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The Influence of Task Dynamics on Inductive Generalizations: How Sequential and Simultaneous Presentation of Evidence Impacts the Strength and Scope of Property Projections

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The Influence of Task Dynamics on Inductive Generalizations: How Sequential and Simultaneous Presentation of Evidence Impacts the Strength and Scope of Property Projections

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ABSTRACT

Young children are remarkably flexible reasoners insofar as they modify their inferences to accommodate the conceptual information or perceptual relations represented in an inductive problem. Children's inductive reasoning is highly sensitive to *what* evidence is presented to them. Four experiments with 115 preschoolers (M_{age} = 4;8) and 119 adults (M_{age} = 21;9) examined whether induction is influenced by *how* evidence is presented. Specifically, these studies explored the extent to which presenting evidence exemplars at the same time (i.e., simultaneous presentation) or one by one (i.e., sequential presentation) would influence property projections to a range of targets. Experiment 1 revealed that simultaneous presentation yielded a higher rate and a broader scope of projections than did sequential presentation. Experiment 2 confirmed that these effects were not due to how items were labeled. Experiments 3 and 4 explored the interplay between evidence presentation and specific task features that impact how participants compare evidence and target exemplars. In Experiment 3, there were no differences between the 2 presentation formats when evidence exemplars were removed prior to the projection phase, thereby eliminating the opportunity to compare evidence exemplars and targets. Finally, Experiment 4 showed that sequential presentation yielded a high rate of projections when participants were not afforded the opportunity to compare exemplars within the evidence sample. These results have implications for understanding the mechanisms that guide children's inductive decisions.

Inductive reasoning, the ability to generalize evidence from a known case to novel cases, plays an integral role in the acquisition and extension of knowledge. For example, knowing that penguins have hollow bones can be used as evidence to predict that other birds, such as robins and ducks, also have hollow bones. Flexibility is a hallmark of early induction. By the age of 5 years, children will modify their inferences in consideration of the conceptual relations (Gelman, 1988; Hayes & Thompson, 2007; Kalish & Gelman, 1992; Lawson & Kalish, 2006; Opfer & Bulloch, 2007; Sloutsky & Fisher, 2008) and perceptual similarity (A. V. Fisher, 2015; Jones, Smith, & Landau, 1991; Sloutsky & Fisher, 2004) between known and novel cases. In other words, children's inductive decisions are influenced by *what* appears in the available evidence. The present studies

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explored a related issue: To what extent is inductive reasoning influenced by *how* evidence is presented?

This question is important because there is tremendous variability in the methods by which we acquire evidence, yet little is known about the degree to which this factor impacts children's inductive decisions. Instead, much of what we know about the development of inductive reasoning comes from studies modeled after a single task—the triad induction task (e.g., Gelman & Markman, 1986). In this task, participants are given evidence about two different exemplars, each of which is attributed a different property (e.g., "This squirrel eats bugs, and this rabbit eats grass"), and then they are asked to project one of the two properties to a target item (e.g., "Does this squirrel eat bugs or grass?"). This task represents a relatively small portion of the inductive problems we face. Seldom are we given all available evidence at a single point and then asked to immediately decide how to generalize that evidence. Typically, evidence comes intermittently, over a short or prolonged period of time, and often, we generalize evidence well after it was obtained. Moreover, the triad task affords the opportunity to make direct comparisons between evidence and target cases and thus draws attention to conceptual and perceptual relations between known and novel cases. The manner in which evidence is made available can make some relations (i.e., conceptual or perceptual) more central for generalization than others (e.g., Goldstone, 1996), thus suggesting that the way an inductive problem is presented determines, to a certain degree, the processes used to compare evidence and target exemplars. The four experiments reported here explored this issue by assessing the impact of sequential presentation of items (i.e., one by one) and simultaneous presentation of items (i.e., at the same time) on property projection.

Sequential presentation and simultaneous presentation have been shown to yield distinct outcomes in a range of cognitive tasks with adults (e.g., Carvalho & Goldstone, 2015; Krueger, 1984; Lappin & Bell, 1972; Lupyan, Thompson-Schill, & Swingley, 2010; Shiffrin, Gardner, & Allmeyer, 1973) and children (e.g., Lipsitt, 1961; Oakes & Ribar, 2005; Quinn & Bhatt, 2010; Son, Smith & Goldstone, 2011). Gentner and Namy (1999) showed that simultaneous presentation of two exemplars (e.g., apple and pear) supported generalization to a relational match (e.g., banana) rather than a perceptual match (e.g., balloon). In a direct comparison of these two presentation formats, Son, Smith, and Goldstone (2011) found that children as young as 3 years of age performed better on a relational sample-to-match task when sample items were presented simultaneously than when they were presented sequentially. Similar findings have been demonstrated in other domains. In a word-learning task with 2-year-olds, Vlach, Ankowksi, and Sandhofer (2012) found that presenting four exemplars at the same time led to a higher rate of generalizations of a novel noun to a target than did presenting each exemplar sequentially (i.e., massed), at least when testing was conducted immediately after presentation. Finally, in associative learning tasks, simultaneous presentation has been shown to provide better support for identifying cues that are shared by exemplars, while sequential presentation has been shown to support identification of properties or cues that differentiate exemplars (Lipsitt, 1961; Williams & Ackerman, 1971; see also Rescorla, 1980). A general conclusion from this work is that these presentation formats engage different processes for comparing stimuli. Simultaneous presentation serves as an invitation to identify underlying similarities between presented items (Boroditsky, 2007; Gentner & Namy, 2006; Gentner & Namy, 1999; Namy & Gentner, 2002), whereas sequential presentation facilitates discrimination between presented items (Lipsitt, 1961; Rescorla, 1980). Given the central role of within-sample comparisons and comparisons between sample and target in property projection (Lopez, Gelman, Gutheil, & Smith, 1992), it seems reasonable to expect these different presentation formats will have unique effects on children's inductive decisions.

