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Do Children Generate Labels to Support Proactive Control?

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Abstract

An important shift in development is the increasing ability to proactively engage executive function instead of reactively. We tested the possible influence of language on proactive control. We used a task in which children had to track a moving novel target shape on a screen in the midst of novel distractor shapes and then identify where the target disappeared. There was no difference in tracking accuracy for previously unseen and unlabeled targets between children who received useful labels for a set of shapes and those who only received generic names. However, children who only received generic names were more likely to provide a label for the unlabeled shapes compared to children who received labels. It is possible that these labels were generated during the task to aid the engagement of proactive control. These findings add to our limited understanding of the relationship between language and proactive control, and provide future directions, such as ways to better measure self-generated labels.

Key words: Executive Function, Proactive Control, Labels and Spontaneous Labeling

Do Children Generate Labels to Support Proactive Control?

Exercising control to achieve goals is an important aspect of daily life; where would we be if we followed our every desire, did not inhibit emotional surges, or were inflexible at switching between tasks? Extensive research shows that goal-directed behavior is supported by cognitive processes called executive function. Executive function is integral to children's everyday experiences, and predicts success across a variety of outcomes such as academics, wealth and health (e.g., Hoskyn, Iarocci & Young, 2017; Moffitt, Arseneault, Belsky, Dickson, Hancox, et al., 2011). Children's communicative and social competencies as well as their ability to control their environment are all connected to their executive functioning (Hoskyn et al., 2017).

As children develop, their executive function shifts from being reactive, engaged in goal-directed behavior the moment the need arises, to proactive, engaged in anticipation of needing it (Andrews-Hanna et al., 2011; Chatham, Frank, & Munakata, 2009; Chevalier, Martis, Curran, & Munakata, 2015; Waxer & Morton, 2011). For example, on a hot sunny day a 5-year-old may reactively go back inside in order to get a hat, whereas a 7-year-old might anticipate the need for a hat and go get one in preparation for heading outside. When comparing proactive control in 5- and 10-year-olds, the 5-year-olds only engage in proactive control when engaging in reactive control is comparatively more difficult (Chevalier et al., 2015). In contrast, 10-year-olds engage in proactive control as much as possible, suggesting that as children age, they start using proactive control more frequently (Chevalier et al., 2015).

Language may aid executive function by providing information that can facilitate the engagement of proactive control (Doebel, Dickerson, Hoover & Munakata, 2017). There is ample empirical evidence indicating that language supports executive function. For example, when children were told to label information pertinent to an upcoming task, it enhanced their task-switching performance (e.g., Kray, Eber & Karbach, 2008; Kirkham, Cruess, & Diamond, 2003). However, only limited research has examined the influence of language on proactive control. For example, one study examined the influence of labels on proactive control by using the Track-It computer task because it has been shown to measure children's proactive control (Doebel, Barker et al., 2017; Fisher, Thiessen, Godwin, Kloos, & Dickerson, 2013). In this study, 4- and 5-year-old children completed the Track-It task by first tracking a novel, grey scale target shape that moved quickly around the screen amidst distractors and then identifying where the target was before it disappeared (Doebel et al., 2017). Successful performance on this task requires tracking the shape's location proactively in anticipation of it disappearing. In the Label condition, children were given familiar one or two syllable words that could be mapped onto the shapes (i.e., 'boot', 'goldfish'). In the Familiarization Only condition, children were given one generic name for all shapes (i.e., "this is a nice shape"). When children learned the label for target shapes, they were nearly twice as likely to be able to track that target shape compared to children who did not learn the labels, which is evidence that language might have a causal role in proactive control (Doebel et al., 2017).

Children may have generalized their use of labels to support tracking targets for which they did not learn labels. Children who were taught labels performed similarly on trials involving labeled targets and trials involving previously unseen and unlabeled targets (Doebel et al., 2017). However, this finding was not tested adequately because: 1) the Track-It task had too few unlabeled trials and was therefore underpowered to test that hypothesis; 2) there were no posttest questions about the unlabeled shapes; 3) this finding was not predicted and thus could have been due to chance. However, if children do generalize labels to unlabeled shapes, this would provide further insight into how labeling affects proactive control by showing that proactive control is enhanced even on unlabeled trials, and that the label training could potentially extend beyond the task itself.

In order to test the previous unexpected finding, the current study randomly assigned children to either a Familiarization Only condition or to a Label condition. In the Familiarization Only condition, children received generic names that could not be mapped onto the shapes (i.e., "one"). In the Label condition, they received one syllable labels that could be mapped onto the shapes (i.e., 'boot'). The labels were familiar and could be mapped onto the shapes in order to provide children with meaningful information that could be used in self-directed speech to support proactive control.

We had three predictions that we preregistered with the Open Science Framework. First, if children generalize labels to unlabeled targets, children in the Label condition (compared to those in the Familiarization Only condition) will be more accurate on Track-It trials involving unlabeled targets. Second, children in the Label condition will be more likely to spontaneously verbalize their independently generated labels on the unlabeled trials in Track-It compared to children in the Familiarization Only condition. Third, in the posttest phase, children in the Label condition (compared to those in the Familiarization Only condition) will be more likely to spontaneously generate a label for the targets used in the unlabeled trials. We conducted an additional analysis investigating whether children who generated labels in the posttest performed better on unlabeled trials Track-It task.

