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Inductive Selectivity in Children's Cross-classified Concepts

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Abstract

Cross-classified items pose an interesting challenge to children's induction since these items belong to many different categories, each of which may serve as a basis for a different type of inference. Inductive selectivity is the ability to appropriately make different types of inferences about a single cross-classifiable item based on its different category memberships. This research includes five experiments that examine the development of inductive selectivity in 3-, 4-, and 5-year-olds ($N = 272$). Overall, the results show that by age 4 years, children have inductive selectivity with taxonomic and script categories. That is, children use taxonomic categories to make biochemical inferences about an item whereas children use script categories to make situational inferences about an item.

Keywords

inductive selectivity; inductive inferences; cross-classification; categorization

Inductive reasoning is an important way in which we broaden the scope of our knowledge by making a conclusion about an unfamiliar item based on known information about a premise category (see Heit, 2007, 2000, for a review). For example, if you know that a robin belongs to the category of bird and has feathers, you can probably conclude that a sandpiper, another bird, has feathers as well, even though you may have never seen a sandpiper before. There is ample evidence that early on in development young children are capable of inductive reasoning (See Hayes, 2007; Murphy, 2002, for a review; See Gelman & Waxman, 2007; Sloutsky, Kloos, & Fisher, 2007, for a discussion regarding underlying mechanisms). Much of this research has focused on the inferences that children make about items that are classified into only one category, namely taxonomic in which the items' common properties serve as the basis for induction (see Gelman, 2003; Krackow & Gordon, 1998; Nguyen, 2008 for discussion).

Yet items rarely fit neatly into only one category at a given level of specificity within a single hierarchy. Rather, items often can be cross-classified into many categories and each of these can potentially provide a very different basis for induction. For example, thinking of someone as belonging to different categories based on their age, gender, occupation, or hobbies may lead to very different inferences about that person, and these inferences may subsequently affect one's interactions with that person. Therefore, cross-classification poses a potential challenge to children's inductive inferences: if an item can be cross-classified into more than one category, which category would a child choose as a basis for induction, and how might the child make this decision? For example, if someone can be categorized into say two categories based on age and gender, do children use their knowledge of the former or latter category to base their inferences? Presently, the answers to these questions

are unclear given the lack of empirical research on the development of inductive reasoning focused on cross-classified concepts. The answers to these questions, however, are of theoretical importance because they not only speak to the issue of children's inductive reasoning, but also to the issue of flexibility in children's cognition. Cognitive flexibility is defined as the ability to consider an item's multiple representations, and research has shown that this ability increases during the preschool years (e.g., see Deák, 2003; Jacques & Zelazo, 2005). Cognitive flexibility may be relevant to children's inductive reasoning with cross-classified concepts because it involves flexibly considering different categories as a basis for induction, as opposed to allowing one category to control all inferences about an item. In considering these different categories, the child must in effect respond positively and negatively for each category, recognizing that different properties are relevant for different categorical inductions, but not others. Thus, the aim of the present research is to investigate children's inductive reasoning using cross-classified concepts. In particular, this research investigates *inductive selectivity*, the ability to appropriately make different types of inferences about a single cross-classifiable item based on its different categories.

Background

Several studies within the adult concepts literature have provided evidence for inductive selectivity in adults. When making an inference about an item that can be cross-classified into more than one category, adults will respond to the specific demands of the induction task, and use the category that best supports the inference (e.g., Heit & Rubinstein, 1994; Murphy & Ross, 2007; Patalano, Chin-Parker, & Ross, 2006; Ross & Murphy, 1999; Verde, Murphy, & Ross, 2005). Research has also shown that the ability for inductive selectivity may be influenced by experience and knowledge (Coley, Shafto, & Stepanova, 2005). A parallel body of research from the social psychology literature has also examined adults' reasoning about people's social categories and the implications for stereotypes (e.g., Macrae, Bodenhausen, & Milne, 1995; Nelson & Miller, 1995).

Although some studies within the conceptual development literature have examined children's knowledge that different categories of items support different kinds of inferences (e.g., perceptual categories as a basis for inferences about physical and perceptual properties, Gelman & Markman, 1986, Study 3; natural kinds as a basis for inferences about composition and internal parts whereas artifacts are used as a basis for inferences about function, Gelman, 1988; Gelman & O'Reilly 1988; evaluative categories as a basis for inferences about the human body, Nguyen, 2008), these studies have not actually examined children's ability for inductive selectivity per se. True inductive selectivity requires children making different inferences about a single item that can be cross-classified into more than one category.

Few studies have examined inductive selectivity in young children, and unfortunately the results of these studies are rather mixed. Kalish and Gelman (1992) found that preschool-aged children know which categories are appropriate to use when making inferences about items with overlapping object and material categories (e.g., wooden pillow belongs to the object category of pillow and material category of wood). By age 4 years, children associate functional properties (e.g., what something is used for) with object categories whereas they associate dispositional properties (e.g., what happens when something gets wet) with material categories. For example, in this study, the researchers told children that glass scissors are used "for partitioning" and that they "will get fractured" if placed in extremely cold water. Then, children were asked if metal scissors or a glass bowl would have these properties. The results showed that by age 4 years, children could accurately attribute the functional property to the object category (e.g., metal scissors) and dispositional property to the material category (e.g., the glass bowl).

In contrast, Nguyen and Murphy (2003) found that it is not until 7 years of age that children appropriately use categories to make selective inferences about cross-classified foods. Nguyen and Murphy (2003) examined foods that could be cross-classified into both taxonomic and script categories; the taxonomically related foods in this study shared common properties (e.g., dairy products such as ice cream) and the script related foods were interchangeable within a routine or event (e.g., birthday party foods such as ice cream). These researchers found that 7-year-olds, but not 4-year-olds, appropriately use taxonomic foods to make biochemical inferences (about the ingredients of foods) and script categories to make situational inferences (about when foods are served).

