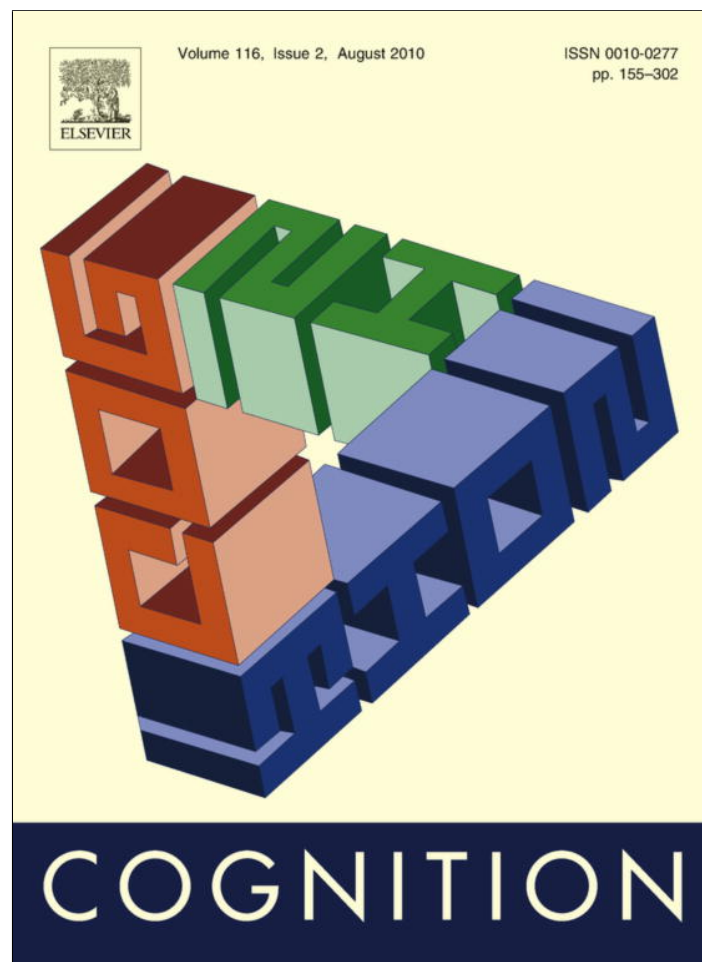


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Cognition

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Becoming self-directed: Abstract representations support endogenous flexibility in children

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ARTICLE INFO

Article history:

Received 7 November 2009

Revised 9 April 2010

Accepted 19 April 2010

Keywords:

Cognitive development

Endogenous flexibility

Verbal fluency

Switching

ABSTRACT

A fundamental part of growing up is going beyond routines. Children become increasingly skilled over the first years of life at actively maintaining goals in the service of flexible behavior, allowing them to break out of habits and switch from one task to another. Their early successes often occur with exogenous (externally-provided) goals, and only later with endogenous (internally-driven) goals – a developmental progression that may reflect the greater demands on selection processes inherent in deciding what to do. Three studies investigated the mechanisms supporting endogenous flexibility, using a verbal fluency task in which children generated members of a category and could decide on their own when to switch from one subcategory to another. Children's verbal fluency related to their performance in a more constrained and well-established switching task (Experiment 1), suggesting that the more complex verbal fluency measure taps the flexibility processes of interest. Children's verbal fluency was also linked to their abstract, categorical representations in both individual difference analyses (Experiment 2) and experimental manipulation (Experiment 3). We interpret these results in terms of the role of abstract representations in reducing selection demands to aid the development of endogenous control.

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1. Introduction

A key aspect of growing up is becoming self-directed in carrying out complex behaviors. Children are often driven by their desires in the moment, but they become increasingly flexible at doing what they are told, even when it requires overcoming prepotent behaviors (e.g. Davidson, Amso, Anderson, & Diamond, 2006). For example, preschool children learn to stop playing and start putting away the toys when told that it is clean-up time. Ultimately, children go on to develop the ability to overcome prepotent behaviors on their own, without being told what to do. For example, a school-age child may turn off the TV and start doing homework without being prompted. This need to switch endogenously from one task to another is pervasive in everyday life. The emergence of such abilities

can be seen as integral to children's self-control in the absence of strong environmental or adult support—arguably key to what it means to grow up.

Despite the importance of endogenous flexibility, relatively little is known about how it develops. This is likely due in part to the difficulty of running well-controlled studies in which children determine when it is time to switch from one task to another, and what task to switch to. Many cognitive flexibility tasks instead provide exogenous cues. For example, the Dimensional Change Card Sorting task (DCCS) provides exogenous cues for when to switch rules (e.g. “We're not going to play the color game any more!”) and what to switch to (e.g. “Now we're going to play the shape game!”) (e.g. Zelazo, 2006). Other tasks provide exogenous cues for when to switch, but require participants to endogenously determine what to switch to, albeit from a limited set of options. For example, in the Flexible Item Selection Task (FIST, Jacques & Zelazo, 2001), children are asked to match pictures on one

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dimension (e.g. color), then on another dimension (e.g. size) (Fig. 1). Although children are not told which dimension to switch to, only one correct dimension remains.

Studying endogenously-driven switching requires tasks that provide no exogenous switch cues. Rather, participants must detect the need to switch (i.e. when behavior must be changed to accomplish a goal), and select what to switch to. One relevant task is semantic verbal fluency, in which participants generate as many items as they can in 1 min from a category, such as animals (e.g. Sauzéon, Lestage, Raboutet, N'Kaoua, & Claverie, 2004). Maximal performance requires clustering (producing words within semantic subcategories) and switching (shifting between subcategories). To accomplish this, participants must endogenously detect the need to switch (e.g. when retrieval of more items from a subcategory fails) and select what to switch to (one of many possible other subcategories and items). Thus, verbal fluency has the potential to serve as a useful tool for investigating the development of endogenous flexibility.

1.1. Relation between exogenous and endogenous switching

Both endogenous and exogenous switching improve during development and decline during aging (e.g. Cepeda, Kramer, & de Sather, 2001; Kavé, Kigel, & Kochva, 2008; Troyer, Moscovitch, & Winocur, 1997). However, the development of endogenous flexibility lags behind that of exogenous flexibility. The basic ability to switch with exogenous cues emerges by age 3–4 for two task rules (e.g. Espy, 1997; Hongwanishkul, Happaney, Lee, & Zelazo, 2005), and by 7–12 for multiple rules (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001) (although exogenous switching shows fine-grained changes in efficiency through adolescence). Performance on the Wisconsin Card Sorting Test (Berg, 1948) (which provides weaker exogenous support through negative feedback) reaches adult levels at age 10, while fluency performance (which relies on fully endogenous control) continues to improve markedly through adolescence (e.g. Ardila, Rosselli, Matute, & Guajardo, 2005; Kavé et al., 2008; Matute, Rosselli, Ardila, & Morales, 2004; Riva, Nichelli, & Devoti, 2000; Sauzéon,

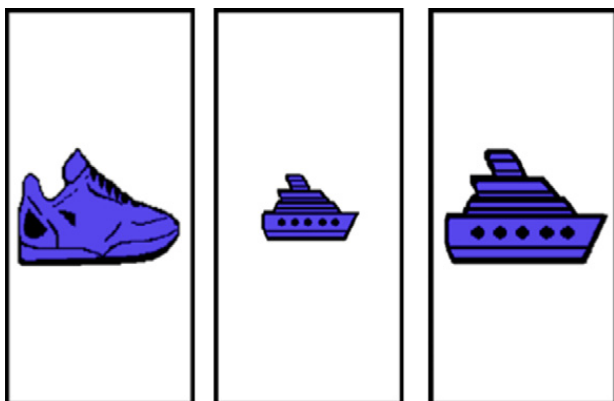


Fig. 1. Example item from the Flexible Item Selection Task (FIST). Children select a pair that matches on one dimension (e.g. shape), then select a pair that matches on a different dimension (e.g. size). Proportion of correct switches (given a correct first pair) is coded.