Method

`Participants

Sixty two 5- and 6-year-old children (M_{age} = 5.74 years, SD_{age} = .22, range = 5.08 to 6.12; females = 33) were enlisted from a database of families who had previously shown interest in participating in child development research. Nine children were excluded due to failing to understand Track-It instructions (*n* = 8) and experimenter error (*n* = 1). For 95% of participants, at least one parent had a four-year college degree and the residual 5% completed high school. The racial makeup of the sample was primarily Caucasian (95%). The ethnic makeup of the sample was predominantly non-Hispanic/non-latino (87%). Parent consent was obtained prior to participation. Once the session was completed, each child was given a small, age-appropriate prize (a book or a toy), and $5 was given to the parents for travel compensation.

Design

A between-subjects experimental design was used to randomly assign children to one of two conditions: 1) an experimental condition in which children received familiar labels for the novel shapes (Label condition); and 2) a control condition in which children received generic names for the novel shapes (Familiarization Only condition). Age and gender were balanced across conditions (Label: M_{age} = 5.75 years, SD_{age} = .22, females = 16, males = 10; Familiarization Only: M_{age} = 5.73 years, SD_{age} = .22, females =13, males = 14). Once the pre-specified target sample size of 62 children was reached, data collection was stopped. A formal power analysis was not conducted because the expected effect size was unknown. Instead, the sample size was chosen to balance two concerns: 1) feasibility of collecting the data within two academic semesters and also 2) a desire to maintain power relative to the original study (31 children per condition compared to the previous 30 children per condition).

Procedure

The study progressed in three phases: 1) a pretest phase in which an experimenter familiarized children with the novel shapes (depicted in an standard letter sized binder; Figure 1, A); 2) a test phase in which children completed Track-It (Figure 1, B); 3) a posttest recall phase that tested the ability of children from both conditions to recall the labels for the novel shapes.

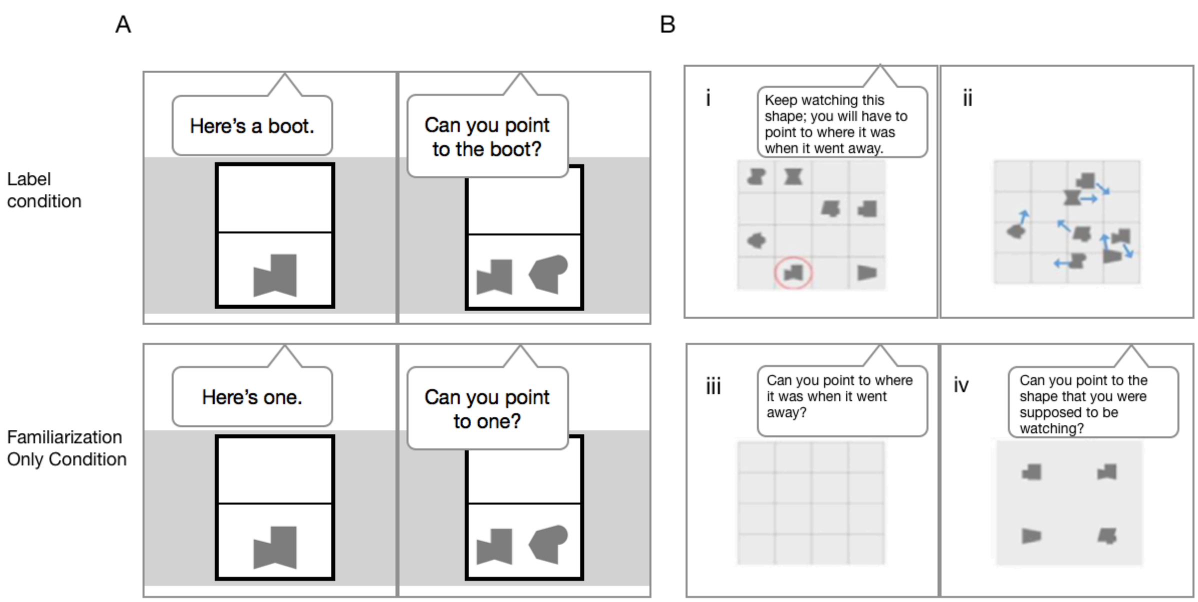

Fig. 1. Procedure schematic. (A) Children were familiarized with five novels shapes that had either meaningful labels or generic names (depiction is of one familiarization), and were subsequently asked to point to one novel shape out of a pair. (B) Children were then instructed to keep track of a moving target shape (i), as it randomly moved across the grid for a minimum of 10 seconds amongst distractors (ii), then poke the screen to show where the shape was before it disappeared (iii), and then poke the shape they were supposed to be tracking.

Although Track-It is an open-source task available online (https://github.com/JohnDickerson/TrackIt), this study used a PsychoPy version that was almost identical except for differences in the operating system. Novel, grayscale, abstract shapes were used to lessen the likelihood of children generating their own labels based on familiar colors or shapes.

Pretest phase.

Label condition. The experimenter and child sat opposite each other at a small table. A binder was centered in front of the child, facing them. One of five novel shapes was centered on each page. The experimenter made eye contact with the child and said the name of the shape while pointing to it and then one or two locations on the shape. The experimenter would point to the shape (Figure 2, A) and the two encircled locations while saying, “Here’s a boot. With a toe here and a heel here.” Then the experimenter would flip the page and present the second novel shape (Figure 2, B) and say, “Here’s a shell. With an opening here.” The experimenter did this with all five shapes consecutively and repeated the procedure three more times such that each shape was seen a total of four times. Pointing to the shape and its target location(s) when