Given these inconsistent results, the development of inductive selectivity remains poorly understood. As we move towards gaining a more comprehensive understanding of children's inductive reasoning, it is important to examine in depth how children make inductive inferences about cross-classified concepts.

The present research includes a series of five experiments that examine the development of inductive selectivity in young children (3-year-olds, 4-year-olds, 5-year-olds) and adults. These studies focus on taxonomic and script categories as a test case for inductive selectivity because research has shown that children can cross-classify items into these categories (Nguyen, 2007; Nguyen & Murphy, 2003). In particular, the present research examined children's selective use of taxonomic and script categories for biochemical and situational inferences, respectively. Biochemical inferences are based on the common properties of items in a taxonomic category whereas situational inferences are based on the role that items in a script category play in a routine or event.

In Experiments 1 and 2, a between-participants design was used in which participants were assigned to one of two conditions, and were asked to make either biochemical or situational inferences about items. Experiments 3 and 4 are follow-ups to these studies. A between-participants design was used as a starting point in these studies so that children could be tested on several trials from different domains without fatiguing children by asking them to make both biochemical and situational inferences. Also, by using a between-participants design, there could be a common basis for comparing results to Nguyen and Murphy (2003), who also used this design. A drawback of a between-participants design, however, is that it cannot show that the same child can make both biochemical and situational inferences from one item. Therefore, in the final study, Experiment 5, a within-participants design was used with a subset of the trials from the previous experiments to minimize the potential for fatigue. An important feature of the present research is the inclusion of items from a variety of domains in the testing materials. For example, taxonomic categories included animals, foods, and clothing and scripts included school time, bed time, and lunch time. This is a different approach than previous developmental work on inductive selectivity, which has focused on items from one domain such as artifacts (Kalish & Gelman, 1992) and foods (Nguyen & Murphy, 2003). It is crucial to include items from a variety of domains because of the possibility of content differences in the acquisition and use of categories (see Coley & Vitkin, 2007; Vitkin, Coley, & Kane, 2005). By examining items from a variety of domains, the current research has potential to provide a clearer picture of the extent to which children are capable of inductive selectivity. Overall, if children have inductive selectivity, then they should use taxonomic categories to make biochemical inferences and script categories to make situational inferences.

Experiment 1

The aim of Experiment 1 was to document young children's ability for inductive selectivity with taxonomic and script categories. Basic level taxonomic categories were the focus of

this investigation because past research has shown that children acquire these categories early in development (see Murphy, 2002) and these categories have rich inductive potential (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; see also Coley, Hayes, Lawson, & Moloney, 2004; Coley, Medin, & Atran, 1997). In Experiment 1, children were assigned to either the biochemical or situational inference condition. In both conditions, children were presented with an induction task in which they saw 18 picture triads. Each triad included a target item and two choices, a choice that shared a basic-level taxonomic relation with the target and a choice that shared a script relation with the target. Children were told for each triad, depending upon the condition, that the target had either a novel biochemical or situational property, and then were asked to infer which of the two choices also shared that property. Thus, if children have the ability for inductive selectivity, then children should tend to select the taxonomic choices, but not the script ones, when making biochemical inferences. Similarly, children should tend to select the script choices, but not the taxonomic ones, when making situational inferences.

Method

Participants—Participants were 96 children: 32 three-year-olds (14 females, 18 males, $M_{\text{age}} = 3.56$, age range = 2.95-3.92); 32 four-year-olds (21 females, 11 males, $M_{\text{age}} = 4.50$, age range = 4.04-4.99); and 32 five-year-olds (17 females, 15 males, $M_{\text{age}} = 5.41$, age range = 5.0-6.16). Thirty two adults also participated in this study as a developmental comparison (22 females, 10 males, $M_{\text{age}} = 19.77$, age range = 18.53-24.36). A separate group of 16 children (6 females, 10 males, $M_{\text{age}} = 3.62$, age range = 3.22-4.0) and 34 adults (22 females, 12 males, $M_{\text{age}} = 19.24$, age range = 17.02-28.87) also assisted in the selection of the stimuli. None of these children or adults participated in the actual study. All participants were recruited from either daycares, schools, or a University located in a predominately European-American, middle class community within the Southeastern United States.

Materials—The materials consisted of fifty-four 2.5×3 inch (6.35×7.62 cm) color photographs of different items that were collected from internet sources. The photographs were arranged into 18 triads consisting of a target and two choices. Each triad was printed on a 8.5×11 inch (21.6×27.9 cm) piece of white paper and placed in a 3-ring binder. Each triad included a target (e.g., cat), a taxonomic choice (e.g., kitten), and a script choice (e.g., pumpkin). Labels were printed under each picture. See Appendix A for a complete list of the triads and the labels that were presented to participants. The taxonomic choices were items from the categories of animals, foods, clothing, furniture, toys, and people. Script choices were based on events or routines such as Halloween, birthday party, and bed-time. Also, to avoid confounding script with taxonomic categories, especially since items in a script category can sometimes share the same taxonomy, special care was taken to use only script choices that did not share a strong taxonomic relationship with the target.

These materials were selected based on data collected from adults and children. A group of 18 adults rated the words for the items from the picture triads to ensure that they were typical and familiar members of their designated category, but not of their undesignated category. For the typicality ratings, adults were asked to rate each item in terms of how typical an instance of a given category it is. For the familiarity ratings, adults were asked to rate the degree to which they were familiar with an item as belonging to a given category. The scales ranged from 1 (*low*) to 7 (*high*). The typicality results showed that for taxonomic categories, the taxonomic matches ($M = 5.75$, $SD = 0.87$) were rated as more typical than the script matches ($M = 1.39$, $SD = 0.57$), $t(17) = 17.08$, $p < .001$. As for the script categories, the script matches ($M = 6.72$, $SD = 0.29$) were rated as more typical than the taxonomic matches ($M = 4.95$, $SD = 0.64$), $t(17) = 13.45$, $p < .001$. The familiarity results also showed that for the taxonomic categories, the taxonomic matches ($M = 6.03$, $SD =$

0.79) were rated as more familiar than the script matches ($M = 1.45$, $SD = 0.54$), $t(17) = 17.25$, $p < .001$. As for the script categories, the script matches ($M = 6.76$, $SD = 0.41$) were rated as more familiar than the taxonomic matches ($M = 5.11$, $SD = 0.73$), $t(17) = 9.90$, $p < .001$.