With these issues in mind, the present studies were designed to achieve two goals. The first goal was to examine if presentation format influences property projection. The second was to assess whether specific task features might influence the extent to which presentation format would impact projections. The studies reported here used a modified version of the standard induction task (e.g., Gelman & Markman, 1986). Participants were presented with an evidence sample that included three exemplars from the same category (e.g., dogs), each of which was attributed the same novel biological property (e.g., "These animals have drotium blood"). The method of evidence presentation was manipulated between participants so that in some cases the evidence exemplars were presented simultaneously and in other cases they were presented sequentially. After the evidence was presented, participants were shown a range of targets (e.g., other dogs, other mammals, nonmammal animals, and nonanimal objects) for which they were first asked to make positive projections (i.e., judgment that a target *has* the property attributed to the evidence exemplars) and then were asked to make negative projections (i.e., judgment that a target *lacks* the property attributed to the evidence exemplars). Thus, the study measured the extent to which presentation format influenced the rate and breadth (i.e., the scope of targets to which properties were projected) of projections.

Specific task features—expected to influence the comparison processes used to support induction—were manipulated across the four experiments. The primary manipulation was whether evidence samples were available (i.e., visible) during the projection phase. Under simultaneous presentation, having the evidence sample available for comparison could encourage the identification of similarities between the evidence exemplars and targets and thus might facilitate projection. In contrast, under sequential presentation, the presence of the evidence sample might encourage discrimination between the evidence exemplars and targets and thus could limit projections. Experiments 1 and 2 explored these possibilities. The specific prediction was that when the evidence sample was available for comparison with targets, simultaneous presentation would lead to a higher rate and broader scope of positive projections than would sequential presentation.

These studies also tested a complementary set of predictions—that the effects of these presentation formats would be attenuated when samples were not available for comparison during projection. Under sequential presentation, removing the samples prior to projection would eliminate the opportunity to differentiate between sample and target items and therefore might be more likely to promote projection relative to when samples are visible during projection. Moreover, under simultaneous presentation, removing the sample would likely decrease the rate of projections—relative to when samples are present —because this method eliminates the opportunity to identify similarities between targets and sample items. Moreover, to the extent that the effects of these presentation formats are dictated by the opportunity to directly compare evidence exemplars and targets, both formats may have a common effect on induction under conditions in which one is unable to make such comparisons. Experiments 3 and 4 explored these possibilities by including conditions in which samples were removed prior to the projection phase of the study.

It is important to note that sequential presentation in the present studies followed a slightly different method than has been used in previous studies. In previous research, sequential presentation was implemented in such a way that an item was presented and labeled and then removed prior to the presentation of the next item (e.g., Son et al., 2011; see also Spencer, Perone, Smith, & Samuelson, 2011). In the sequential conditions in Experiments 1 and 3, each evidence exemplar remained visible after it was presented. Having exemplars available for comparison during presentation might support differentiation between these items, which may contribute to a narrower range of projections. If so, then prohibiting differentiation between sample exemplars by removing each item after presentation might lead to a broader range of generalizations relative to conditions in which items are available during the presentation of evidence. The present studies explored this possibility by modifying the method used to present evidence during sequential presentation: Whereas in Experiments 1 and 3, each evidence exemplar was left visible after it was initially presented, in Experiment 4, each evidence exemplar was removed after it was presented.

Finally, each of these studies included a sample of preschool-age children and adults. Adults were included to serve as a developmental endpoint. This task is a novel task, and therefore, it is not entirely clear how adults will respond. Presentation format has been shown to influence comparison processes in adults and children, and so both groups might demonstrate the same patterns of projections. However, it is also possible these formats will have different effects on these two groups. Children might be disposed to identify similarities, rather than differences, between exemplars (Hammer, Diesendruck, Weinshall, & Hochstein, 2009; see also Rhodes & Liebenson, 2015), which might make them less susceptible to the pattern of narrow projections predicted under sequential presentation.