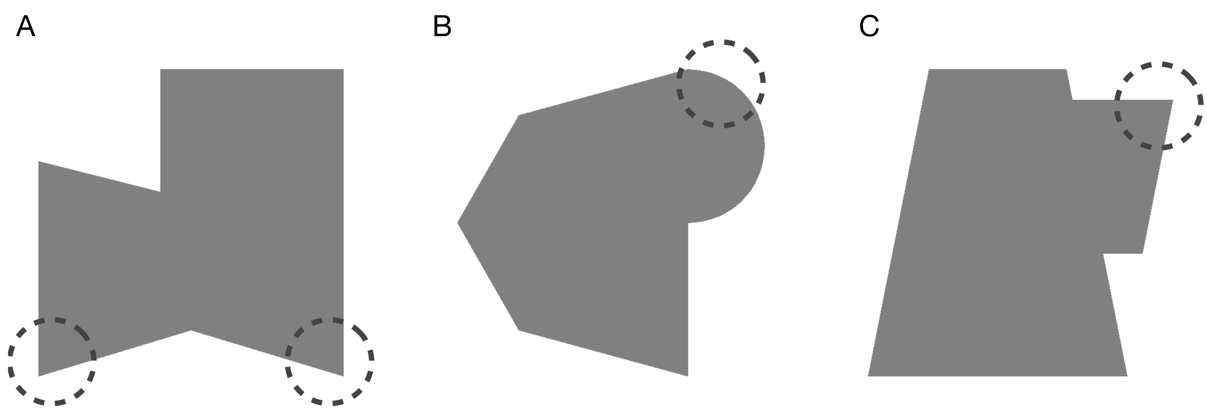

Fig. 2. Three out of the five novel shapes that children were familiarized with prior to tracking them as the target shapes in the proactive control task (Track-It). Children in the Label condition learned familiar, labels that could be mapped onto these shapes (“boot”, “shell” and “shirt” for Shapes A, B and C, respectively). The Familiarization Only condition received generic that could not be mapped onto these shapes (“one”, “thing” and “shape” for Shapes A, B and C, respectively). The dashed line circles show the areas the experimenter would point to, in both conditions, when introducing the shapes. The five specific shapes that children were trained on varied out of a total of eight novel shapes (see Appendix A).

introducing the labels enhanced the possibility of children understanding how the labels could apply to the novel shapes and that the shapes were not arbitrary. The novel shapes were designed to be distinct (some had sharp angles, others had round edges, etc.) in order to mimic the distinctiveness of familiar shapes. The Label condition and Familiarization Only condition were equated on the processes of shape familiarization because previous work has found that familiarization can support object tracking (Oksama & Hyönä, 2008; Pinto, Howe, Cohen, & Horowitz, 2010).

Immediately after introducing labels to the novel shapes in the binder, the experimenter administered 20 "recognition" trials without feedback in which the child was asked to point to one of two novel shapes on a page that matched a particular label. The recognition trials were a check on whether kids across conditions were equivalent in recognizing the shapes they were familiarized with. Each page had two shapes centered next to one another. The experimenter would say, "Look at these two. Can you point to the [target label]?" Regardless of whether the child's answer was correct or incorrect, the experimenter would move on to the next page. Each shape had four trials. The location of the target was counterbalanced between the left and right of the page across trials. The order of the target shapes was pseudorandom, with the constraint that the same target could not appear twice or more in a row. There were four shape sets (A, B, C and D) that a child was randomly assigned to. In each shape set, the choice of the five novel shapes and the pseudorandom order were changed slightly to reduce the influence of extraneous variables, such as priming effects or the possible influences of a particular shape (see Appendix B).

Familiarization Only condition. This condition closely matched the Label condition in all aspects except that the shapes were given generic names instead of useful labels ("one", "something", "a thing", "a shape" and "something else"). As in the Label condition, the experimenter sat opposite the child with the binder centered in front of the child on the table. The experimenter pointed to the shape while giving the generic name and pointed to one or two locations on the shape. For example (Figure 2, A), the experimenter said, “Here’s one. Look here and look here.” By following the same pointing procedure as in the Label condition, children in the Familiarization Only condition focused their attention on the same areas of the shapes. We used five, distinct generic names to minimize the possibility of children using the words to facilitate tracking. It is possible for children in the Familiarization Only condition to use and generalize the generic names they received to support proactive control via self-directed speech. However, evidence suggests that abstract goal representations (i.e., having to track a shape) can manifest from linguistic experience (i.e., learning the shape’s name) and that nonspecific cues are less effective than labels in activating abstract representations (Rougier, Noelle, Braver, Cohen, O’Reilly, 2006; Edmiston and Lupyan, 2015). Therefore, it is likely that children in the Familiarization Only condition find the generic names irrelevant, and do not use or generalize them.

Next, the experimenter administered 20 recognition trials without feedback. This procedure was identical to the Label condition.

Test phase.

Introduction to the proactive control task. Our modified Track-It task presented children with a 4 x 4 grid on a computer screen that contained seven novel, gray scale shapes (Figure 1, B). One of those seven shapes was the target shape, and the remaining six were made up of three different distractor shapes that were duplicated. Children were instructed to watch the target shape as it moved around the grid amongst other moving novel shapes. The experimenter introduced the first trial by pointing to the target shape that was temporarily encompassed by a red circle and stating, “We are going to play a game where you need to keep looking at this one right here. It will move all over the screen for a little while. The other shapes will be moving too. Your job is to keep looking at this one. The shapes will all go away and you’ll have to poke the screen quickly where this one was right before it went away. So keep looking at this one. OK?”