Lestage, Raboutet, N'Kaoua, & Claverie, 2004; Welsh, Pennington, & Groisser, 1991). Even in adults, cognitive control demands are higher for endogenous than exogenous switching (Bryck & Mayr, 2005; Forstmann, Brass, Koch, & von Cramon, 2005; Lie, Specht, Marshall, & Fink, 2006). Exogenous and endogenous switching may rely on partially shared mechanisms, while endogenous flexibility likely requires additional processes, making it more demanding and later to emerge during development.

1.2. Selection demands and the role of abstract, categorical representations in switching

One way endogenously-driven switching may be more demanding than exogenously-cued switching is in terms of selection demands. In endogenously-driven switching tasks (e.g. verbal fluency), competition among many alternative responses must be resolved in order to select one response. In contrast, in exogenously-cued switching tasks, participants are told what to do (e.g. sort by color), and thus selection demands are minimal. We propose that one potential mechanism supporting the ability to select what to switch to is the activation of abstract, categorical representations. Abstract representations encompass groups of lower-level instances (e.g. *farm animals* encompasses *horse, cow, pig*, etc.), coding for the shared features of category members while generalizing over irrelevant within-category variance (e.g. Son, Smith, & Goldstone, 2008). Abstract representations can provide top-down support for the relevant category members (Rougier, Noelle, Braver, Cohen, & O'Reilly, 2005), which may reduce competition from extra-category items, thus reducing selection demands. In the verbal fluency task, this process would limit the set of competing items from the entire set of all category members (e.g. all foods) down to the small pool in the subcategory (e.g. the 10 vegetables a child knows) when generating words within clusters, and to the small pool of other subcategories (e.g. fruits, breakfast foods) when switching between clusters. Thus, abstract, categorical representations may serve the same function as exogenous cues, constraining the search space, and so reducing selection demands.

Young children, who have a limited ability to resolve competition (e.g. Kail, 2002), may benefit from abstract representations even when selection demands are relatively low. For example, 3-year-olds who use more abstract rules are better able to switch exogenously in the DCCS task (Kharitonova, Chien, Colunga, & Munakata, 2009). Likewise, on the FIST, 4-year-olds switched more when the first dimension was labeled (e.g. color), providing an abstract dimension representation (Jacques, Zelazo, & Lourenco, submitted for publication). In endogenous switching tasks, where competition may be even higher due to multiple alternative responses, abstract representations may play a particularly important role in reducing selection demands.

1.3. Goals of the current studies

We propose that abstract, categorical representations of the task space reduce selection demands, allowing children

to more successfully switch endogenously from one task to another. Experiment 1 tests the relation between endogenously-driven switching during verbal fluency and a more constrained and established switching task (FIST, Jacques & Zelazo, 2001), to assess whether switching during verbal fluency taps cognitive flexibility, and not solely language-specific abilities. Experiment 2 explores the potential link between categorical representations and endogenously-driven switching during verbal fluency, and tests the replicability of Experiment 1. Experiment 3 tests whether categorical representations play a causal role in improving endogenously-driven switching, through a manipulation designed to promote the use of abstract subcategory representations (e.g. “vegetables” when producing foods in the verbal fluency task). Five-year-old children were selected for these studies because they are old enough to successfully complete the verbal fluency task (e.g. Riva et al., 2000) but still young enough to show individual differences in ability to switch on a more constrained switching task.

2. Experiment 1

This experiment tests the correlation between endogenously-driven switching between subcategories during verbal fluency and switching during the more constrained and established FIST task (Jacques & Zelazo, 2001). Since non-specific factors might contribute to a correlation between these tasks, two control measures were also included: a visual priming measure of implicit memory, and category vocabulary. If switching during verbal fluency taps cognitive flexibility, performance on this task should correlate with performance on FIST, and this relation should hold even when controlling for age, verbal ability (as assessed by category vocabulary), and general task performance or motivation (as assessed by visual priming).

2.1. Method

2.1.1. Participants

Fifty 58–62-month-olds participated in this experiment ($M = 60.2$; range 58.1–61.9; 24 girls). Eight participants were excluded from analysis due to fussiness (4), not speaking English as a first language (2), or chance performance on the first (pre-switch) selection in FIST (2). In addition, four participants did not complete the visual priming task, and two of these participants also did not complete the category vocabulary task, due to fussiness. Thus, data on the main tasks (verbal fluency and FIST) were available for 42 participants, and a complete set of measures was available for 38 participants. All participants were recruited from a database of families who had volunteered to participate in research, and parents gave informed consent. Parents were paid \$5 for travel expenses, and children received a small prize.

2.1.2. Design and procedure

All participants completed tasks in the same order: verbal fluency (animals and foods), FIST, visual priming, and category item picture-naming vocabulary. Children were

individually tested in a single session lasting approximately 45 min, with breaks given as needed.

2.1.2.1. Verbal fluency. In the verbal fluency task, children were asked to generate words from two semantic categories (animals and foods), after first completing a practice category (toys) to familiarize them with the task and help them become comfortable talking to the experimenter. One minute was given for each category.

To make the task engaging for children it was presented as a game. Children were given a clear plastic cup into which the experimenter placed a small pompom for each word the child produced. A 1-min sand-timer was used to help motivate children to stay on-task. Children were told: “We’re going to play a game where we think of lots and lots of words. I bet you’re really good at thinking of words, aren’t you? I’ll tell you what kinds of words to think of, and every time you tell me one, I’ll put a pompom in your cup. Let’s see how many pompoms you can get before all the sand is gone. I’ll bet you can get a lot! And when we are all done thinking of words, you can trade the pompoms for some stickers.” Before each category, the experimenter said: “This time I want you to tell me as many [category name] as you can think of. Can you think of lots and lots of [category name]? Ready, go!” If there was a pause of 10 s or more between items, the child was prompted (“Good job, can you tell me some more [category name]?”).

Verbal fluency data were transcribed from audio recordings, and coded by the experimenter and two independent raters blind to data on all other tasks. Coders identified clusters of semantically or phonologically related items (e.g. “lion, tiger, cheetah” when producing animals). Phonological clusters (words beginning with the same sound) were included in the scoring protocol for consistency with previous developmental studies of semantic verbal fluency (e.g. Koren, Kofman, & Berger, 2005). However, as only one child produced any phonological clusters, this has minimal impact on the results. A weighted switch score was calculated as follows: one point was awarded for each switch after a cluster of two related items, two points for a switch after three related items, three points for switch after four related items, and so forth. A weighted switch score was used because it reflects increasing confidence as cluster size increased that children were truly clustering and switching. Unweighted scoring systems (e.g. Troyer et al., 1997), which count every transition between subcategories (including between single, unclustered items) equally, have been criticized for confounding switching with a failure to cluster (e.g. Abwender, Swan, Bowerman, & Connolly, 2001). Abwender and colleagues (2001) therefore suggest counting only switches after clusters. We expand on this suggestion by weighting switch scores by cluster size. Inter-rater reliabilities were high ($>.90$ for all pairs).