Experiment 1

In this study, participants were given evidence about three exemplars that shared the same property and then were asked to make property projections for a range of targets. The property was always a novel biological feature (e.g., drotium blood). The three evidence exemplars were from the same basic-level[1] mammal category (e.g., cats), and the targets ranged from items in the same basic-level category to nonanimals. For approximately half the participants, the three evidence exemplars were presented sequentially (i.e., one by one), and for the other participants, the same evidence exemplars were presented simultaneously (i.e., at the same time). The main prediction was that simultaneous presentation, which was expected to draw attention to the similarities between evidence and target exemplars, would yield a higher rate and broader range of positive projections than would the sequential presentation.

[1]While the evidence exemplars are described as representing basic-level categories, they were neither attributed basic-level labels nor were the three exemplars always representative of items at the level of abstraction that is traditionally referred to as the basic level (e.g., Rosch et al., 1976). For example, there were two categories of "cats" represented by either domesticated cats or wild cats, and other items may have been more prototypical basic-level cases of mammals (e.g., dogs) than others (e.g., rodents).

Participants

Forty preschoolers (M_{age} = 4;10, SD = 9.12 months; 22 girls) and 42 adults (M_{age} = 21;1, SD = 27.12 months; 28 women) participated in this study. Adults were undergraduates who received partial course credit for their participation. Preschoolers were recruited from local day-care programs, and these programs were given a small donation for their involvement. Participants were representative of the racial, ethnic, and class diversity of a medium-sized Midwestern U.S. city.

Design, materials, and procedure

Participants responded to eight items, each of which included an evidence sample and 12 targets. The evidence sample included three animals that covered a basic-level mammal category (e.g., dog). The targets included three animals from each of four categories that varied in their level of abstraction relative to the evidence category: basic level, superordinate level (i.e., animals from a different basic-level mammal category), animal (i.e., animals from a different superordinate-level category), and nonanimals. For example, for the dog item, for which the evidence sample included a *Golden Retriever*, *black Lab*, and a *German Shepherd*, the targets were represented by other dogs (e.g., *Dalmatian*), other mammals that were not dogs (e.g., *fox*), other animals that were not mammals (e.g., *robin*), and nonanimal objects (e.g., *cherry*). A list of exemplars used for the samples and targets is presented in Table 1. Each item was represented by a photograph that was mounted on a 5-cm × 5-cm index card.

Participants learned about a novel biological property that was attributed to the three evidence exemplars. The properties were modeled after those used in other studies on the development of inductive reasoning (e.g., Gelman, 1988). In the

Table 1. Evidence exemplars and targets used in Experiments 1 through 4.

		Targets			
Item	Evidence Sample	Basic Level	Superordinate	Animal	Nonanimal
Cats (domestic)	Persian, Siamese, Burmese	Abyssinian, munchkin, tabby	Bunny, guinea pig, squirrel	Snail, snake, painted turtle	Apple, cat toy, tree
Horses	Brown horse, white horse, black horse	Gypsy, brown horse, miniature horse	Camel, gazelle, rhino	Carp, finch, lizard	Grapes, bush, saddle
Rodents	Mouse, hamster, gerbil	Jerboa, chipmunk, shrew	Badger, bushbaby, squirrel	Fly, bass, snapping turtle	Bananas, flowers, wheel
Dogs	Golden Retriever, black Lab, German Shepherd	Shih Tzu, Shorthaired Pointer, Dalmatian	Hyena, jackal, fox	Robin, crocodile, bee	Cherry, plant, car
Cattle	Brown cow, white cow, black cow	Bull, Tudanca, Ankole-Watusi	Bison, goat, pig	Hawk, pufferfish, butterfly	Book, pear, tree
Bears	Grizzly bear, polar bear, black bear	Spectacled bear, brown bear, sun bear	Elephant, hippo, seal	Octopus, praying mantis, eagle	Orange, bush, bike
Cats (wild)	Lion, tiger, cheetah	Cougar, panther, jaguar	Giraffe, zebra, bat	Crow, sea turtle, beetle	Plum, sunflower, slide
Primates	Gorilla, baboon, chimp	Orangutan, lemur, squirrel monkey	Beaver, deer, wolf	Mosquito, tortoise, shark	Coconut, mushroom, broccoli

simultaneous condition (N_{adults} = 22, $N_{\text{preschoolers}}$ = 21), the three evidence exemplars were presented at the same time and participants were told that the animals in the sample shared the same property (e.g., "These animals have drotium blood inside"). In the sequential presentation condition (N_{adults} = 20, $N_{\text{preschoolers}}$ = 19), each evidence exemplar was presented one by one and each one was attributed the same novel biological property (e.g., "This animal has drotium blood inside… . This animal has drotium blood inside… . This animal has drotium blood inside."). In both cases, the sample exemplars were presented side by side and placed approximately 40 cm in front of the participant. There were small differences between the two conditions in the amount of time during which the exemplars were available for encoding. In the simultaneous condition, all evidence exemplars were visible for about 5 s before the projection phase was initiated. In the sequential condition, there was an approximately 1-s gap between the presentation of each item, and thus, after the final item was presented, the first item had been visible for approximately 3 s while the last item became visible. To better equate the amount of time available to process the stimuli in the conditions, in the sequential condition after the last item was presented, the experimenter waited approximately 3 s before initiating the projection phase. In both conditions, the evidence sample was left visible during the projection phase.