To examine the extent to which underlying concepts may resemble each other, these adults were also asked to rate the visual similarity between each target and its two choices separately, using only the words for the items. Participants were asked to rate on a scale ranging from 1 (*not at all visually similar*) to 7 (*very visually similar*) whether the items look like each other in their minds. The results showed that although visual similarity was relatively low for targets and their taxonomic choices ($M = 3.37$, $SD = 1.8$) as well as for targets and their script choices ($M = 1.06$, $SD = 0.15$), there was a significant difference between the ratings, $t(17) = 5.55$, $p < .001$.

Because basic level taxonomic items may visually resemble each other in the abstract, it was crucial to use specific pictures in this study that were visually dissimilar. Thus, a different group of 16 adults also rated the visual similarity of the pictures of each target and its two choices separately to ensure that perceptual similarity would be low, and would not dominate the choices in the study. For the visual similarity ratings, participants were asked to rate whether the picture pairs look like each other in the photographs. The scale ranged from 1 (*not at all visually similar*) to 7 (*very visually similar*). The visual similarity ratings were low for targets and their taxonomic choices ($M = 1.78$, $SD = 0.66$) as well as for targets and their script choices ($M = 1.11$, $SD = 0.11$), and did not differ significantly from each other.

In any test of induction it is important to first establish that children are knowledgeable of the categories to be used in the induction task. To establish that even the youngest age group in this study had knowledge of the categories in the picture triads, a group of 3-year-olds participated in a categorization task using these triads. In this task, children were presented with the picture triads and were asked to categorize the targets using basic-level taxonomic and script relations. For example, on one trial, children saw a cat (target), kitten (taxonomic choice), and pumpkin (script choice) and then heard, "This is a cat. Show me another cat." On another trial, children saw the same picture triad again, but heard, "This is a Halloween thing. Show me another Halloween thing." Although it is conceivable that some of the taxonomic choices could be considered as a part of a script category (e.g., a kitten in a Halloween script), recall that the results from the adult typicality and familiarity ratings showed that the script choices were stronger associates than the taxonomic ones. Thus, what is most relevant for the purposes of this study is whether children can pick the designated category choice. In fact, the results indicated that 3-year-olds were able to match the targets with their designated category choices 82% of the time, which is significantly above chance (50%), $t(15) = 7.10$, $p < .001$.

Procedure—Children were tested individually in a quiet area of their classroom by a researcher for approximately 15 minutes. Children participated in one of two conditions: biochemical or situational. In both conditions, children were presented with the same stimuli, except that the directions and test question differed by condition. In particular, children in the biochemical condition heard the following directions, "This game is about stuff inside of things. Some things have the same stuff inside and some things have different stuff inside. I'll use funny sounding words to talk about the stuff inside of things. Your job is to figure out which things have the same stuff inside." Children in the situational condition heard the following directions, "This game is about things that go together during special times. Some things go together during the same special time and some things do not. I'll use

funny sounding words to talk about special times. Your job is to figure out which things go together during the same special time.”

Following the directions, children were presented with each of the picture triads, one at a time. In the biochemical condition, children were told that a target item had novel stuff inside and were asked to select another item that also had the same stuff (e.g., “Mip is special stuff inside of a cat. Do you think a kitten or pumpkin also has the same special stuff inside?”). Children in the situational condition, in contrast, were told that an item is for a novel special time and were asked to select another item that was also for the same special time (e.g., “A cat goes with a special time called Mip. Do you think a kitten or pumpkin also goes with the same special time?”). Novel words were used for the properties so that children could make inferences from the new information provided in the study.

Adults participated in a paper and pencil version of the task. The picture triads were presented to children and adults in one of two random orders within each condition.

Results and Discussion

The data were scored for accuracy. In the biochemical condition, a 1 was assigned to participants’ taxonomic choices, and a 0 to participants’ script choices. In contrast, in the situational condition, a 1 was assigned to participants’ script choices, and a 0 to participants’ taxonomic choices.

To first examine whether there were any domain differences in the data, performance on the individual trials was examined across the age groups. The results indicated there were no apparent domain differences.

The scores were then collapsed across the 18 trials and converted into percentages. A 2×4 (Condition [biochemical, situational] $\times$ Age Group [3-year-olds, 4-year-olds, 5-year-olds, adults]) ANOVA was then conducted on these data. The results showed a main effect of Condition ($F(1, 127) = 30.65, p < .001, \eta_p^2 = 0.20$) and Age Group ($F(3, 127) = 11.36, p < .001, \eta_p^2 = 0.22$). These main effects were moderated by a Condition $\times$ Age Group interaction, $F(3, 127) = 3.22, p = .025, \eta_p^2 = 0.07$. Please see Figure 1.

This interaction was examined by conducting follow-up age comparisons for the biochemical and situational conditions, separately; each analysis showed significant age differences, $F_s(3, 60) = 8.50, 6.41, p's < .001$. In the biochemical condition, adults and 5-year-olds were significantly more accurate than the 4-year-olds, Tukey HSD, $p's < .001$. In the situational condition, adults were significantly more accurate than 4- and 5-year-olds, Tukey HSD, $p's < .05$. Three-year-olds were also significantly more accurate than 4-year-olds, Tukey HSD, $p = .01$. There were no other significant differences between the age groups within each condition.