2.1.2.2. Flexible Item Selection Task (FIST). The FIST was presented on a laptop computer equipped with a touchscreen. On each trial, children viewed three pictures varying in size, shape, and color, and are asked to select a pair based on one dimension (e.g. color), then switch to another

dimension (e.g. size) (Fig. 1). First, children were presented with one demonstration trial, in which the experimenter demonstrated picking two pictures that match on one dimension (e.g. color) and then two that match on a different dimension (e.g. size). Children were told: “First, I’m going to touch two pictures that go together in one way. So I’m going to touch this picture here (e.g. small yellow boat), and this picture here (e.g. large yellow boat), because these two pictures go together in one way. This picture over here (e.g. large red boat) does not go with these two pictures here, does it? No! So these two pictures go together in one way. Now do you know what I’m going to do? I’m going to touch two pictures that go together but in a different way. So I’m going to touch this picture here (e.g. large yellow boat) and this picture here (e.g. large red boat), because these two pictures go together but in a different way. This picture over here (e.g. small yellow boat) does not go with these two pictures here, does it? No! So these two pictures go together in a different way. So see, these two pictures here go together in one way (e.g. yellow boats), and these two pictures here (e.g. large boats) go together in a different way. Now it’s your turn!” Children then completed two practice trials with feedback, before completing 15 trials without feedback (“Touch two pictures that go together in one way. Now touch two pictures that go together in a different way. OK.”). Switching was coded as the proportion of second selections correct, given a correct first selection.

2.1.2.3. Visual priming (Drummey & Newcombe, 1995). The visual priming task was included as a control measure, to ensure that any individual differences effects are not the result of differences in general ability or motivation be-

tween children. This task was chosen because it is a challenging task (and thus should tap general ability and motivation) but is not believed to require cognitive control processes (Drummey & Newcombe, 1995). Ten line drawings of common objects were presented on the computer screen for 2 s each. Children were instructed to watch carefully and not say anything. Then, children were presented with degraded pictures (10 old and 10 new), and asked to guess what the picture was (“Now I’m going to show you some more pictures, but they’re going to look like pictures with pieces missing, kind of like a puzzle. I bet you’re good at doing puzzles! So we’re going to play a guessing game—I’m going to show you these pictures with pieces missing and I want you to try to guess what’s in the picture”). Progressively less degraded pictures (six levels) were presented until the child correctly named the picture, or until the complete picture was revealed (Fig. 2). Visual priming was calculated as the difference between the average level at which new and old pictures were correctly identified.

2.1.2.4. Category picture-naming vocabulary. Children were asked to name colored pictures of 20 animals and 20 foods. All unique category words were counted, even if they were not the correct name for the picture (e.g. rooster instead of turkey).

2.2. Results

2.2.1. Data filtering and validation

For all analyses, outliers were excluded for which the absolute value of $Df\beta$ (the change in the standardized regression coefficient resulting from excluding that case)

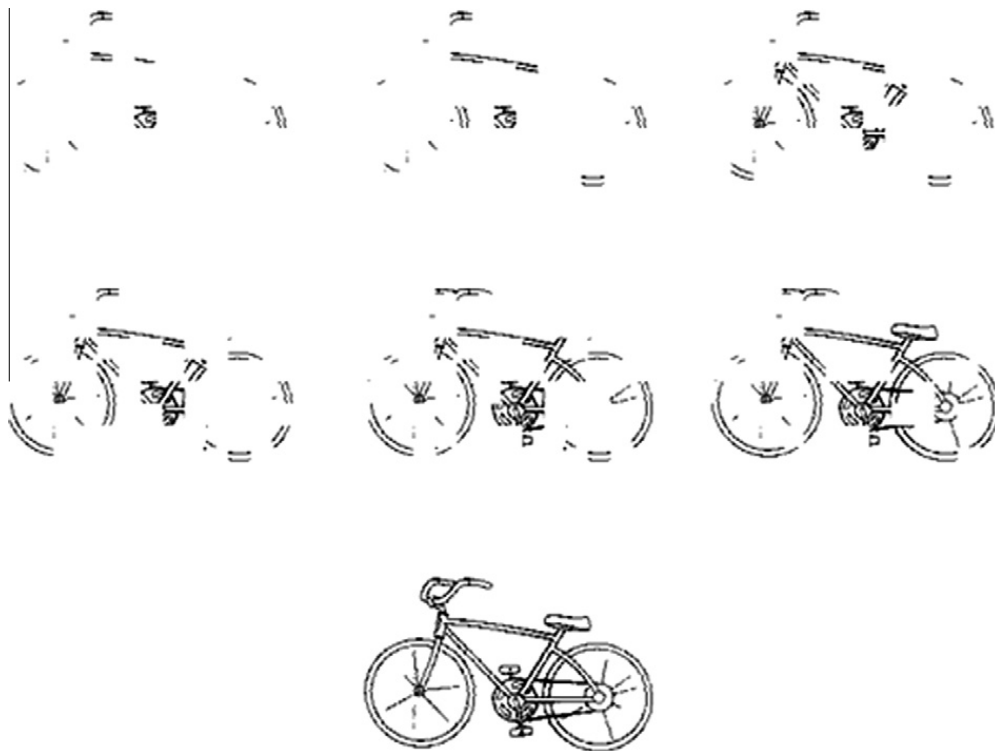


Fig. 2. Example stimuli from visual priming task. Pictures are revealed one at a time on the computer screen until the child correctly identifies the object.

exceeded $2/\sqrt{N}$. This resulted in the exclusion of no more than four cases from any analysis. Missing values on visual priming and picture naming were replaced with the mean for the purpose of including all cases in the regression analysis; excluding these cases did not change the pattern of results. Validating the visual priming task, children were able to identify old pictures significantly earlier ($M = 4.56$, $SD = 0.57$) than new pictures ($M = 5.31$, $SD = 0.44$) ($t(36) = 9.34$, $p < .001$). In the verbal fluency task, children switched marginally more when generating animals ($M = 3.49$, $SD = 2.08$) than foods ($M = 2.77$, $SD = 1.72$) ($t(37) = 1.92$, $p = .063$). However, as is standard for scoring the verbal fluency task, all analyses use the combined score (animals and foods) to give a more reliable estimate.

2.2.2. Verbal fluency and FIST

Descriptive statistics are given in Table 1, and examples of good and poor performance on verbal fluency are given in Table 2. All variables were entered simultaneously into a regression model, presented in Table 3. Endogenously-driven switching during verbal fluency predicted switching during FIST, controlling for age, visual priming and category vocabulary ($r(32) = .347$, $p = .044$).

Table 1
Descriptive statistics for Experiment 1.

Measure	Mean	Standard deviation	Range
VF switch score	6.00	3.21	0–13
FIST prop. switch	0.84	.18	0.33–1.0
Category vocabulary prop. correct	0.93	0.06	0.73–1.0
Visual priming	0.77	0.50	–0.60 to 1.70

Table 2
Examples of good and poor performance on verbal fluency. Switches between subcategories are calculated as the number of switches weighted by cluster size, such that a switch after a cluster of two items is awarded 1 point, after a cluster of three items, two points, and so forth. In the good performance example, the child would receive a switch score of eight (switching after seven zoo animals, two aquatic animals, and two pets, and finishing with two reptiles), while in the poor performance example, the child would receive a switch score of 0 (a single zoo animal cluster, with no switches). While coding of semantic subcategories is necessarily somewhat subjective, inter-rater reliability was high ($>.85$ for all pairs of raters, across all three experiments).