Demonstration trial. To initiate the first trial, the experimenter stated, “This time we are going to do it together. I will follow it with the wand this time so that you can see what shape I’m watching.” Once the shapes vanished from the screen, the experimenter pulled back the wand from the screen and asked, “Can you point to the screen where it was when it went away?” If the child was accurate, the experimenter said, “Good job, that is where it was at the end - right before it went away, right? So I will poke the screen right here quickly like this.” If the child was wrong, the experimenter said, “Actually, the one I was watching went away right here, so I will poke right here quickly like this.” The demonstration trial could be repeated up to two times if the child answered incorrectly in order to increase the likelihood that children fully comprehended the task. If trials needed to be repeated, the experimenter would say, “Okay, we are going to try that again just to make sure you understand. Remember, you need to keep looking at this one as it moves around the screen and then point to where it was when it went away.”

Memory check. After every proactive control trial, the children were tested on their ability to recognize what shape they were instructed to track in the previous trial. They were presented with a 2 x 2 grid of four shapes containing three distractor shapes and the previous target shape. The experimenter said, “OK. Now can you quickly point to the shape that you were supposed to keep watching?" Children received corrective feedback on the demonstration trials but not on future test trials.

Test trials. At the start of the first test trial, the experimenter stated, "OK. Let's do that again. But this time, you'll play by yourself! This time your job will be to look at a different one. You'll have to keep watching this one but use your eyes only, OK? Keep watching this one." The experimenter did not say anything on subsequent trials. In test trials children no longer pointed to where the shape was, and instead used a rubber-tipped stick to quickly poke the screen to indicate where the target was when it vanished. Children had to poke the screen as quickly as possible in order to record reaction times. Additionally, the experimenters recorded whether children spontaneously and audibly verbalized a label on each trial.

Children completed a total of 30 trials; 20 test trials that used two shapes from the pretest phase, and the remaining 10 unlabeled trials that consisted of two new shapes. Two unlabeled, gray scale, novel shapes the children had not seen before the Track-It task were used in the unlabeled trials (Figure 3). The 10 unlabeled trials were presented intermittently between test trials to see if children in the Label condition would generalize labels to the two previously unseen unlabeled shapes in order to facilitate their proactive control. Two shapes for which children either learned labels (Label condition) or generic names (Familiarization Only) were taken from the pretest phase to be used as the target shapes in the test trials. Children visually tracked each of the two test trial target shapes 10 times; the order of presentation was fixed and pseudorandom such that the same target shape was not presented more than once every two trials.

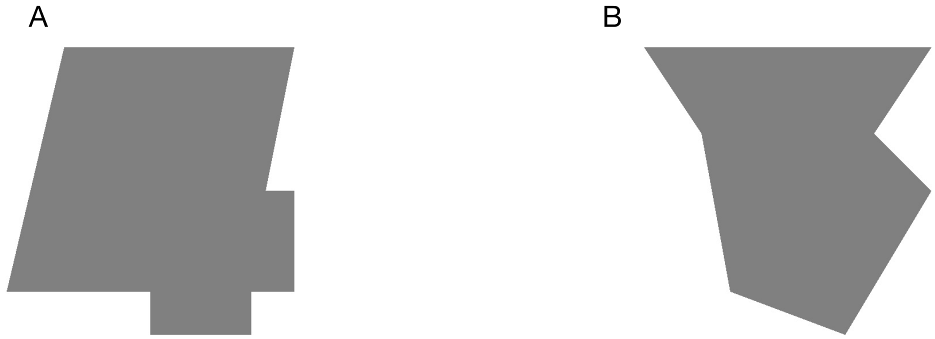

Fig. 3. The two unlabeled novel shapes which were only seen in Track-It test trials. Each shape appeared five times, for a total of 10 unlabeled trials. Both shapes were included in the posttest phase, in which both the shapes from the pretest phase and the unlabeled shapes were shown four times each, in a pseudorandom order.

Additionally, the 20 test trials included a phonological manipulation that all of the children in the Label condition experienced. Out of the 20 test trials, half contained distractors with labels that were phonologically similar to the target shapes, and the other half contained distractors that were phonologically different to the target shapes. For example, a phonologically similar trial had the target shape set as ‘boot’ and the distractor shapes set as ‘boat’, ‘bat’ and ‘bow’, whereas on a phonologically different trial the target shape was instead set as ‘shelf’ with the distractors remaining the same. However, the phonological manipulation was included for other hypotheses that are unrelated to this study.

The speed of both target and distractor shapes was set to 60 frames per second. The target and distractor shapes subtended around 2 degrees of the viewing angle at a viewing distance of 60 centimeters. These parameters, in addition with the number of distractor shapes, were chosen based on past publications and pilot data suggesting they provide a level of difficulty that would avoid ceiling and floor effects in this age group (Doebel et al., 2017). The target and distractor shapes moved on linear paths to imitate the default object movement setting of the original Track-It software. At the start of each new trial, seven shapes appeared, each in the center of one of the 16 grid squares (with no shapes starting in the same square). They then moved randomly to different squares until the minimum trial length of 10 seconds was surpassed. The target shape always disappeared at a random location. Trials lasted at least 10 seconds and individual trial length varied slightly to comply to motion restrictions (Fisher et al., 2013).

Posttest phase.

After the children completed the Track-It task, they were tested on their ability to recall the labels or generic names for the novel shapes they had previously learned. This section was located at the back of the binder that was centered on the table in front of the child. The experimenter prefaced the first trial by saying, “OK, now I’m going to ask you for the names of some shapes. If they don’t have a name you can say ‘I don’t know.’” The experimenter would thereafter ask, “What’s this one called?” Children were not given any feedback. They completed 28 trials (four trials per shape) that were pseudorandom. The two unlabeled shapes from the Track-It task were included in the 28 trials to see if children spontaneously generated a label for them.