Participants’ performance in each of the conditions was also compared to chance (50%). All of the age groups were significantly above chance in the biochemical condition, $t's(15) > 3, p's < .05$. Three-year-olds and adults were significantly above chance in the situational condition, $t's(15) > 8, p's < .001$. However, 4- and 5-year-olds were not above chance in the situational condition.

To explore individual differences in the data, three response patterns were established based on binomial probability, $p < .05$. If a participant selected between 13-18 correct choices (out of 18), they were considered an *accurate responder*. If a participant selected between 6-12 correct choices, they were considered an *inconsistent responder*. Finally, if a participant selected 5 or less correct choices, then they were considered an *inaccurate responder*. The

results of this analysis are presented in Table 1. Notably, Table 1 shows that the majority (over half) of the participants in the biochemical condition were accurate responders. Table 1 also shows that the majority of the 3-year-olds and adults, but not the 4- and 5-year-olds in the situational condition were accurate responders.

Overall, the results for the 4- and 5-year-olds in the situational condition are somewhat odd, and raises concern regarding the use of basic level taxonomic categories in this experiment. It is possible that the basic level taxonomic categories may have influenced some of the 4- and 5-year-olds' situational inferences. That is, some children in these age groups may have been willing to make taxonomic choices because they expected items at the basic level to be more similar in the abstract, despite the visually dissimilarity of the actual stimuli. The explicit labeling of items in the picture triads may have also activated these children's expectations for basic level categories. This possibility would be consistent with the adult visual similarity ratings of the words for the items in which targets and their taxonomic choices were rated as being more visually similar than targets and their script choices. Since similarity is a defining feature of basic level categories, but not superordinate ones, using items at the superordinate level may help to minimize these possibilities. In other words, children may not have many strong expectations about superordinate category members, unlike basic level categories, because items in a superordinate level category do not always share obvious similarities (see Murphy, 2002). Experiment 2 was designed to address this concern with the use of superordinate level categories. The use of these categories in Experiment 2 also afforded the opportunity to examine whether children are capable of inductive selectivity with higher level categories.

Experiment 2

A modified version of the picture triads from Experiment 1 was used in Experiment 2. These picture triads included superordinate level taxonomic choices that shared an abstract relationship with the targets, instead of basic level ones. The script choices in the picture triads remained the same as in Experiment 1 since script categories are defined by the role that items play in a routine or event, and are not organized into hierarchies of increasingly abstract categories. If the basic level taxonomic categories in Experiment 1 had an influence on inferences in the situational condition, then replacing them with superordinate level taxonomic categories in Experiment 2 should address this concern. Thus, if children have the ability for inductive selectivity with abstract categories, then they should select the superordinate level taxonomic choices, but not script ones, when making biochemical inferences. In contrast, children should select the script choices, but not the taxonomic ones, when making situational inferences.

Method

Participants—Participants were 96 children: 32 three-year-olds (15 females, 17 males, $M_{\text{age}} = 3.55$, age range = 2.58-3.94), 32 four-year-olds (19 females, 13 males, $M_{\text{age}} = 4.51$, age range = 4.06-4.99), and 32 five-year-olds (13 females, 19 males, $M_{\text{age}} = 5.55$, age range = 5.17-6.00). Thirty two adults also participated (26 females, 6 males, $M_{\text{age}} = 19.11$, age range = 17.00-27.99). A separate group of eight three-year-old children (4 females, 4 males, $M_{\text{age}} = 3.57$, age range = 3.07-4.00) and 34 adults (24 females, 10 males $M_{\text{age}} = 19.06$, age range = 17.02-21.97) also assisted in stimuli selection; none of these participants participated in the actual study. All participants were recruited from either daycares, schools, or a University located in a predominately European-American, middle class community within the Southeastern United States.

Materials—The stimuli included 18 picture triads. These triads were the same as in Experiment 1 except that the basic level taxonomic choices were replaced with

superordinate level ones (e.g., cat: kitten vs. pumpkin from Experiment 1 became cat: monkey vs. pumpkin in Experiment 2). See Appendix B. The same group of 18 adults from Experiment 1 also provided typicality, familiarity and visual ratings of these stimuli with scales ranging from 1 (*low*) to 7 (*high*). The results from the typicality ratings indicated that for the taxonomic categories, the taxonomic matches ($M = 6.37$, $SD = 0.79$) were more typical than the script matches ($M = 1.31$, $SD = 0.37$), $t(17) = 22.64$, $p < .001$. As for the script categories, the script matches ($M = 6.73$, $SD = 0.33$) were more typical than the taxonomic matches ($M = 1.57$, $SD = 0.33$), $t(17) = 38.28$, $p < .001$. The results from the familiarity ratings also indicated that for the taxonomic categories, the taxonomic matches ($M = 6.45$, $SD = 0.69$) were rated as more familiar than the script matches ($M = 1.40$, $SD = 0.50$), $t(17) = 21.84$, $p < .001$. As for the script categories, the script matches ($M = 6.75$, $SD = 0.41$) were rated as more familiar than the taxonomic matches ($M = 1.58$, $SD = 0.33$), $t(17) = 34.14$, $p < .001$.

These adults also provided visual similarity ratings of the words for the targets and their choices. The results indicated that visual similarity was low, and that there was not a significant difference between the targets and their taxonomic choices ($M = 1.49$, $SD = 0.85$) and the targets and their script choices ($M = 1.12$, $SD = 0.47$).

A different group of 16 adults also provided visual similarity ratings for the photographs of the targets and their choices. The results indicated that the visual similarity between targets and their taxonomic category choices ($M = 1.12$, $SD = 0.20$) and between targets and their script choices ($M = 1.03$, $SD = 0.07$) was low, and did not differ significantly from each other.