Good performance example		Poor performance example	
Word	Time	Word	Time
Lion	0:01	Elephant	0:01
Zebra	0:04	Jaguar	0:02
Elephant	0:05	Jaguar (repeat)	0:11
Hippo	0:07	Lion	0:29
Rhinoceros	0:10	Tiger	0:30
Giraffe	0:11	Elephant (repeat)	0:46
Tiger	0:22		
Turtle	0:30		
Fish	0:39		
Cat	0:42		
Dog	0:44		
Lizard	0:46		
Snake	0:58		

Table 3
Endogenously-driven switching during verbal fluency significantly predicts exogenously-cued switching during FIST, controlling for age and general ability (vocabulary and visual priming).

Predictor	Beta	t	p	Zero-order correlation	Partial correlation
VF switch score	.373	2.10	.044	.549	.347
Age	-.038	-.027	.792	-.064	-.047
Category vocabulary prop. correct	.299	1.66	.108	.524	.281
Visual priming	-.024	-.017	.867	.031	-.030

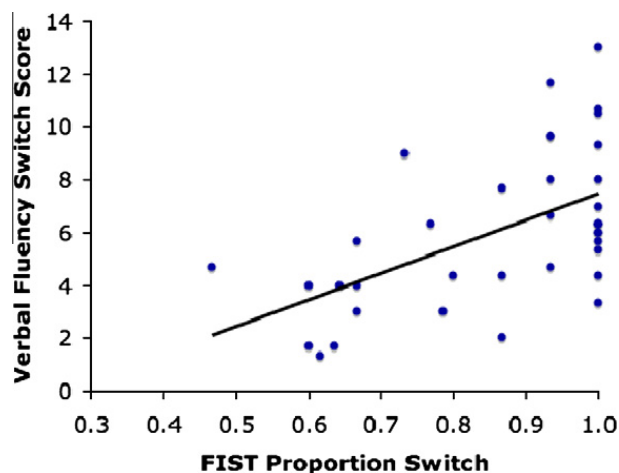


Fig. 3. Endogenously-driven switching during verbal fluency significantly predicts exogenously-cued switching during FIST (X-axis begins at chance for FIST).

2.3. Discussion

Children showed a relation between endogenously-driven switching during verbal fluency and switching during FIST, suggesting that endogenously-driven switching during verbal fluency partially relies on cognitive processes and/or neural mechanisms shared with more established switching tasks. Thus, the more complex and unconstrained verbal fluency task appears to tap the flexibility processes of interest. However, there is also substantial unshared variance. Indeed, some children who switched perfectly on the FIST nonetheless switched poorly during verbal fluency. We suggest that this may reflect the greater demands on selection processes inherent in more unconstrained switching tasks, such as deciding which of many possible exemplars to generate in the verbal fluency task.

Abstract categorical representations of the task space may be important for enabling children to switch during verbal fluency, by reducing these selection demands. Representing a subcategory, such as “fruit”, when thinking of foods, would substantially reduce the number of possible items that must be selected between when producing items in a cluster (since selection is between fruits, rather than all foods). In addition, subcategory representations would be expected to reduce selection demands when switching, since selection would be between all subcategories (e.g. vegetables, meats, breakfast foods), rather than

between all foods. This theory is consistent with evidence that patients with frontal damage are most impaired on language tasks when selection demands are high, and have difficulty producing items from large categories and switching between subcategories (Randolph, Braun, Goldberg, & Chase, 1993; Robinson & Cipolotti, 2004; Robinson, Shallice, & Cipolotti, 2006), and with evidence that abstract, categorical representations support switching on the DCCS (Kharitonova et al., 2009) and FIST (Jacques, Zelazo et al., submitted for publication). However, the relation between categorical representations, selection demands, and endogenously-driven switching has not been systematically investigated, and has not been explored in children (see Fig. 3).

3. Experiment 2

A first step towards testing whether abstract representations improve cognitive flexibility by reducing selection demands is to determine whether such representations are related to endogenous flexibility. Experiment 2 tests this question by exploring whether children who form more categorical, as opposed to associative, representations show better endogenously-driven switching during verbal fluency.

3.1. Method

3.1.1. Participants

Fifty 58–62-month-old children participated in this experiment ($M = 59.6$; range 58.2–61.7; 21 girls). Nine participants were excluded due to fussiness (5), equipment failure (2), or parental interference (1). In addition, four participants did not return for a second session (due to illness or family schedule) and thus did not complete the picture-sorting task, two did not complete the picture-sorting task due to fussiness, and two did not complete the Expressive Vocabulary Test (testing stopped before ceiling was reached). Visual priming data were not available for six participants because of a technical problem. Thus, data on the main tasks (verbal fluency and FIST) were available for 32 participants. All participants were recruited from a database of families who had volunteered to participate in research and parents gave informed consent. Parents were paid \$5 for travel expenses, and children received a small prize.

3.1.2. Design and procedure

Children were tested individually in two sessions, each lasting 30–45 min, approximately a week apart. In the first session, all participants completed tasks in the following order: verbal fluency (animals and foods), FIST, Expressive Vocabulary Test (EVT), and visual priming. In the second session, all participants first completed a category picture-sorting task (animals and foods), followed by other tasks for another study (which will not be discussed here).

3.1.2.1. Verbal fluency. Verbal fluency was administered as in Experiment 1. Children received the same instructions and practice category as in Experiment 1. Verbal fluency

data were transcribed from audio recordings, and coded by the experimenter and two independent raters blind to data on all other tasks. Coders identified clusters of semantically or phonologically related items (e.g. “lion, tiger, cheetah” when producing animals). Weighted switch scores were calculated as in Experiment 1. Inter-rater reliabilities were high ($>.85$ for all pairs).

3.1.2.2. FIST. FIST was administered as in Experiment 1, except for changes in the demonstration trial instructions designed to improve sensitivity. In Experiment 1, children scored unexpectedly well on FIST, switching correctly on an average of 12/15 trials. Thus, power may have been reduced by ceiling effects. To improve sensitivity in this age range, the amount of instructional support was reduced. During the demonstration trial, children were told: “First I’m going to touch two pictures that go together in one way. So I’m going to touch this picture here and this picture here, because these two pictures go together in one way. Now do you know what I’m going to do? I’m going to touch two pictures that go together but in a different way. So I’m going to touch this picture here and this picture here, because these two pictures go together in different way. Now it’s your turn!” (see Fig. 4).

3.1.2.3. Expressive Vocabulary Test (EVT). The EVT was substituted for the category picture naming task used in Experiment 1 to provide a more complete, valid, and reliable measure of verbal ability. The EVT (Pearson Assessments, Bloomington, MN) is a standardized, nationally normed, expressive vocabulary test. Children are shown colored pictures, and asked to name them, or provide synonyms (e.g. “Can you tell me another word for father?”). Testing continues until children reach ceiling (five items in a row incorrect), and raw scores are then converted into a percentile score based on age.