The projection phase was identical for the two conditions. The 12 targets were arranged in random order, in three separate rows of 4, and were placed below the evidence sample. Participants were first asked to make positive projections from the sample to the targets: "Which of these (gesturing to the targets) do you think HAVE <property> like these (gesturing to the sample)?" The experimenter collected the items chosen by the participant. When participants appeared to be finished, they were again prompted to choose targets they believed had the property (e.g., "Do you think any of these others HAVE <property>?"). After they made their final selection, participants were asked to make negative projections: "Which of these (gesturing to the remaining targets) do you think DO NOT HAVE <property>?" The experimenter waited a few seconds after it appeared participants were done responding and then provided a second prompt to select targets that lacked the property (e.g., "Do you think any of these others DO NOT HAVE <property>?"). After their final response, the next item was then presented. All items were presented in random order. Participants were also asked to explain their answers; however, their explanations are not reported here.

Children were tested in a quiet location at their preschool, and adults were tested in a quiet lab room on their campus. Both groups were told that during the study, they would "see some pictures of some animals and then answer some questions." The procedure took approximately 20 min.

Results

The main analyses in this and the other experiments reported here focused on a composite projection score. Positive projections (i.e., decisions that a target would have the property attributed to the evidence sample) were coded as "1," negative projections (i.e., decisions that a target would lack the property attributed to the evidence sample) were coded as "–1," and targets for which there was no projection were coded "0." Projection scores were generated for each participant by subtracting the average positive projections for each

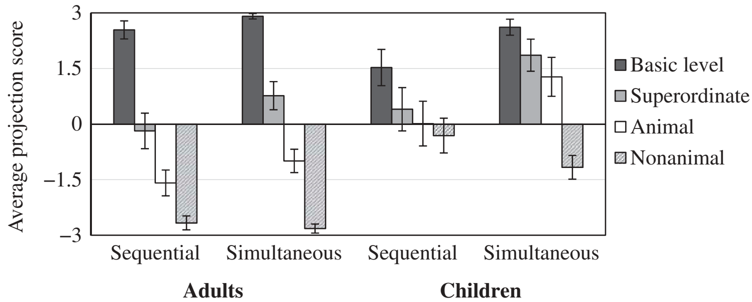

Figure 1. Average projection scores across all targets in both conditions for adults and children in Experiment 1. Error bars represent ± 1 standard error from the mean.

category from the average negative projections for each category. Because there were three targets for each category, the scores for each category could range from 3 to −3 (see Figure 1).

Average projection scores were submitted to a mixed analysis of variance (ANOVA) with age (adults, children) and presentation format (sequential, simultaneous) as the between-subjects variables and target (basic level, superordinate, animal, nonanimal) as the within-subjects variable. All three main effects were significant: age, $F(1, 78) = 18.45$, $p < .001$, $d = 0.96$, due to higher overall projection scores for children ($M = 0.69$, $SD = 0.64$) than for adults ($M = -0.28$, $SD = 0.60$); condition, $F(1, 78) = 9.65$, $p = .003$, $d = 0.71$, due to higher projection scores in the simultaneous condition ($M = 0.56$, $SD = 0.62$) than in the sequential condition ($M = -0.14$, $SD = 0.65$); and target, $F(3, 234) = 293.51$, $p < .001$, $d = 3.88$, due to a stepwise decrease in projection scores as targets moved from specific to general (basic > superordinate > animal > nonanimal; all comparisons, $p < .001$ [Tukey's HSD]).

There was also a Target × Age interaction, $F(3, 234) = 31.46$, $p < .001$, $d = 1.27$. For basic-level targets, adults exhibited higher projection scores ($M = 2.76$, $SD = 0.50$) than did children ($M = 2.09$, $SD = 1.39$), $F(1, 80) = 8.38$, $p = .005$, $d = 1.41$. For the remaining targets, children exhibited higher projection scores than adults: superordinate targets ($M_{\text{children}} = 1.17$, $SD = 1.97$; $M_{\text{adults}} = 0.28$, $SD = 1.28$), animal targets ($M_{\text{children}} = 0.68$, $SD = 2.13$; $M_{\text{adults}} = -1.31$, $SD = 1.19$), and nonanimal targets ($M_{\text{children}} = -1.09$, $SD = 1.21$; $M_{\text{adults}} = -2.78$, $SD = 0.41$; all $Fs > 5.93$, $ps < .02$, $ds > 0.94$). These results indicate that children projected properties more broadly than adults.