A group of 3-year-olds also participated in a categorization task using these picture triads to establish that even young children have knowledge of the categories presented in the triads. In this task, children were presented with the picture triads and were asked to categorize the targets using superordinate level taxonomic and script relations. For example, on one trial, children saw a cat (target), monkey (taxonomic choice), and pumpkin (script choice) and then heard, "This is an animal. Show me another animal." On another trial, children saw the same picture triad again, but heard, "This is a Halloween thing. Show me another Halloween thing." The results showed that children were quite knowledgeable of the superordinate level taxonomic and script categories presented in the triads. Children were 96% accurate on the categorization task, which was significantly above chance level of performance (50%), $t(7) = 20.03$, $p < .001$. Note that this level of performance is markedly higher than Rosch et al. (1976, Experiment 8) who found that 3-year-olds were 55% correct on superordinate level categorization (see also Blaye & Jacques, 2009). It is possible that this discrepancy is due to differences in methodology. Although Rosch et al. (1976, Experiment 8) presented children with picture triads, including a target, a superordinate choice and a random distracter choice, they did not use category labels. Rather, children were asked to put together "the two that are alike, that are the same kind of thing." In the case of the current study, the category labels in the test questions may have conveyed important information to children about what kinds of similarity to pay attention to in the categorization task.

Procedure—The procedure was the same as in Experiment 1.

Results and Discussion

The data were scored for accuracy as in Experiment 1. A 2×4 (Condition [biochemical, situational] $\times$ Age Group [3-year-olds, 4-year-olds, 5-year-olds, adults]) ANOVA was then conducted on these data. The results showed a main effect of Condition ($F(1, 127) = 12.28$, $p < .001$, $\eta_p^2 = 0.09$) and Age Group ($F(3, 127) = 25.61$, $p < .001$, $\eta_p^2 = 0.39$). These main

effects were moderated by a Condition $\times$ Age Group interaction, $F(3, 127) = 3.24, p = .024, \eta_p^2 = 0.07$. Please see Figure 2.

This interaction was examined by conducting follow-up age comparisons for the biochemical and situational conditions, separately; each analysis showed significant age differences, $F_s(3, 60) = 20.17, 6.80, p's < .001$. In the biochemical condition, 5-year-olds and adults were significantly more accurate than 3- and 4-year-olds, Tukey HSD, $p's < .05$. In the situational condition, adults were significantly more accurate than 3-year-olds, Tukey HSD, $p = .001$. There were no other significant age group differences within each condition.

Participants' performance in each of the conditions was also compared to chance (50%). Only 4-year-olds, 5-year-olds, and adults were significantly above chance in the biochemical condition, $t's(15) > 3, p's < .05$. All of the age groups were significantly above chance in the situational condition, $t's(15) > 5, p's < .05$.

To explore individual differences in the data, response patterns were also examined as in Experiment 1. The results are presented in Table 1, and indicate that the majority (over half) of the participants in each age group were accurate responders in both of the conditions, with the exception of 3-year-olds in the biochemical condition.

Overall, the results from Experiment 2 are somewhat similar to those of Experiment with two exceptions. First, unlike in Experiment 1, the response pattern data from the situational condition show that the majority of 4- and 5-year-olds were accurate responders. It is possible that these children's situational inferences in Experiment 2 were not as influenced by the taxonomic choices because they were at the superordinate versus the basic level. The difference in results between Experiments 1 and 2 suggests that some 4- and 5-year-olds may have strong expectations about taxonomic categories in which they are especially in tune to the fact that similarity is a defining characteristic of basic, but not superordinate level categories.

Second, 3-year-olds in Experiment 2 were not above chance in the biochemical condition. This finding with young children is overall in keeping with Gelman and O'Reilly (1988) who examined 4- and 8-year-olds' ability to draw inferences about the internal parts of taxonomically related items. These researchers found that 4- and 8-year-olds made more inferences within the basic level (e.g., dog) versus the superordinate level (e.g., animal). They also found that superordinate level categories were substantially more difficult for younger children than basic level categories.

Three-year-olds' relatively low level of performance in the biochemical condition raises the question of whether the superordinate level taxonomic categories used in the induction task were sufficiently salient or accessible for young children. While the data from the categorization task used for the stimuli selection indicated that young children were knowledgeable of the categories used in the induction task, it is possible that young children in the actual study were not spontaneously thinking of these category relations due to a lack of category salience or accessibility. In an induction task it is important that children first spontaneously categorize a target item into a category, such as a taxonomic one, and then use this category knowledge to make an inference. If 3-year-olds in this study were not spontaneously thinking of the targets in the biochemical condition in terms of the abstract relationship that they share with the taxonomic choices, then it is difficult to ascertain the extent to which young children's low level of taxonomic responding in the biochemical condition was due to an inability for inductive selectivity or lack of category salience. If young children's performance in this study can be attributed to lack of category salience or accessibility, then activating the superordinate level taxonomic categories to make them more salient in the biochemical condition could potentially reveal children's ability to use

these categories for biochemical inferences. This possibility was further investigated in Experiments 3 and 4.

Experiment 3

The goal of Experiment 3 was to help elucidate the extent to which 3-year-olds are capable of inductive selectivity with abstract level taxonomic categories. In order to examine this issue, a priming procedure was used in Experiment 3 that involved the explicit presence of superordinate level taxonomic category labels. In this study, children participated only in the biochemical condition and were initially primed with superordinate level taxonomic category labels (e.g. animals, food) before being asked to make a biochemical inference. If 3-year-olds are capable of inductive selectivity with superordinate level categories, then priming these categories in the biochemical condition should reveal children's use of these categories for biochemical inferences.

Method

Participants—The participants included 16 three-year-olds (7 females, 9 males, $M_{\text{age}} = 3.54$, age range = 3.04-3.99). Children were recruited from the same community as in the previous studies. None of these children had previously participated in these studies.