Coding

The only variable that needed to be coded for analysis was the spontaneous verbalizations children generated during the Track-It task. In this study, a label was defined as a one- to three-word name that would designate a category or dimension (e.g., ‘dog’, ‘four’, ‘circle thing’, ‘my little fish’ etc.). An experimenter would then code for whether a child generated a label or not on each unlabeled Track-It trial.

Analytic Approach

The data were modeled using mixed-effects logistic regression and implemented within the lme4 software package version 1.1-15 (Bates, Maechler, Bolker, & Walker, 2015) in R version 1.0.143 (R Core Team, 2017). Logistic regression was chosen due to the binary dependent variables. Additionally, as the dependent variables were measured within subjects, modeling for within-subjects error strengthens the reliability of parameter estimates (Judd, MClelland, & Ryan, 2011). For models containing Track-It trial accuracy, the memory for the target on given trials was added as a fixed effect. Additionally, because there was a total of four Track-It shapes (two test shapes, and two unlabeled shapes), this was controlled for in the analyses for the first prediction which focused on Track-It accuracy. To address dependence between Track-It test trials measured within participants and to account for individual differences in accuracy across trials, random intercepts for individual participants were also included in all models.

Significant results are presented as odds ratios such that the increase in the odds of label generation in the posttest phase is associated with a unit increase on a given model parameter. The full R script used to run these analyses can be found online (https://osf.io/f4np2/).

Results

To test our first prediction that providing children with labels would result in better proactive control, we first investigated the effect of condition (Label versus Familiarization) on the likelihood of correctly tracking unlabeled shapes in Track-It. Contrary to our prediction, tracking performance between children in the Label condition ($M_{accuracy}$ = .69, *SE* = .06) and children in the Familiarization Only condition ($M_{accuracy}$ = .69, *SE* = .05) was not significantly different (*p* = .66) (Figure 4). Next, we repeated the above analyses including only the labeled shapes from the test trials. Again, accuracy did not differ significantly between children in the Label condition ($M_{accuracy}$ = .66, *SE* = .06) and children in the Familiarization Only condition ($M_{accuracy}$ = .67, *SE* = .05) (*p* = .90). Furthermore, we repeated the above analysis including only phonologically different trials to explore the possible influence of the phonological manipulation on accuracy. Phonologically different trials did not differ significantly between children in the Label condition ($M_{accuracy}$ = .65, *SE* = .06) and children in the Familiarization Only condition ($M_{accuracy}$ = .66, *SE* = .05) (*p* = .92).

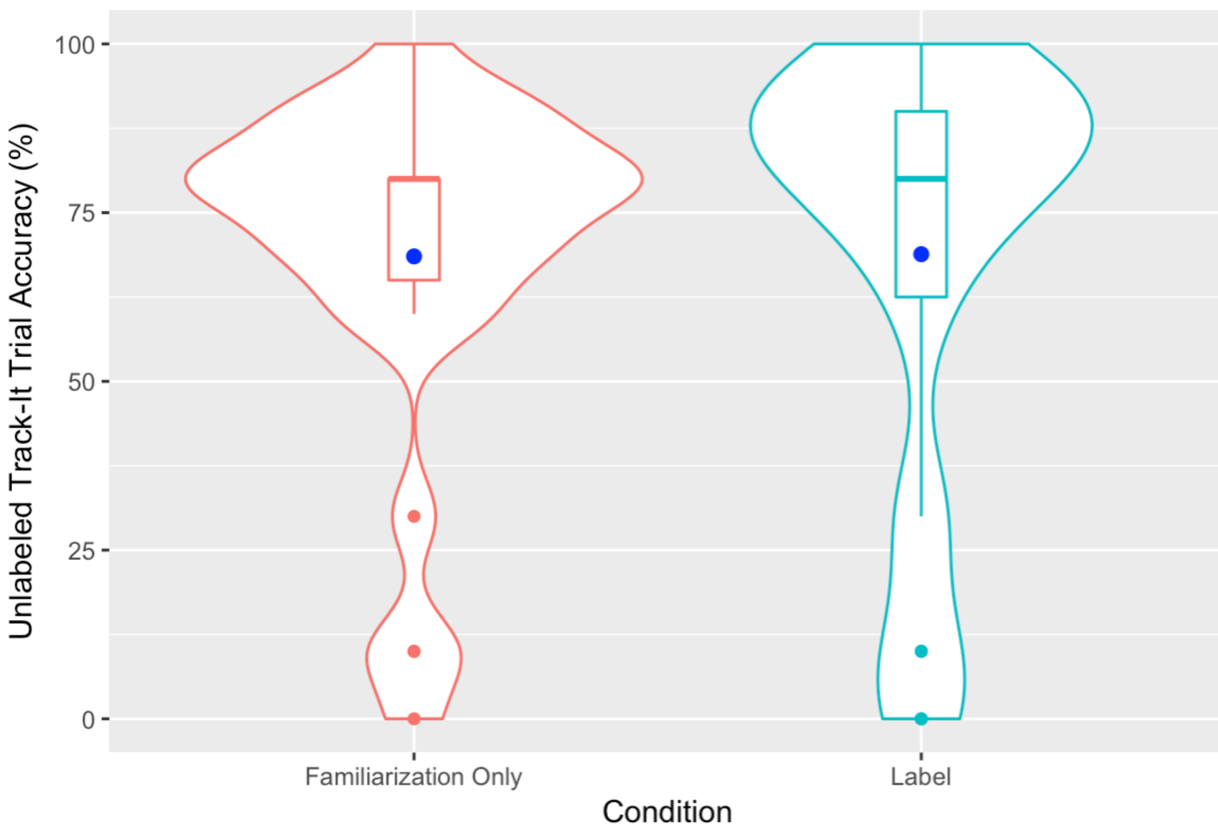

Fig. 4. Children were not more accurate in tracking unlabeled shapes after learning labels for other shapes, contrary to our prediction. Error bars represent 95% confidence intervals.