The analysis also revealed a significant Target × Condition interaction, $F(3, 234) = 7.51$, $p < .001$, $d = 0.67$. Simple-effects analyses showed higher projection scores in the simultaneous condition than in the sequential condition for basic-level targets ($M_{\text{Sequential}} = 2.01$, $SD = 1.42$; $M_{\text{Simultaneous}} = 2.77$, $SD = 0.48$), superordinate targets ($M_{\text{Sequential}} = 0.07$, $SD = 1.86$; $M_{\text{Simultaneous}} = 1.30$, $SD = 1.31$), and animal targets ($M_{\text{Sequential}} = -0.84$, $SD = 1.96$; $M_{\text{Simultaneous}} = 0.11$, $SD = 1.90$; all $Fs > 5.00$, $ps < .03$, $ds > 0.61$). There were no condition differences for nonanimal targets. Separate analyses revealed these effects were consistent across both age groups. Thus, for both age groups, simultaneous presentation led to higher projection scores than did sequential presentation.

The next analysis considered the consistency with which participants exhibited different patterns of projections. The composite projection score is useful for understanding the relationship between negative and positive projections under conditions in which participants only provided these types of projections. However, in this study, participants could also choose to not project properties. Inspection of overall patterns of projection revealed differences in the degree to which adults and children exhibited these different types of responses. Children exhibited a binary pattern of responses such that they either made positive projections (54%) or negative projections (43%); they rarely chose to not project a property to a target (3%). In contrast, adults made positive projections to 32% of the targets and negative projections to 40% of the targets, and they chose to not project to 28% of the targets.

Because adult responses were distributed across three different response types, the rates of their positive projections, negative projections, and "nonprojections" were compared to the chance of showing any of these response types at random (M = 1.00, assuming an equal likelihood of exhibiting positive projections, negative projections, and nonprojections within a category [of 3 exemplars]). In the sequential condition, adults showed a consistent (i.e., different from chance) pattern of positive projections to basic-level targets (M = 2.73), $t(19)$ = 17.32, p < .001, d = 7.94, and a consistent pattern of negative projections to animal and nonanimal targets (both Ms > 1.80; both ts > 3.06, ps < .007, ds > 1.40). In the simultaneous condition, there was a consistent pattern of positive projections to basic-level targets (M = 2.91), $t(21)$ = 85.66, p < .001, d = 37.38, and a consistent pattern of negative projections to nonanimal targets (M = 2.82), $t(21)$ = 31.47, p < .001, d = 13.73. Additionally, adults exhibited a consistent pattern of nonprojections for superordinate and animal targets in the simultaneous condition (both Ms > 1.59; both ts > 2.99, ps < .008, ds > 1.30). These results indicate some subtle condition differences in adult responses: Adults were more consistent in making negative projections in the sequential condition and were more consistent in making "nonprojections" in the simultaneous condition.

Given that children demonstrated a binary pattern of responses, the rate at which they made positive projections and negative projections was compared to a chance level of M = 1.50 (assuming an equal likelihood of either a positive projection or a negative projection to targets within a category). In the sequential condition, children exhibited a consistent pattern of positive projections to the basic-level targets (M = 2.24), $t(18)$ = 3.71, p = .002, d = 1.74. In contrast, in the simultaneous condition, there was a consistent pattern of positive projections for basic-level, superordinate, and animal targets (all Ms > 2.00; all ts > 3.78, ps < .001, ds > 1.79). No other patterns were significant. These results are consistent with the main findings reported earlier: Children made positive projections to a broader range of targets when evidence exemplars were presented simultaneously compared with when they were presented sequentially.

Discussion

The results support the hypothesis that simultaneous presentation would lead to a higher rate and broader range of positive projections than the sequential presentation. Children and adults exhibited higher projection scores in the simultaneous condition than in the sequential condition for three out of the four targets. For children, this pattern was marked by a consistent preference to make positive projections in the simultaneous condition, whereas for adults, it was likely due to a lower overall rate of negative projections in the simultaneous condition (33%) compared with the sequential condition (51%). Moreover, adults showed greater consistency in their negative projections in the sequential condition, a finding that is consistent with the idea that this format, because it supports differentiation between stimuli, led to a more exclusive range of plausible targets to which these older participants were willing to project properties. Despite some differences between the two groups, the overall results support the conclusion that the processes elicited by the way evidence is presented had a significant impact on inductive generalization in young children and adults. The remaining studies sought to replicate and extend these findings.