Materials—The same 18 picture triads from Experiment 2 were used in Experiment 3. A modified version of the procedure in the biochemical condition from Experiment 2 was used in Experiment 3. The difference was that in Experiment 3, children were initially primed with a superordinate level taxonomic category label before being asked to make an inductive inference. The aim of this priming was to help activate, and increase the salience of the superordinate level taxonomic categories for the children. In particular, children heard the researcher introduce a superordinate level taxonomic category, were asked to repeat the category label, and then heard the researcher use the label in reference to the target item. For example, children heard on one trial, "We're going to talk about animals now. Can you say animal? This is a cat. It's an animal. Mip is special stuff inside of a cat. Do you think a monkey or pumpkin also has the same special stuff inside?"

Results and Discussion

The data were scored as in Experiments 1 and 2 for accuracy. To analyze the data, 3-year-olds' performance was compared to chance (50%). The results show that 3-year-olds were 53% accurate, which was not significantly above chance.

To further examine individual differences in the data, 3-year-olds' response patterns were also examined using the same response pattern categories from Experiments 1 and 2. The results reveal that there were very few accurate responders (12%). Most of the children were inconsistent (81%) and inaccurate (6%) responders.

Overall, 3-year-olds' performance in Experiment 3, even with priming, was fairly similar to performance in Experiment 2. Recall that in Experiment 2, children in the biochemical condition were 55% accurate. A possible interpretation of these findings is that 3-year-olds have limited ability for inductive selectivity with taxonomic superordinate level categories. However, this interpretation assumes that the priming procedure in Experiment 3 effectively increased the salience of these categories for children. Because children were asked to simply repeat category labels provided by the researcher, it is quite possible that this procedure may not have effectively induced children to think about the taxonomic relationship between the targets and taxonomic choices. Thus, a new priming procedure was developed and tested in Experiment 4. This procedure was based on the categorization task

described in the Methods section of Experiment 2, which revealed that 3-year-olds can categorize the test items at the superordinate level.

Experiment 4

The goal of Experiment 4 was to further examine the extent to which 3-year-olds are capable of inductive selectivity with abstract level taxonomic categories. In order to examine this issue, in Experiment 4, children were initially asked to categorize a target item before being asked to make a biochemical inference. The rationale for this methodology was to more strongly prime the superordinate category in the biochemical condition. If 3-year-olds are capable of inductive selectivity with superordinate level categories, then directly priming these categories in the biochemical condition should reveal children's use of these categories for biochemical inferences.

Method

Participants—The participants included 16 three-year-olds (10 females, 6 males, $M_{\text{age}} = 3.53$, age range = 3.12-3.96). Children were recruited from the same community as in the previous experiments, and had not participated in these experiments.

Materials—The same 18 picture triads from Experiment 3 were used in Experiment 4.

Procedure—The procedure for Experiments 3 and 4 was similar, except that children in Experiment 4 were initially asked to categorize a target, were provided with corrective feedback if necessary, and then were asked to use the target to make an inductive inference. For example, children heard on one trial, "This cat is an animal. Show me another animal. Mip is special stuff inside of a cat. Do you think a monkey or pumpkin also has the same special stuff inside?"

Results and Discussion

The results from the categorization task demonstrate that children were extremely accurate, even without corrective feedback ($M = 97\%$, $SD = 2\%$). Children's level of accuracy was significantly above chance, $t(15) = 69$, $p < .001$.

Notably, the results from the inference task show that children selected the correct choices 77% ($SD = 28\%$) of the time, which was significantly above chance (50%), $t(15) = 3.7$, $p = .002$. This level of accuracy markedly contrasts with 3-year-olds' level of accuracy in Experiment 3 ($M = 53\%$, $SD = 17\%$).

To further examine individual differences in the data, 3-year-olds' response patterns were also examined using the same response pattern categories as in the previous experiments. The majority of children (68%) were accurate responders, unlike in Experiment 3 (12%). The remaining children in Experiment 4 were inconsistent (18%) and inaccurate (12%).

Thus, it appears that 3-year-olds' performance in the previous experiments may not be due to young children's inability for inductive selectivity with superordinate level taxonomic categories, but perhaps due to these categories being insufficiently salient or accessible to children.

Experiment 5

Thus far, Experiments 1-4 have used a between-participant design to examine inductive selectivity by showing that different groups of children can use taxonomic categories for biochemical inferences and script categories for situational inferences. However, to

demonstrate true flexibility in children's induction, it is important to also show that the same children are able to appropriately make both biochemical and situational inferences from a common set of items. Thus, a within-participant design was used in Experiment 5.

Method

Participants—The participants included 48 children: 16 three-year-olds (9 females, 7 males, $M_{\text{age}} = 3.62$, age range = 3.23-3.94); 16 four-year-olds (8 females, 8 males, $M_{\text{age}} = 4.49$, age range = 4.16-4.87); 16 five-year-olds (8 females, 8 males, $M_{\text{age}} = 5.46$, age range = 5.01-5.98). Sixteen adults also participated in this study (7 females, 9 males, $M_{\text{age}} = 19.65$, age range = 18.91-21.13). All of the participants were recruited from the same community as in the previous experiments. None of these children had participated in these previous experiments.

Materials—The stimuli included 12 picture triads, six basic-level ones from Experiment 1 and six superordinate-level ones from Experiment 2. This subset of picture triads was selected to be representative of the domains and events tested in Experiments 1 and 2, and are indicated with an asterisk in Appendices A and B.

Procedure—The procedure in Experiment 5 was similar to the procedure in Experiments 1 and 2, except that each participant played two games, the biochemical game about the stuff inside of things and the situational game about things that go together during special times. Thus, participants were asked to make biochemical and situational inferences from the same picture triads for a total of 24 trials. It should also be noted that for 3-year-olds, the priming procedure from Experiment 4 was used for the superordinate level trials in the biochemical game to give children a chance to demonstrate flexible inductive selectivity.

