusion, children's difficulty with the isolation effect supports Hunt and Lamb's (2001) argument that distinctiveness is not inherent to an item. Rather, having the underlying memory processes necessary to generate item-specific differences against a background of similarity is crucial to the isolation effect. The current research suggests that organizational processing and cognitive flexibility likely play a role in preschoolers' demonstration of a semantic isolation effect. Although we chose to limit our focus to determine whether guided categorical processing and cognitive flexibility were related to an early semantic isolation effect, cognitive flexibility is likely broadly related to the isolation effect (e.g., memory for perceptually or numerically distinct information). Further research examining the isolation effect in other contexts and other individual differences will contribute to our understanding of the factors that underlie age-related changes in memory development.

Acknowledgments

The authors express their thanks to Douglas Levine for helpful discussions regarding analyses. In addition, we thank Paul Grey, Parnia Haj, Jessica Kowalski, Elizabeth Leavitt, and Ivy Lehtinen for help with data collection and the families who participated in the study.

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