Experiment 2

The goal of this experiment was to test an alternative interpretation of the results from Experiment 1. It could be argued that the condition differences were due to different labeling conventions used in the two formats. During simultaneous presentation, evidence exemplars were described with a single label used to mark the entire sample (e.g., "These animals <property>"), and during sequential presentation, each animal was given its own label (e.g., "This animal <property>"). Attribution of properties to the entire group of "animals" may have elicited the expectation, especially in children, that the sample was representative of the entire class of animals and therefore licensed broad generalization. Though it is important to note that because the labeling convention in the simultaneous condition involved a nongeneric (i.e., "these animals"), one might have expected it to yield a narrower pattern of projections (e.g., Cimpian, 2013; Graham, Gelman, & Clarke, 2016). It is also possible that the redundant use of labels (e.g., three in the sequential condition compared to one in the simultaneous condition) narrowed the scope of projections. Experiment 2 explored these possibilities. This study replicated the Simultaneous condition from Experiment 1 with the exception that in this case, the items were not labeled until after the initial presentation of the three exemplars, and when they were presented, each exemplar was labeled separately and marked as a single individual (e.g., "This animal <property>"). If the comparison processes elicited by simultaneous presentation of items was responsible for the pattern of broad generalizations, the responses in this experiment should resemble those from the simultaneous condition in Experiment 1. Conversely, if the labeling convention was responsible for the results in Experiment 1, responses should be similar to the narrow pattern of projections exhibited in the sequential condition.

Method

Participants. Eighteen preschool-age children (M_{age} = 4;6, SD = 11.52 months; 10 girls) and 21 adults (M_{age} = 22;9, SD = 18.72 months; 13 girls) participated in this experiment. Procedures for recruitment and the methods of reimbursement were the same as in Experiment 1. These participants were not included in any other experiments reported here.

Design, materials, and procedure. Everything was the same as in the simultaneous condition in Experiment 1 with the exception that in this case, immediately after the three evidence exemplars were placed in front of the participant, the experimenter labeled and attributed a property to each (e.g., "This animal has drotium blood. . . . This animal has drotium blood. . . . This animal has drotium blood."). The targets were then presented, and the sample exemplars remained visible while participants were asked to make projections.

Results and discussion

The analytic approach was the same as in Experiment 1. Average projection scores were submitted to a repeated-measures ANOVA, which revealed an effect of target, $F(3, 111) = 366.22$, $p < .001$, $d = 6.36$, and age, $F(1, 37) = 26.93$, $p < .001$, $d = 1.70$, as well as an interaction between these variables, $F(3, 111) = 8.75$, $p < .001$, $d = 1.71$. As suggested by Figure 2 and confirmed by simple-effects analyses, the results revealed the same pattern that was shown in Experiment 1: For basic-level targets, adults exhibited higher projection scores than did children, $F(1, 37) = 7.92$, $p = .008$, $d = 0.87$, and for all other targets, children exhibited higher projection scores than did adults (superordinate targets, animal targets, and nonanimal targets, all $Fs > 7.52$, $ps < .008$, $ds > 0.88$).

As was the case in Experiment 1, adults showed a mixed pattern of responses, with 40% positive projections, 27% negative projections, and 33% nonprojections. Comparisons to chance ($M = 1.00$) revealed that adults showed a consistent pattern of positive projections to basic-level and superordinate targets ($Ms > 1.58$, both $ts > 3.68$, $ps < .002$, $ds > 3.67$) and negative projections to nonanimals ($M = 2.77$), $t(21) = 24.89$, $p < .001$, $d = 10.86$. Adults also showed a consistent pattern of nonprojections to superordinate and animal targets ($Ms > 1.40$, both $ts > 2.49$, $ps < .03$, $ds > 1.07$).

Children exhibited a binary pattern of responses such that they tended to either make positive projections (71%) or negative projections (25%); only 4% of responses involved nonprojections. Thus, these comparisons used the same threshold that was used in Experiment 1 ($M = 1.50$) to determine the extent to which children showed a consistent preference in their projections. Based on this criterion, children exhibited consistent patterns of positive projections for basic-level, superordinate, and animal targets (all $Ms > 2.28$, all $ts > 2.63$, $ps < .03$, $ds > 1.14$). There was also a consistent pattern of negative projections for nonanimal targets ($M = 2.08$), $t(21) = 2.71$, $p = .01$, $d = 1.18$.

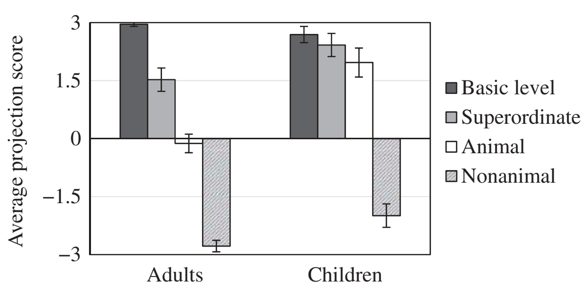

Figure 2. Average projection scores across all targets for children and adults in Experiment 2. Error bars represent ± 1 standard error from the mean.

The findings from Experiment 2 replicated the results from the simultaneous condition in Experiment 1 and thus support the conclusion that the broad pattern of projections was due to the simultaneous presentation of items rather than the method used to label items.