The biochemical and situational inference games as well as the superordinate and basic level trials within each game were presented in blocks that were counterbalanced.

Results and Discussion

The data were scored for accuracy as in the previous experiments. Two summary variables were then created, one for biochemical and one for situational inferences, by collapsing across their respective trials, and converting these scores into percentages. A 2×4 (Inference [biochemical, situational] $\times$ Age Group [3-year-olds, 4-year-olds, 5-year-olds, adults]) ANOVA was then conducted on these data. The results revealed a main effect of Age Group, $F(3, 60) = 12.38$, $p < .001$, $\eta_p^2 = 0.38$, but not a main effect of Inference or an interaction between the two variables. Adults ($M = 96\%$, $SD = 5\%$) were significantly more accurate than 3-year-olds ($M = 70\%$, $SD = 19\%$) and 4-year-olds ($M = 76\%$, $SD = 16\%$), Tukey HSD, p 's $< .001$. Five-year-olds ($M = 88\%$, $SD = 9\%$) were also significantly more accurate than 3-year-olds, Tukey HSD, $p < .001$. There were no other significant age differences. Please see Figure 3.

Participants' overall performance was also compared to chance (50%). All of the age groups performed significantly above chance, t 's(15) > 4 , p 's $< .001$.

Three response patterns similar to the previous experiments were also established based on binomial probability, $p < .05$. If a participant provided 16-24 correct responses (out of 24), then they were considered an *accurate responder*. If a participant provided between 9-15 correct responses, then they were considered an *inconsistent responder*. Finally, if a participant provided 8 or less correct responses, then they were considered an *inaccurate responder*. Table 2 indicates that half or more of the 3-year-olds, 4-year-olds, 5-year-olds, and adults were accurate responders.

These results from Experiment 5 are generally consistent with the previous experiments, offering additional evidence from a within-participants design for children's flexible induction.

General Discussion

The goal of this research was to examine the development of inductive selectivity in children, particularly whether children selectively use taxonomic and script categories to make inductive inferences about cross-classified items. Five experiments were conducted to this end. Experiment 1 demonstrated that 3 year-olds can selectively use basic level taxonomic categories for biochemical inferences and script categories for situational inferences. Interestingly, the 4- and 5-year-olds in Experiment 1 had particular difficulty using script categories for situational inferences. It appeared that some of the children were selecting the basic level taxonomic choices for the situational inferences because of their expectations that items in these categories share similarity. To minimize this possibility, Experiment 2 included only superordinate level taxonomic categories, which do not always share obvious similarities. The results of Experiment 2 demonstrated that 4- and 5-year-olds do indeed have inductive selectivity with superordinate level taxonomic and script categories. Three-year-olds, however, had particular difficulty using the superordinate level taxonomic categories for biochemical inferences. Experiments 3 and 4 investigated the possibility that young children may not have been spontaneously thinking of these category relations due to a lack of category salience or accessibility. These experiments revealed signs of inductivity selectivity in 3-year-olds when they were directly primed with taxonomic category relations. While these studies used a between-participants design, showing that two different groups of children from each of these age groups have inductive selectivity, Experiment 5 used a within-participants design to test this ability in one group of children from each age group. The results from Experiment 5 provided corroborating evidence for children's inductive selectivity.

Overall, these findings contrast those of Nguyen and Murphy (2003) who found inductive selectivity in 7-year-olds, but not younger children. This discrepancy in results could be due to the fact that Nguyen and Murphy (2003) tested only the domain of food, whereas the present research tested a variety of domains. The present research included only 3 food-related categories, compared to 15 food-related categories in Nguyen and Murphy (2003). By providing children with different categories from a variety of nonfood-related domains, children in the current study perhaps had more opportunities to demonstrate their ability for inductive selectivity more generally compared to children in Nguyen and Murphy (2003). Thus, the results of Nguyen and Murphy (2003) may be particularly idiosyncratic to the food categories used in that study. However, the findings of the current research do complement and extend the findings of Kalish and Gelman (1992) who found inductive selectivity in 4-year-olds using the object and material categories of artifacts. Coley and colleagues (see Shafto, Coley, & Vitkin, 2007) have also found similar results with older, school-aged children. They have found that school-aged children will draw upon different kinds of category knowledge, depending upon the property in question in an induction task. For example, school-aged children use their knowledge of an item's taxonomic relations when reasoning about its insides, but will use their knowledge of its ecological relations (based on habitat/predation) when reasoning about how a disease might impact an ecosystem. These researchers explain how properties in an induction task can provide helpful clues to what category to use as a basis for generalization.

A question that emerges from the current research is how do children determine which category to use for an inference when an item can be cross-classified into two categories? In this research, one category type did not necessarily dominate or control all of children's

inferences. Rather, children appeared to be sensitive to the property they were being asked to generalize in the inductive selectivity task, and used the category that was most relevant for the inference. When asked to consider the biochemical properties of items, children used basic and superordinate level taxonomic categories for their inferences. That is, children used their knowledge that items in a taxonomic category share common features including biochemical ones. In contrast, when asked to consider situational properties of items, children used script categories for their inferences. That is, children used their knowledge that items in a script category share the same role in a routine or event as a basis for their situational inferences.

Research on inductive selectivity in adults also provides some additional insight into this question. Murphy and Ross (1999) examined inductions for items that were in two categories. Murphy and Ross (1999) found that adults often paid attention to both taxonomic and script categories when making their inductions. For example, participants read about the level of amino acids in fruits and snacks (among other properties and other categories). When they were asked to decide the level of amino acids in apples (which are both a fruit and a snack), they showed evidence of using the levels in both categories to produce an answer. The results of Murphy and Ross (1999) point out that multiple categories of an item can in some circumstances be simultaneously taken into account and coordinated (see also Hayes, Kurniawan, & Newell, 2011). Therefore, young children must eventually learn not to decide whether an item belongs to one category or the other, but to take both categories into account in making an accurate induction. Future research should examine the relationship between cognitive flexibility and children's sensitivity to different kinds of category information that can be used for inferences about cross-classified items. Similar research on children's cognitive flexibility, for example, has shown that children are able to switch classification strategies in response to contextual changes (e.g., Deák & Bauer, 1995, 1996; Blaye & Bonthoux, 2001; Blaye & Jacques, 2009). Examining this relationship could begin to uncover the underlying mechanisms of these abilities in young children.