3.1.2.4. Visual priming. Visual priming was administered as in Experiment 1, except that a shorter version was used. The task was shortened as children in Experiment 1 showed signs of fatigue and sometimes became fussy during the longer version of the task. Twelve items showing the strongest priming effects were selected from the original 20 items. One order was used for all participants, as is standard to improve sensitivity to individual differences.

3.1.2.5. Picture-sorting. Children were asked to sort two sets of 22 picture items (animals and foods). In addition, the last two items in each set were non-category members (two furniture items or two vehicles), to provide a measure of whether children could sort pictures categorically. Children were presented with color pictures, one at a time, which were labeled by the experimenter. After the pictures had been previewed once, the children were asked to sort them (“Now we’re going to make piles of all the pictures you think go well together. You can make as many different piles as you want to”). For each item children were asked: “Here’s a [item label]. Does it go well with any of these piles, or does it need its own pile?” Children were coded as passing picture-sorting if they grouped the two non-category items (e.g. the two vehicles) together and separately

from the other items. The original motivation for using this task to measure category representations was to examine whether children were able to sort cards by subcategories (e.g. put farm animals together and separately from zoo animals). However, the primary task of free sorting all the animals and foods proved too difficult for this age group; children's sorting often appeared to be driven by perceptual factors, such as color or shape, rather than semantic factors, leading to generally poor performance and providing no information about individual differences. The simpler task of sorting the non-category members with each other and separate from the other items was a more sensitive measure of individual differences in category representations. Although this simpler task requires sorting by larger categories (e.g. animals vs. vehicles) while the verbal fluency task requires switching between subcategories (e.g. farm animals and zoo animals), we argue that both tasks tap abstract, categorical representations.

3.2. Results

3.2.1. Data filtering and validity

For all analyses, outliers were excluded as in Experiment 1. This resulted in the exclusion of no more than four cases from any analysis. Missing values on visual priming and EVT were replaced with the mean for the purpose of including all cases in regression analyses; excluding these cases did not change the pattern of results. Validating the visual priming task, children were able to identify old pictures significantly earlier ($M = 4.21$, $SD = 0.67$) than new pictures ($M = 5.81$, $SD = 0.54$) ($t(35) = 14.65$, $p < .001$). In the verbal fluency task, there was no significant difference between switching when generating animals ($M = 3.13$, $SD = 2.09$) and foods ($M = 2.63$, $SD = 1.63$) ($t(36) = 1.41$, $p = .168$). As in Experiment 1, all analyses use the combined score.

3.2.2. Verbal fluency and FIST

Descriptive statistics are given in Table 4. All variables were entered simultaneously into a regression model, pre-

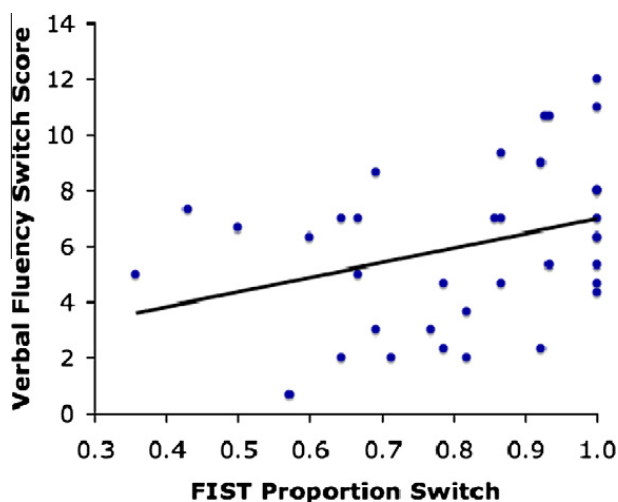


Fig. 4. Endogenously cued switching during verbal fluency significantly predicts exogenously-cued switching during FIST in Experiment 2 (X-axis begins at chance for FIST).

Table 4
Descriptive statistics for Experiment 2.

Measure	Mean	Standard deviation	Range
VF switch score	5.9	3.3	0.7–14
Pass picture sort	43.9% pass	–	–
FIST prop. switch	0.79	0.20	0.33–1.0
EVT percentile	81.1	18.1	34–99.9
Visual priming	1.6	0.66	0.5–2.8

sented in Table 5. Children showed a relation between endogenously-driven switching during verbal fluency and switching during FIST, replicating Experiment 1. Endogenously-driven switching during verbal fluency predicted switching during FIST, controlling for age, visual priming and expressive vocabulary (EVT) ($r(32) = .369$, $p = .032$).

3.2.3. Role of categorical representations

Of the 35 children who completed the picture-sorting task, 18 (51%) passed picture-sorting (sorting the two non-category members together and separately from the other cards for both the animal and food picture sort), while nine children (26%) failed picture-sorting, and eight children (23%) showed mixed performance (passing for one sort but not the other). Children who passed the picture-sorting task switched more during verbal fluency ($M = 6.6$, $SD = 2.9$) than children who failed picture-sorting ($M = 3.3$, $SD = 2.2$) ($t(25) = 3.09$, $p = .005$). Children who showed mixed performance switched more during verbal fluency ($M = 7.1$, $SD = 4.1$) than children who failed picture-sorting ($t(15) = 2.43$, $p = .028$), and did not differ from those that passed both sorts ($t(24) = -0.33$, $p = .7$); thus, children passing at least one sort were grouped together for the analyses below. When children showing mixed performance are excluded, the same results are found. The relationship between picture-sorting and verbal fluency appears to be somewhat specific, as there was no relationship between picture-sorting and visual priming ($M = 1.7$, $SD = .66$ vs. $M = 1.4$, $SD = .52$; $t(33) = 1.14$, $p = .3$). Children who passed at least one picture-sorting trial had higher EVT scores ($M = 85.9$, $SD = 14.2$ vs. $M = 67.8$, $SD = 20.0$; $t(33) = 2.97$, $p = .006$); however, controlling for EVT scores, children who passed at least one picture-sorting trial still switched more during verbal fluency ($F(1, 32) = 5.95$, $p = .02$), but not on FIST ($F(1, 32) = 1.30$, $p = .3$). Thus, the ability to use categories to sort cards predicts endogenously-driven switching in verbal fluency, but not switching on the more constrained FIST task, beyond general ability alone.

Table 5
Endogenously-driven switching during verbal fluency significantly predicts exogenously-cued switching during FIST, controlling for age and general ability (vocabulary and visual priming).

Predictor	Beta	t	p	Zero-order correlation	Partial correlation
VF switch score	.333	2.24	.032	.332	.369
Age	.395	2.78	.009	.301	.441
EVT	.377	2.62	.013	.445	.420
Visual priming	-.025	-0.17	.864	.071	-.031

3.3. Discussion

Endogenously cued switching during verbal fluency and switching during FIST are related, even when controlling for non-specific factors (verbal ability and implicit memory). This finding replicates and extends Experiment 1, using a standardized measure of expressive vocabulary to control for verbal ability, suggesting that the more complex verbal fluency measure taps cognitive flexibility processes shared with more constrained switching tasks. In addition, children who were able to correctly sort two extra-category items (e.g. chair and stool) together and apart from category items (e.g. animals) switched significantly more during the endogenous verbal fluency task, controlling for general ability. This finding is consistent with the idea that endogenously-driven switching imposes high selection demands, and abstract, categorical representations may support endogenously-driven switching by reducing the number of competing alternatives. We elaborate this possibility and consider alternatives after presenting the results of Experiment 3.