Experiment 3

Up to this point, the results indicate that sequential presentation elicits positive projections to a narrow range of targets and a greater willingness to make negative projections (at least for adults), whereas simultaneous presentation supports positive projections to a broad range of targets. Experiment 3 explored the extent to which these different outcomes were facilitated by the opportunity to compare evidence exemplars and targets. In Experiment 1, the narrow pattern of projections in the sequential condition might have been due to heightened discrimination between the exemplars in the sample and the targets, whereas the broad pattern of projections in the simultaneous condition may have been facilitated by the opportunity to identify similarities between evidence exemplars and targets. Experiment 3 explored this possibility by removing samples prior to soliciting projections, thereby eliminating the opportunity to compare evidence exemplars and targets. The prediction was that doing so might increase the scope of projections in the sequential condition and decrease the scope of projections in the simultaneous condition (relative to Experiment 1). Alternatively, if the results from Experiments 1 and 2 reflect differences in how individuals form an inductive base from which to generalize or were due to some other factor unrelated to how evidence is compared to targets, then removing the sample prior to soliciting projections should have the same effect as when the sample is present during projection.

Participants

Thirty-eight children (M_{age} = 4;8, SD = 9.12 months; 21 girls) and 38 adults (M_{age} = 21;9, SD = 20.88 months; 23 women) participated in Experiment 3. Participants were recruited from the same population as in the first two experiments, and the method of reimbursement was the same as it was in those experiments. These participants were not included in any of the other experiments reported here.

Design, materials, and procedures

This study was identical to Experiment 1 with one exception. As was the case in Experiment 1, presentation format was manipulated between participants by either presenting items all at the same time or presenting them one by one. The temporal dynamics of the presentation were the same as they were in Experiment 1. However, in this case, after the items were visible for a few seconds during presentation (i.e., approximately 5 s and 7 s in the simultaneous and sequential conditions, respectively), they were removed prior to the presentation of the targets to ensure that participants were not able to directly compare evidence exemplars and targets. The targets were presented approximately 3 s after the evidence exemplars were removed.

Results and discussion

The analytic approach was the same as in the other experiments reported here. Projection scores were calculated and then submitted to a mixed ANOVA with age (adults, children) and presentation format (sequential, simultaneous) as the between-subjects variables and target (basic level, superordinate, animal, nonanimal) as the within-subjects variable. There were effects of target, $F(3, 216) = 397.93$, $p < .001$, $d = 4.76$, and age, $F(1, 72) = 17.28$, $p < .001$, $d = 0.97$, both of which were qualified by a Target × Age interaction, $F(3, 216) = 19.38$, $p < .001$, $d = 1.03$. As was the case in Experiments 1 and 2, adults exhibited higher projection scores to the basic-level targets than did children, and children exhibited higher projection scores than did adults for the other three targets (all *F*s > 9.98, *p*s < .003, *d*s > 0.86). However, as suggested by Figure 3, there was no effect of condition, and this factor did not interact with the other variables. Separate analyses confirmed no condition differences for any of the targets across both age groups.

As was the case in the other experiments, adults showed a mixed distribution of responses (33% positive projections, 33% negative projections, and 34% nonprojections), and children showed a binary pattern of projections (60% positive projections, 38% negative projections, and 2% nonprojections).

For adults, one-sample comparisons to chance ($M = 1.00$) confirmed that in both conditions, they demonstrated a consistent pattern of positive projections to basic-level targets (both *M*s > 2.94, *t*s > 77.10, *p*s < .001, *d*s > 33.64) and negative projections to nonanimal targets (both *M*s > 2.86, *t*s > 33.80, *p*s < .001, *d*s > 14.75). Additionally, adults consistently chose to not project properties to superordinate and animal targets in both conditions (all *M*s > 1.60, *t*s > 3.10, *p*s < .02, *d*s > 1.35).

For children, one-sample comparisons to chance ($M = 1.50$) revealed a common pattern of positive and negative projections in both conditions. Children consistently made positive projections to basic-level and superordinate targets in the sequential condition (both *M*s > 2.17, *t*s > 4.22, $p < .002$, *d*s > 1.84) and the simultaneous condition (both *M*s > 1.92, *t*s > 2.92, *p*s < .01, *d*s > 1.27). Both conditions also elicited a consistent pattern of negative projections for nonanimal targets (both *M*s > 2.22, *t*s > 2.56, *p*s < .02, *d*s > 1.11). There were no consistent patterns of projections for the animal targets.

These individual-level analyses replicate the group-level findings: There were no condition differences in the patterns of projections. However, there were some group differences. Children consistently made positive projections to more targets than did adults,

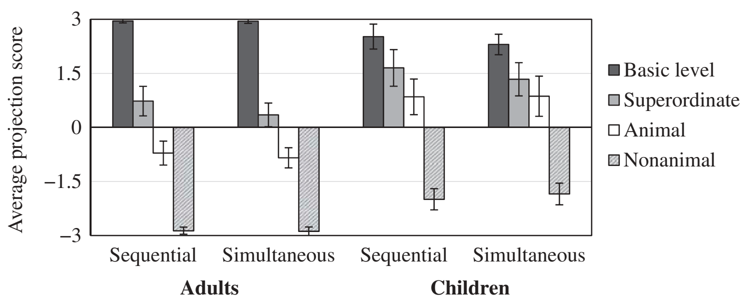

Figure 3. Average projection scores across all targets in both conditions for adults and children in Experiment 3. Error bars represent ± 1 standard error from the mean.

whereas adults were more consistent in their decision to not project properties compared with children.