We then tested our second prediction that children who received labels for some shapes would be more likely to spontaneously produce and verbalize labels for unlabeled shapes during

Track-It. In contrast with this prediction, children in the Label condition did not produce more spontaneous labels than children in the Familiarization Only condition (p = .19). Such that approximately 8% of children (n = 2) in the Label condition spontaneously verbalized labels for unlabeled shapes, while approximately 18% of children (n = 5) in the Familiarization Only condition spontaneously verbalized labels.

Our third prediction was that children who received labels for some shapes would be more likely to self-generate labels for unlabeled shapes in the posttest phase. Surprisingly, we observed the opposite effect, such that children in the Label condition self-generated fewer labels than those in the Familiarization Only condition. The odds of children in the Familiarization Only condition generating labels were almost 900 times the odds in the Label condition (OR = 891, χ^2 = 11.71, p < .001, 95% CI [-5.2*10^8, -24.05]). However, these parameter estimates were likely inflated due to quasi-complete data separation, as label self-generation was almost exclusive to children in the Familiarization Only condition (63% of children in the Familiarization Only condition self-generated verses 19% in the Label condition). The bias of these estimates appeared to be worsened when subject was included as a random effect. To remove the within-subject dependence and, thus, the need to include subject as a random effect, we tested two additional models investigating each of the two unlabeled shapes individually. Consistent with our original model, condition significantly predicted self-generation of labels for both unlabeled shapes (Shape 1: OR = 13.00, p = .002, 95% CI [-94.63, -2.89], Shape 2: OR = 22.91, p = .005, 95% CI [-445.86, -3.78]).

We conducted an additional exploratory analysis to determine whether generating labels for unlabeled shapes in the posttest was associated with better tracking of those shapes. Label generation did not predict tracking performance (p = .66). Children who generated labels for both unlabeled shapes in the posttest, had an average unlabeled Track-It trial accuracy of 63%. Children who only labeled one of the two unlabeled shapes, had an average unlabeled Track-It trial accuracy of 76%. Children who did not label either each shape had an average unlabeled Track-It trial accuracy of 69%.

Discussion

Contrary to our hypothesis, children in the Label condition did not generate labels for novel shapes to support proactive control; however, the collective findings are still consistent with labels influencing proactive control. Contrary to our first hypothesis, children in the Label condition, compared to those in the Familiarization Only condition, did not show better accuracy on Track-It trials involving unlabeled shapes. Additionally, children in the Label condition, compared to those in the Familiarization Only condition, did not show better accuracy on Track-It test trials involving labeled shapes. Our second hypothesis was also not supported, as children in the Label condition were not more likely to spontaneously verbalize their independently generated labels on the unlabeled trials in Track-It compared to children in the Familiarization Only condition. However, in regards to our third hypothesis, children in the Familiarization Only condition rather than the Label condition were more likely to generate labels for those shapes in the posttest phase. Therefore, this study highlights that the influence of labels on proactive control is not precise and that children who did not receive labels may have generated labels to aid proactive control.

Although our finding that there is no significant effect of label training on Track-It accuracy does not replicate past results (Doebel et al., 2017), there are reasons to think this may not mean that labels do not help. The current study design contains a phonological manipulation, which was not included in the prior study. This phonological manipulation could have hurt performance in the Label condition relative to the Familiarization Only condition because the phonologically similar trials generated a higher risk of children getting confused between the similarly sounding target and distractors, subsequently confusing children's use of labels across all trials. This possible confusion may explain why children in the Label condition were not significantly more accurate on phonologically different trials compared to children in the Familiarization Only condition.

Additionally, the phonological manipulation may have had surprising downstream effects. For example, if children were confused by the phonologically similar trials, they may have believed that using labels was a bad strategy and would subsequently be less likely to use labels across all trials and to generate labels. When labels are easily confused they do not serve the purpose of distinguishing between stimuli and may even be detrimental. This is supported by prior research that found that participants who used descriptive labels that they did not fully understand to differentiate nonverbal stimuli were significantly worse at differentiating than participants who did not use labels and participants who used labels they did understand (Melcher & Schooler, 1996). It is possible that labels are only helpful in identifying and tracking target shapes when they cannot be confused with the distractors, and this can be tested in future work by creating separate conditions to test the effects of phonological manipulation instead of the manipulation occurring in only one condition.

Furthermore, subtle changes in the design that were meant to enhance condition equivalence may have selectively boosted children's performance in the Familiarization Only condition relative to the Label condition. In the previous study, children in the Familiarization Only condition were told that all the shapes were 'nice ones' (Doebel et al., 2017). Although the current study also used generic names, these names differed across shapes. Indeed, assigning each shape its own generic name in the pretest phase may have prepared children in the Familiarization Only condition to view the shapes as individual, separate agents and therefore easier to distinguish between the target and distractors on Track-It. Similarly, the individual generic names may have prepared children in the Familiarization Only condition to generate more helpful and distinct names for both test trial shapes and unlabeled shapes, resulting in a similar Track-It performance to children in the Label condition. Thus, there are numerous possibilities for why Track-It accuracy did not significantly differ across conditions.