We suggest two potential reasons for why picture-sorting performance did not predict switching on FIST. First, FIST is a more constrained task in which the dimension to be switched to is fully specified by the picture stimuli. Thus, as discussed in the Introduction, FIST has lower selection demands than the fully-endogenous verbal fluency task. If abstract representations improve switching by reducing selection demands, they would be expected to confer a greater benefit when selection demands are high (as in the verbal fluency task). Second, the picture-sorting task taps abstract *semantic* representations of categories used in the verbal fluency task (e.g. animals), while FIST may rely instead on *perceptual* categories (size, shape, and color) not assessed by the picture-sorting task. We return to this point in the General Discussion.

In terms of why children showed such poor picture-sorting performance overall, one possibility is that the picture stimuli provided highly salient perceptual information that interfered with children's ability to use their conceptual knowledge to sort the pictures. That is, the pictures may have induced children to sort based on color or shape rather than subcategory, or to focus on the perceptual differences between items in a subcategory rather than their similarities. Future experiments using word cards instead of pictures, with slightly older children who are able to read, may address this question.

The relationship between picture-sorting and verbal fluency is suggestive, but we cannot infer a causal link between abstract, categorical representations and endogenous switching from this study of individual differences. Experiment 3 tests this causal link.

4. Experiment 3

Experiment 3 tests a manipulation designed to improve endogenously-driven switching by promoting the use of abstract subcategory representations (e.g. fruit when producing foods). While adults discover and make use of these structures spontaneously, some young children appear not

to, and may benefit from prompts that support abstract representations of the task space. If abstract, categorical representations support endogenous flexibility, providing children with examples of subcategories should improve switching during verbal fluency more than providing them with examples of individual category members. While providing children with subcategories could be viewed as making the task less endogenous, this manipulation does not provide children with any cues as to *when* to switch, nor are children instructed to use these subcategories, unlike the direct instructions children receive at each step in exogenously-cued tasks. Moreover, we can measure children's switching to subcategories that were not provided, as a purer measure of endogenous switching.

4.1. Method

4.1.1. Participants

Twenty-five 58–62-month-old children ($M = 59.9$, range 58.1–61.8, 15 girls) participated in this experiment. One participant was excluded due to fussiness, leaving 12 in each condition. All participants were recruited from a database of families who had volunteered to participate in research and parents gave informed consent. Parents were paid \$5 for travel expenses, and children received a small prize.

4.1.2. Design and procedure

All participants were tested individually in one session lasting approximately 45 min. All participants completed tasks in the following order: verbal fluency (animals and food, subcategory label or control condition), picture-sorting, FIST, EVT, and visual priming.

4.1.2.1. Verbal fluency. Verbal fluency was administered and scored in the same way as in Experiments 1 and 2, with an added between-subjects manipulation. After completing a practice category (household items), children generated foods and animals. In the subcategory label condition, the experimenter provided three initial subcategory labels (e.g. desserts, breakfast foods, and vegetables), while in the control condition, the experimenter provided three exemplars from the same three subcategories, without labeling the subcategory (e.g. cupcakes, toast, and onions). The subcategory label manipulation could be interpreted as actually drawing children's attention away from more abstract representations (e.g. "food") towards less-abstract representations (e.g. "desserts"), contradicting the claim that this manipulation increases reliance on abstract representations. However, children in both conditions hear the large category labels ("foods" and "animals") the same number of times – the distinction is whether they additionally hear subcategory labels (e.g. "desserts") or exemplar labels (e.g. "cupcake"). If any benefits to switching were caused by drawing attention away from the more abstract representations (e.g. "food"), it is not clear why exemplar labels would be any less effective than subcategory labels at doing so.

Subcategories were selected to be familiar and salient to children, based on clusters of items produced in Experiments 1 and 2. Exemplars given in the control condition

were selected based on age of acquisition norms (Morrison, Chappell, & Ellis, 1997) and items produced in Experiments 1 and 2, to be familiar to children, but infrequently produced (by an average of only 4% children across Experiments 1 and 2), so as not to significantly impact children's options. For example, for the food category, children in the subcategory label condition were told: "We're going to think of lots of foods. There are so many different kinds of food. There are desserts – yes, desserts are food, I know desserts! There are breakfast foods – yes, breakfast foods are food, I know breakfast foods! There are vegetables – yes, vegetables are food, I know vegetables! Vegetables, desserts and breakfast foods – there are so many kinds of food! Let's think of more foods!" Children in the control condition were told: "We're going to think of lots of foods. There are so many different kinds of food. There are cupcakes – yes, cupcakes are food, I know cupcakes! There are onions – yes onions are food, I know onions! There is toast – yes, toast is food, I know toast! Cupcakes, onions and toast – there are so many kinds of food! Let's think of more foods!" Both groups were then given the same example item (e.g. "cookie"), with the experimenter saying, "I'll get you started – cookie! Now it's your turn—can you tell me more foods?" If abstract representations promote switching in endogenously-driven tasks, providing children with abstract subcategory information that can be used to group items should improve performance beyond simply providing exemplars in the control condition.

Verbal fluency data were transcribed from audio recordings, and coded by the experimenter and two independent raters blind to data on all other tasks. Coders identified clusters of semantically or phonologically related items (e.g. "lion, tiger, cheetah" when producing animals). Weighted switch scores were calculated as in Experiments 1 and 2. Inter-rater reliabilities were high (>.90 for all pairs).

4.1.2.2. Picture-sorting. A modified version of the picture-sorting task in Experiment 2 was used, designed to give a more sensitive measure of children's ability to use categorical information to sort. Children were asked to sort 12 pictures into piles that "go well together": four each, animals, foods, furniture, and vehicles. Children were first shown all the pictures and told the name of each. Then, the experimenter presented the pictures one at a time, in random order, for children to sort into piles. The picture-sorting task was included to test whether the labeling manipulation may carry-over, affecting the degree to which children sort categorically in the picture-sorting task. Number of categories correctly sorted (all four category members placed together and separately from other category members) was scored.

4.1.2.3. FIST, visual priming, and EVT. These tasks were administered as in Experiment 2. FIST was included to determine if the cueing manipulation in the verbal fluency task would carry over to FIST performance. Visual priming and EVT were included as control tasks to ensure that the two experimental groups do not differ on all measures.

4.2. Results

4.2.1. Data screening and validity

Validating the visual priming task, children were able to identify old pictures significantly earlier ($M = 4.49$, $SD = 0.86$) than new pictures ($M = 5.92$, $SD = 0.48$) ($t(23) = 8.1$, $p < .001$). On the picture-sorting task, children sorted significantly more than zero categories correctly ($t(23) = 4.0$, $p = .001$), suggesting that they understood the instructions. (Since children could sort cards into any combination and group size, the number of possible outcomes is extremely large. Thus, the exact chance level is difficult to calculate but is essentially zero.)

In the verbal fluency task, there was no significant difference between switching when generating animals ($M = 3.00$, $SD = 1.94$) and foods ($M = 2.44$, $SD = 2.08$) ($t(23) = 1.12$, $p = .273$). As in Experiments 1 and 2, all analyses use the combined score.