With all of that said, it is crucial to also consider alternative explanations for children's performance in the present studies. First, it could be argued that children were not selectively making appropriate inferences, but rather avoiding one category for a certain inference since these studies included only two response choices. For example, children may only know that taxonomic categories support biochemical inferences, and so when they were asked to make a situational inference, they may have avoided selecting the taxonomic choice as opposed to actively selecting the script choice. Or, children may only know that script categories support situational inferences, and so when they were asked to make a biochemical inference, they avoided selecting the script choice as opposed to actively selecting the taxonomic choice. The use of a between-participants design in Experiments 1-2 begins to address this concern. Since children were randomly assigned to one of two conditions, it seems unlikely that half of the children in each age group by coincidence had a consistent tendency to avoid taxonomic categories, and the other half a consistent tendency to avoid script categories. However, to directly address this concern, future research would need to include a third unrelated or perceptual choice that allows children a chance to avoid one category and to show active selection of another category. If children have inductive selectivity, then they should be more likely to select the taxonomic choice compared to the script or unrelated choices when they are asked to make a biochemical inference. Similarly, if children have inductive selectivity, then they should be more likely to select the script choice compared to the taxonomic or unrelated choices when they are asked to make a situational inference (c.f., antithematic bias, Golinkoff, Shuff-Bailey, Olguin, & Ruan, 1995).

Another alternative explanation for children's performance, specifically when making situational inferences, is that children may have been drawing on their script memory for routines and events, as opposed to actually making inferences. In this research, the phrasing "special times" and its emphasis throughout the directions could have evoked children's script memory. As a result, children may have simply mapped the novel words for the "special times" onto familiar scripts that they recall. This strategy could have then led children to the script choices if they were treating the novel words and familiar scripts as equivalent (e.g., treating "mip" as Halloween). In future research, children could be asked to justify their choices, which would help clarify how children interpreted the novel words. Similarly, in future research, children could be taught novel script categories that do not map onto familiar ones. This way, children would not be able to use a translation strategy in the induction task. Clearly there is much left to do in continuing to investigate script-based inductive inferences. The present studies are viewed as one important step among many in this investigation since the role of script categories in the induction process has not been well documented compared to taxonomic categories (see Krackow & Gordon, 1998).

Taken together, the results of the current investigation reveal that by age 4 years, children have inductive selectivity, using taxonomic and script categories for biochemical and situational inferences, respectively. With sufficient category priming, 3-year-olds also show signs for the emergence of inductivity selectivity. Overall, this ability for inductive selectivity is a significant achievement, allowing children to use their knowledge to understand the complexities of a single item that can be cross-classified into more than one category.

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Appendix A: Stimuli for Experiment 1 and Experiment 5*

Target	Taxonomic	Script
*Cat	Kitten	Pumpkin
Reindeer	Fawn	Christmas tree
Bunny	Rabbit	Easter candy
*Cake	Torte	Present
Sandwich	Sub	Lunch Table
Watermelon	Cantaloupe	Picnic basket
*Pajamas	Night shirt	Toothbrush
Coat	Jacket	Snowman
Bikini	Bathing suit	Pool
*Table	Picnic bench	Plate
Bed	Crib	Night gown
Desk	School table	Back pack
*Rubber duck	Duckling	Soap
Beach pail	Bucket	Swimsuit
Sled	Sleigh	Snowflake

Target	Taxonomic	Script
*Nurse	Doctor's helper	Band-aid
Teacher	Professor	Book
Clown	Silly person	Circus tent

Appendix B: Stimuli for Experiments 2, 3, 4, and 5*

Target	Taxonomic	Script
*Cat	Monkey	Pumpkin
Reindeer	Bear	Christmas tree
Bunny	Lion	Easter candy
*Cake	Bread	Present
Sandwich	Cereal	Lunch Table
Watermelon	Tomato	Picnic basket
*Pajamas	Dress	Toothbrush
Coat	T-shirt	Snowman
Bikini	Jacket	Pool
*Table	Bookcase	Plate
Bed	Chair	Night gown
Desk	Crib	Back pack
*Rubber duck	Ball	Soap
Beach pail	Legos	Swimsuit
Sled	Blocks	Snowflake
*Nurse	Baker	Band-aid
Teacher	Police officer	Book
Clown	Mom	Circus tent

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Figure 1.
Experiment 1: Percent accuracy in the biochemical and situational conditions for each age group.

Figure 2.
Experiment 2: Percent accuracy in the biochemical and situational conditions for each age group.

Figure 3.
Experiment 5: Percent accuracy for biochemical and situational inferences for each age group.

Table 1

Percentage of Response Patterns in Experiments 1-4									
Pattern	Biochemical			Situational					
	3s	4s	5s	3s	4s	5s	adults	3s	adults
Experiment 1									
Accurate	75	56	100	94	63	25	44	81	
Inconsistent	25	31	0	6	37	62	44	19	
Inaccurate	0	13	0	0	0	13	12	0	
Experiment 2									
Pattern									
Accurate	19	63	88	100	63	81	94	88	
Inconsistent	75	37	12	0	37	19	6	2	
Inaccurate	6	0	0	0	0	0	0	0	

Table 2

Percentage of Response Patterns in Experiment 5

	3s	4s	5s	adults
Pattern				
Accurate	50	63	94	100
Inconsistent	50	34	6	0
Inaccurate	0	0	0	0