Additional evidence to support that labels may help is the surprising finding that children in the Familiarization Only condition produced more labels for unlabeled shapes in the posttest than children in the Label condition. Although there were no differences in Track-It accuracy between conditions, children in the Familiarization Only condition generating labels in the posttest indicates that they may have spontaneously generated labels during Track-It in order to better track the shape. The possibility that these labels were created prior to the posttest phase is supported by the finding that children in the Familiarization Only condition consistently gave the same labels for each unlabeled shape on two or more of the four posttest trials. Although children may have generated the labels during the posttest and gave them consistently, this seems unlikely given that: 1) The question the experimenter asked in the posttest phase did not prompt for consistency, so children likely did not feel pressured to give consistent labels. 2) In the posttest section of the binder, the five shapes from the pretest phase appeared before the two unlabeled shapes and this layout was repeated four times, so it would be somewhat difficult to remember labels that were generated on the spot for the unlabeled shapes in between getting asked for names of the five pretest shapes. However, wether children generated labels for unlabeled shapes during posttest did not significantly predict unlabeled Track-It trial accuracy. A possible reason for this null result is that children in the Label condition did generate labels for the unlabeled shapes but did not report them in the posttest due to confusion around the question asked by the experimenter: "I'm going to ask you for the names of some shapes. If they don't have a name you can say 'I don't know.'" Children in the Label condition may have thought they should only give labels for the shapes the experimenter taught them in the pretest phase, whereas children in the Familiarization Only condition did not have this prior experience to bias their interpretation. Therefore, it is possible that children in both conditions generated labels to aid their proactive control, but that children in the Label condition did not report their generated labels in the posttest.

Due to limited research examining the effect of language on proactive control, future work should further explore our finding that children who were only given generic names produced more labels when asked, compared to children who were given labels, and that label production did not significantly affect Track-It accuracy. Future work could test this finding in a similar way as in this study but with two key differences: 1) Phonological manipulations should be examined separately in order to not risk encountering down-stream effects that could influence the effect of labeling on proactive control. 2) Questions asking children about the labels they self-generated should be worded in such a way that children are comfortable providing labels across conditions. Given the advantages of using language in tasks requiring executive function (e.g., Emerson & Miyake, 2003; Fernyhough & Fraley, 2005; Flavell, Beach, & Chinsky, 1966; Kirkham, Cruess, & Diamond, 2004; Kray, Eber, & Karbach, 2008), the effect of language on proactive control should be further examined.

Conclusion

Although the current study found no difference in Track-It performance on unlabeled trials between children who received labels and those who received generic names, it still suggests that language may influence the engagement of proactive control which is consistent with previous findings. Children who were only given generic names produced significantly more labels for unlabeled shapes in the posttest phase compared to children who were given labels, and potentially used these self-generated labels to help them engage proactive control in Track-It. Future work can further examine the relationship between language and proactive control by looking at the influence of phonological distinctiveness on the utility of labels, and developing questions that encourage children to provide the labels they generated to help engage in proactive control. Goal-directed behavior predicts success across a variety of important outcomes, and so it is imperative that future work continues to explore the influence of language in order to develop effective interventions that aid the engagement of proactive control.

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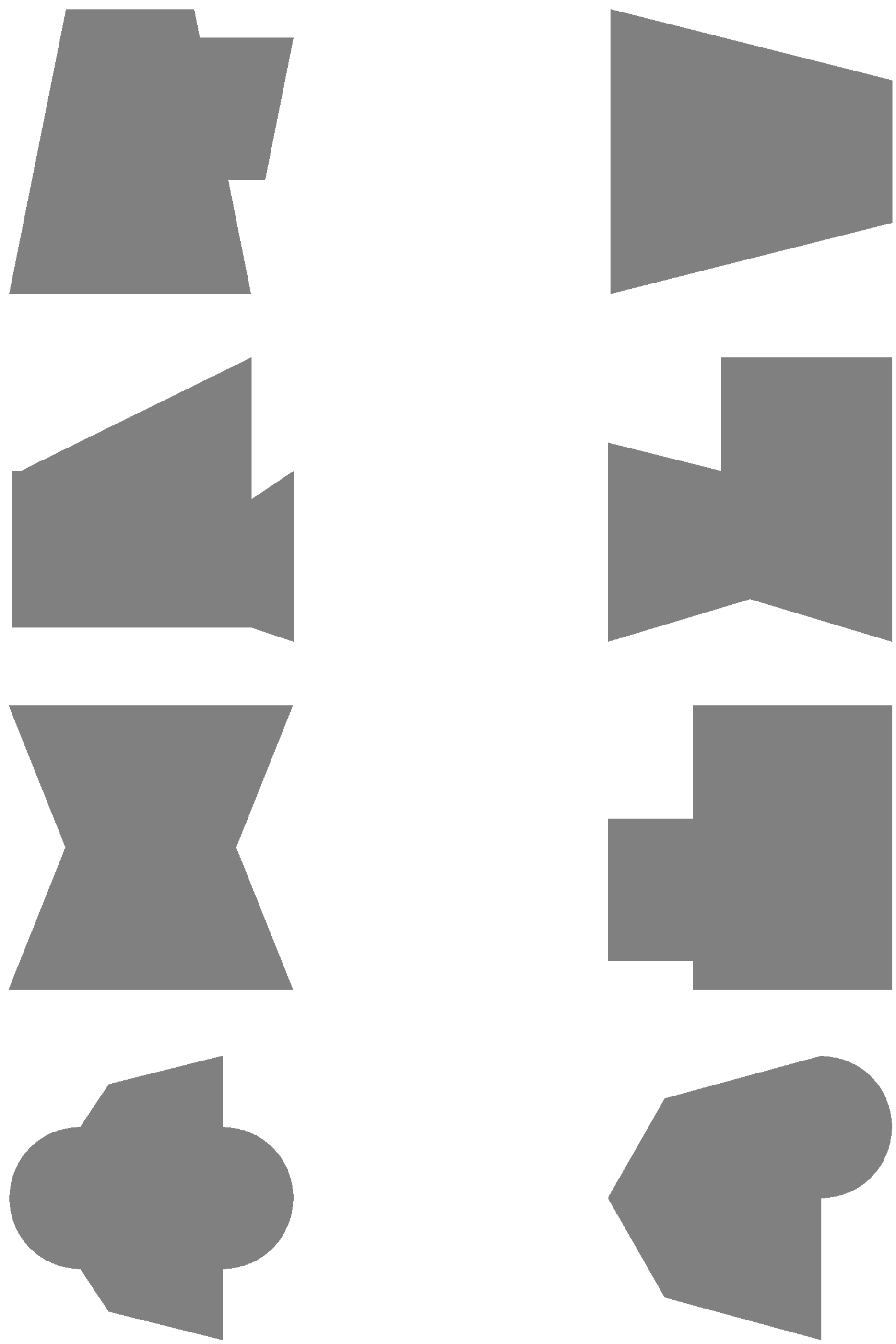
Appendix A