4.2.2. Effect of labeling subcategories on verbal fluency and picture-sorting

Descriptive statistics are given in Table 6. As predicted, children in the subcategory label condition generated more words ($M = 18.9$, $SD = 4.5$) than those in the control group ($M = 14.3$, $SD = 3.9$) ($t(22) = 2.71$, $p = .013$), and switched more during verbal fluency ($M = 7.4$, $SD = 3.1$) than those in the control condition ($M = 3.7$, $SD = 2.0$) ($t(22) = 3.46$, $p = .002$). This switching advantage was not limited to the subcategories the children were presented with: Children in the subcategory condition switched more than children in the control condition to both labeled subcategories ($M = 4.7$, $SD = 2.6$ vs. $M = 2.4$, $SD = 1.6$, $t(22) = 2.59$, $p = .017$) and to other subcategories ($M = 2.5$, $SD = 2.1$ vs. $M = 1.2$, $SD = 0.8$, $t(22) = 2.06$, $p = .051$). The difference between groups was not due to differences in general ability or age, as children in the two conditions did not differ in age ($t(22) = 1.04$, $p = .310$), EVT score ($t(22) = .956$, $p = .349$), or visual priming ($t(22) = -1.34$, $p = .194$). The effects of labeling subcategories in verbal fluency did not carry over to picture-sorting performance ($t(22) = 1.27$, $p = .219$) or to FIST ($t(22) = 0.35$, $p = .731$).

Table 6

Descriptive statistics for Experiment 3. Note: VF number of words is total words generated in animals and foods categories. Picture sort scores are number of correctly sorted categories out of 4.

Measure	Mean	Standard deviation	Range
<i>Subcategory label group:</i>			
VF switch score	7.4	3.1	2.3–10.7
VF number of words	18.9	4.5	10–25
VF cluster size	1.9	0.4	1.3–2.7
Picture-sorting	1.8	1.8	0–4
FIST prop. switch	0.77	0.24	0.3–1.0
EVT percentile	77.5	14.0	58–99.5
Visual priming	1.2	0.7	0.3–2.3
<i>Control group:</i>			
VF switch score	3.7	2.0	0.3–7.0
VF number of words	14.3	3.9	5–19
VF cluster size	1.7	0.4	1.2–2.7
Picture-sorting	0.9	1.4	0–4
FIST prop. switch	0.73	0.20	0.5–1.0
EVT percentile	71.2	18.4	30–98
Visual priming	1.7	1.0	0.2–3.2

To test for the possibility that providing subcategory labels does not specifically increase switching, but rather non-specifically increases the number of words produced, and thus the opportunity to accrue larger clusters and switch scores, scores were normalized for number of words and cluster size. Normalizing for the number of words produced or average cluster size, children in the subcategory label condition still switched significantly more than those in the control condition ($t(22) = 2.40$, $p = .025$, and $t(22) = 2.64$, $p = .015$, respectively). Because switching is thought to partly determine the number of words generated (e.g. Troyer et al., 1997), Troyer and colleagues (e.g. Troyer, 2000; Troyer et al., 1997) have compellingly argued that correcting switches for total words generated is inappropriate, as it amounts to correcting a cause for its effect. Therefore, we focus on the non-normalized switch scores, but include the alternative normalized analysis here.

4.3. Discussion

As predicted, children who were provided with subcategory labels, designed to induce the use of abstract, categorical representations, generated more words and switched more during verbal fluency than children who were provided exemplars, independent of age or general ability. We interpret this effect primarily in terms of the role of abstract representations in reducing selection demands to aid endogenous control. Specifically, abstract subcategory representations (e.g. of fruits when generating foods) constrain the search space to only subcategory members, reducing selection demands. Likewise, when a subcategory is exhausted, necessitating a switch to another subcategory, selecting a new subcategory (e.g. vegetables, from among the small set of food subcategories) imposes lower demands than selecting from among all possible items in the category (e.g. carrot from among all possible foods). Thus, we argue that the effect of abstract representations on selection demands is central to their ability to support endogenous flexibility.

The results of Experiment 3 could also reflect a role of subcategory labels in serving as retrieval cues (e.g. “vegetables” is associated with vegetable exemplars, and thus cues their retrieval). However, if the subcategory labels acted only as retrieval cues for associated exemplars, they would be expected to increase the number of words generated only within the cued subcategories, and not improve switching to non-cued subcategories. A retrieval cue account could be expanded to suggest that subcategory labels also cue other subcategory representations. This expanded account seems compatible with our focus on the role of abstract representations in reducing selection demands (within and among subcategories) to support endogenous flexibility.

The results of Experiment 3 demonstrate for the first time that children show benefits specific to the cueing of categorical representations in an endogenously-driven switching task. As noted earlier, while children who hear subcategory labels are provided with initial cues, they are not cued during the task itself, and thus must still detect the need to switch and select what to switch to endoge-

nously. This is in clear contrast to more exogenously-cued tasks, such as FIST, where children are explicitly instructed when to switch on every trial. Nor are children in Experiment 3 dependent on only the subcategories provided to them by the experimenter, as children also switched significantly more to other subcategories, which they had not been provided with. Thus, providing children with some initial help in activating abstract representations appears to help them to subsequently act in a self-directed manner. However, this benefit did not transfer to later tasks, suggesting that children may only benefit from cues that are provided immediately before, and/or specific to, the task at hand.

Similarly, in the memory retrieval and semantic knowledge literature, there is evidence that children do not spontaneously use such abstract representations, but can benefit from cues to do so. For example, in picture-sorting and free-recall tasks without explicit strategy instructions, 4 and 5-year-olds tend not to use any identifiable category structure, and often rely on perceptual information (Blaye, Bernard-Peyrone, Paour, & Bonthoux, 2006; Blaye & Bonthoux, 2001). While even 7–10-year-olds do not spontaneously group items by category during free-recall, inducing children to use such categories (through explicit instruction or sorting) improves recall (Ackerman, 1996; Corsale & Ornstein, 1980; Rabinowitz, 1984). In addition, providing children with category labels helps 4 and 6-year-olds (but not 3-year-olds) to correctly say that pairs of pictures belonging to the same category are alike (Nguyen, 2007). Thus, providing children with initial support to activate abstract, categorical representations may be beneficial across domains where children must access and organize semantic information.

5. General discussion

Early in development, children rely on exogenous support from adults and the environment around them in order to behave flexibly. Gradually, however, children gain endogenous control over their behavior, and are able to flexibly switch between tasks without being told what to do. This set of experiments begins to shed light on what drives this critical aspect of development. Experiments 1 and 2 suggest that endogenously-driven switching in situations requiring selection between many competing alternatives taps aspects of cognitive flexibility shared with more constrained tasks that have been previously used to examine switching in children. However, endogenously-driven switching nonetheless appears to be more demanding and later to emerge during development. We suggest that this may be due to higher selection demands in endogenously-driven tasks. Although selection may play a role in both endogenously-driven switching and switching on more constrained tasks, this demand is most likely higher during endogenously-driven switching, where there are more alternative responses. Thus, abstract, categorical representations that reduce selection demands may be particularly beneficial during endogenously-driven switching. In accord with this prediction, Experiments 2 and 3 demonstrate that abstract, categorical representations are linked

to endogenous switching during verbal fluency; children with more categorical representations make more endogenous switches, and providing children with category information increases their subsequent endogenous switching, to both the categories provided and to other categories.