The eight total novel shapes, from which five were chosen for each condition.



Appendix B

The four shape sets (A, B, C and D) with their corresponding labels or generic names. Sets were counterbalanced across the Label condition and the Familiarization Only condition. Children viewed all the five shapes belonging to their respective shape sets in the pretest phase and posttest phase in a pseudorandom order. The first two shapes of each shape set (i.e., ‘boot’ and ‘shelf’ for the Label condition, and ‘one’ and ‘something’ for the Familiarization Only condition) were used as the target shapes in the Track-It test trials, with the remaining three shapes used as the distractors. The 20 Track-It test trials included a phonological manipulation that all of the children in the Label condition experienced. Out of the 20 test trials, half contained distractors that were phonologically similar to the target shapes, and the other half contained distractors that were phonologically different to the target shapes. For example, a phonologically similar trial for the shape sets C and D in the Label condition had the target shape set as ‘boot’ and the distractor shapes set as ‘boat’, ‘bat’ and ‘bow’, whereas on a phonologically different trial the target shape was instead set as ‘shelf’ with the distractors remaining the same. Additionally, in order to minimize possible extraneous effects of certain shapes (e.g., some shapes being easier to track than others because of their appearance), in both conditions the first two shapes in shape sets A and C were switched in sets B and D. For example, in the Label condition, the shape corresponding with the label ‘boot’ in set A becomes the shape corresponding with the label ‘shelf’ in set B. For the same reason of minimizing extraneous effects, the last three shapes in sets A and B are different from the last three shapes in sets C and D in both the Label condition and the Familiarization Only condition.

Label Condition

Shape set A.

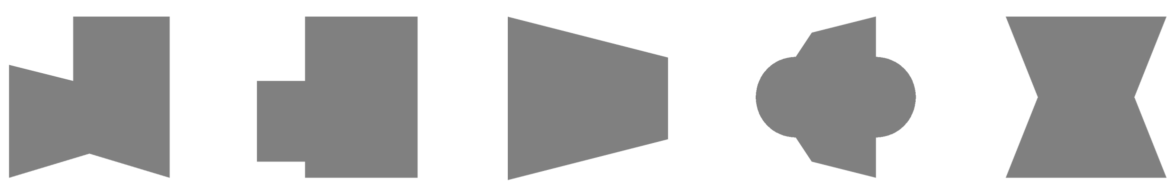
boot shelf shell shirt shed

Shape set B.

boot shelf shell shirt shed

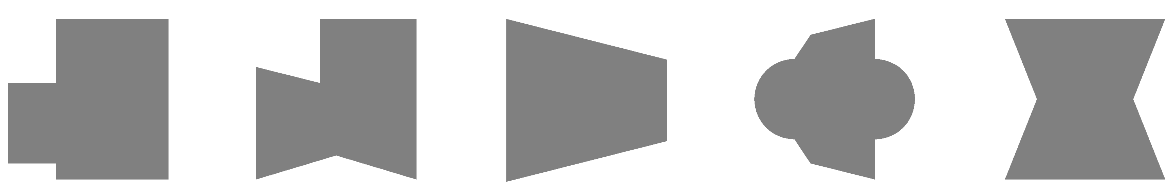
Shape set C.

boot shelf boat bat bow



Shape set D.

boot shelf boat bat bow



Familiarization Only Condition

Shape set A.

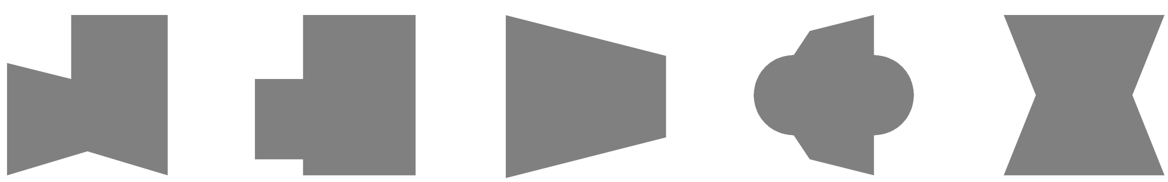
one something a thing a shape something else

Shape set B.

one something a thing a shape something else

Shape set C.

one something a thing a shape something else



Shape set D.

one something a thing a shape something else