Given the subjective nature of coding categories associated with exemplars generated in verbal fluency, one might ask how well adult coding captured children's categories across our three studies. Several types of evidence suggest that the coding was valid. First, across all three of our studies, the intervals between words within clusters ($M = 4.25$ s, $SD = 2.15$) were significantly shorter than intervals between non-clustered words ($M = 7.09$ s, $SD = 2.74$) ($t(105) = -10.12$, $p < .001$), just as is found in adults (e.g. Gruenewald & Lockhead, 1980; Pollio, 1964; Rosen & Engle, 1997). Second, there are commonalities across development in the structuring of semantic space. For example, young children (5–6 years), older children, and adults all organize animals by habitat/environmental context (e.g. farm animals, zoo animals) (Crowe & Prescott, 2003; Grube & Hasselhorn, 1996; Storm, 1980). While there is clear development in semantic representations beyond early childhood (e.g. in the understanding that clouds are non-living and plants are living; Carey, 1988; Piaget, 1960; Richards & Siegler, 1986), the semantic categories relevant for the current studies appear to be in place by early childhood. Third, if children did not share the adult subcategories used in the subcategory label condition of Experiment 3, this manipulation should not have been effective in reducing selection demands and improving performance. Thus, although children likely have some idiosyncratic categories not captured by the coding scheme, their semantic representations appear to be similar enough to adults' to make the current coding method valid, such that different semantic spaces are not driving our results.

To quantify how subcategory representations could reduce selection demands, we used Latent Semantic Analysis (LSA, Landauer, Foltz, & Laham, 1998) to calculate the amount of competition (defined as LSA entropy, which increases as more items are more equally associated with a category or subcategory label) between exemplars (items generated by at least two children across experiments) given either category (animals, foods) or subcategory (e.g. farm animals, vegetables) labels. LSA entropy was calculated as in Snyder and Munakata (2008), except that the youngest child space (General Reading through 3rd grade) was used. Briefly, association strength between a category or subcategory label and each exemplar was calculated using LSA. Competition was then computed as entropy across these LSA association values ($H = -\sum(p(i) \cdot \ln p(i))$, where $p(i)$ is the cosine between the label and each exemplar, divided by the sum of LSA cosines across exemplars). Entropy is zero when there is only one associate and increases as multiple exemplars are more equally associated with the category or subcategory label. Competition between exemplars was substantially lower given subcategory labels than category labels (Table 7). Moreover, competition between subcategories (e.g. farm animals, zoo animals, ocean animals, etc.) was substantially lower than between all exemplars (Table 7). Thus, subcategory representations can reduce competition both when

Table 7

Competition (calculated as LSA entropy) between all exemplars in each category, between exemplars within example subcategories, and between subcategories. Subcategory representations substantially reduce competition both within clusters and when switching.

	Foods	Animals
Entropy between all exemplars in category ^a :	4.43	4.11
Entropy between exemplars in example subcategories ^b :	Vegetables: 2.71	Farm animals: 2.15
	Desserts: 2.16	Ocean animals: 2.48
	Breakfast foods: 2.26	Zoo animals: 2.57
Entropy between subcategories ^c :	2.12	1.68

^a Entropy calculated across LSA cosines between each category label (animals, foods) and each exemplar generated by at least two children across studies.

^b Entropy calculated across LSA cosines between each subcategory label (e.g. farm animals) and each exemplar judged to belong to that subcategory generated by at least two children across experiments.

^c Entropy calculated across LSA cosines between all subcategories produced by children for each category and the category label.

switching between subcategories and when selecting items within clusters.

These analyses also highlight the importance of the match between categories and the domain in which switching is assessed. That is, abstract categorical representations should only be effective in reducing selection demands (and thus improving switching), when they are associated with the exemplars that must be switched between. This may explain why the benefit of abstract categorical representations on switching during verbal fluency in Experiments 2 and 3 did not transfer to FIST. Such benefits might only be apparent when appropriate abstract representations (size, shape, and color for FIST) are provided or measured. Future work is needed to test this possibility, as well is the broader generalizability of our findings to other tasks and domains.

This selection-demand perspective may suggest commonalities between cognitive abilities that have generally been treated as distinct in the literature: switching from one thing to another (e.g. subcategories in verbal fluency, and dimensions in FIST and DCCS) and selecting between competing alternatives in situations that do not require switching (e.g. saying a word to complete a sentence, where there are multiple possible responses). That is, selection must occur whenever multiple representations compete, whether those representations are of the dimensions a picture can be sorted by in FIST and DCCS, the multiple items that could be generated next during verbal fluency, or the multiple words that complete a sentence.

Our findings relating endogenous flexibility and abstract representations add to a growing body of evidence linking executive function to abstract, symbolic, and categorical representations (e.g. Gentner, 2003; Jacques, Blaye, Prusky, & Ellefsen, submitted for publication; Kharitonova et al., 2009; Luria, 1959). The ability to form and employ such representations in the service of cognitive control may be tied to the maturation of anterior prefrontal cortex. Several theories posit a caudal-rostral gradient in PFC, such

that increasingly abstract representations are supported by more anterior areas (Badre, 2008; Christoff & Gabrieli, 2000; Koechlin, Ody, & Kouneiher, 2003). Of particular relevance, it has been suggested that the gradual maturation of rostral PFC may underlie children's ability to use increasingly abstract rules to guide behavior (Bunge & Zelazo, 2006). Such hierarchical models suggest that abstract representations (e.g. of a subcategory in the verbal fluency task) in anterior PFC regions may provide top-down support to bias competition between less-abstract representations (e.g. of individual exemplars in the verbal fluency task) in more posterior regions of PFC, reducing selection demands.

Although we have focused on selection, endogenously-driven switching may require additional processes not required by exogenously-cued switching, such as monitoring for the need to switch. This may require sustained goal maintenance and some degree of metacognition, which are challenging for young children (e.g. Marcovitch, Boseovski, & Knapp, 2007; Pillow, 2008). For example, switching at the optimum time during verbal fluency requires sustained goal maintenance (e.g. maintaining the goal to generate as many items from the category as possible) as well as maintenance of the current subcategory, and detecting when further retrieval from the current cluster is unlikely, thus motivating a switch. In addition, while we have focused on the role that abstract representations may play in reducing selection demands, they may also aid other processes relevant to endogenous flexibility, such as retrieval. Thus, while we believe that abstract representations and selection processes are key, endogenous flexibility is a complex phenomenon in which multiple additional mechanisms likely also play a role.

While children's exogenously-cued switching has been studied extensively, much less work has been focused on understanding the processes and representations supporting the development of endogenous flexibility. The real world is replete with endogenous switching demands – as we move through the tasks in our day we must control and sequence our own behavior in the absence of strong environmental support. Our findings highlight the importance of selection processes and abstract representations in such self-directed behavior. These findings may have implications for how best to scaffold children towards becoming more self-directed. Helping children form more abstract, categorical representations of their options may aid them in endogenously switching from one activity to another. For example, helping preschool-age children learn the names for different activities in their day (e.g. “play time”, “getting ready to go outside”), rather than just their component activities (“putting on your coat”) may help them begin to transition between activities without being told what to do. Investigating such processes should inform an understanding of how we come to do the right thing, in the right place, at the right time, without being told – a fundamental part of growing up.

Acknowledgments

Many thanks to Eliana Colunga and Al Kim for valuable discussions. Thanks also to Lauren Gindin, James Kole, Char

Coombs and Meghan Cronk who served as independent data coders, and to all the members of the Cognitive Development Center for their assistance and helpful discussions. This research was supported by grants from the National Institutes of Health (RO1 HD37163 and P50 MH079485).

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