Comparison between Experiments 1 and 3. The final set of analyses compared projection scores in Experiment 1 to those in Experiment 3 to directly examine the degree to which the absence or presence of the evidence sample during projection influenced projections. This analysis involved an ANOVA with age (adults, children), condition (simultaneous, sequential), and experiment (sample present/Experiment 1 vs. sample absent/Experiment 3) as between-subjects variables and target (basic level, superordinate, animal, nonanimal) as the within-subjects variable. Critically, there was a significant three-way interaction between target, condition, and experiment, $F(3, 148) = 5.04$, $p = .02$, $d = 0.61$. Separate Condition × Experiment analyses revealed higher projection scores in the sequential condition in Experiment 3 than in Experiment 1 for the basic-level, superordinate, and animal targets (all Fs > 8.20, ps < .006, ds > 0.60), and the projection scores for the nonanimal targets were significantly lower in Experiment 1 than in Experiment 3, $F(1, 76) = 4.95$, $p = .03$, $d = 0.48$. Additional analyses confirmed these patterns held for both age groups. The analyses revealed that in the simultaneous condition, were no significant differences in projection scores for any of the targets across the two experiments.

These results indicate that the absence of sample items during projection had a significant impact on inductive inferences, particularly when evidence exemplars were presented sequentially. The comparison between projection scores in Experiment 1 and Experiment 3 demonstrates this point: When items were presented sequentially, the presence of the evidence sample during generalization (Experiment 1) supported a narrower range of projections than when these same items were present during generalization (Experiment 3). Whether the evidence sample was present or absent did not have a significant effect on projections in the simultaneous condition, thus suggesting the broad pattern of generalizations in this condition is warranted, to a large extent, by processes elicited during the presentation of evidence.

Experiment 4

This final experiment focused on whether the ability to compare exemplars *within* the evidence sample would influence induction. The explanation for the narrower rate of projections for sequential presentation in Experiment 1 compared with Experiment 3 is that the presence of the evidence sample during projection offered the opportunity to differentiate between evidence and target items, thus licensing generalizations to fewer targets. From this perspective, it is possible that leaving evidence exemplars visible while the sample is presented might encourage differentiation within the sample and thereby restrict projections. In other words, discrimination within the sample might create a narrow inductive base from which to generalize. If it is the case, then a sequential presentation paradigm in which each item is removed prior to the presentation of the next should offer fewer chances to differentiate between items and therefore lead to a higher rate of projections than when these items are not removed (e.g., Experiments 1 and 3). Experiment 4 was designed to test this prediction.

Method

Participants. Nineteen preschool-age children (M_{age} = 4;5, *SD* = 11.28 months; 9 girls) and 18 adults (M_{age} = 22;2, *SD* = 19.56 months; 10 women) participated in Experiment 4. Participants were recruited from the same population as in the first three experiments, and the method of reimbursement was the same as it was in those experiments. These participants were not included in any of the other experiments reported here.

Design, materials, and procedures. The method was identical to the sequential presentation condition in Experiment 3 with the exception that after each evidence exemplar was presented and attributed a property (e.g., "This animal has drotium blood"), it remained visible for 1 s before being removed. After the final evidence exemplar was removed, there was a 3-s delay before initiating the projection phase.

Results

An Age × Target ANOVA yielded effects of target and age, as well as an interaction between these two variables, $F(3, 105) = 26.65$, $p < .001$, $d = 1.74$. As suggested by Figure 4, children exhibited higher projection scores than did adults for superordinate targets, animal targets, and nonanimal targets (all *F*s > 7.77, *p*s < .01, *d*s > 0.93). In contrast to the other experiments reported here, there was not a significant difference between children and adults in projection scores for the Basic-level targets ($F < 0.10$, *ns*).

As was the case in the other experiments, children showed a binary pattern (70% positive projections, 24% negative projections, and 6% nonprojections), and adults showed a distributed pattern (40% positive projections, 27% negative projections, and 33% nonprojections). For adults, one-sample comparisons to chance ($M = 1.00$) revealed a consistent pattern of positive projections for basic-level targets ($M = 2.91$), $t(17) = 44.71$, $p < .001$, $d = 21.68$, a consistent pattern of negative projections for nonanimal targets ($M = 2.65$), $t(17) = 37.46$, $p < .001$, $d = 18.17$, and a consistent pattern of nonprojections for superordinate and animal targets (*M*s > 1.70, *t*s > 4.17, $p < .001$, *d*s > 2.20). For children, comparisons to chance ($M = 1.50$) revealed a consistent pattern of positive projections to basic-level, superordinate, and animal targets (*M*s > 2.30, all *t*s > 5.20, *p*s < .001, *d*s > 2.52).

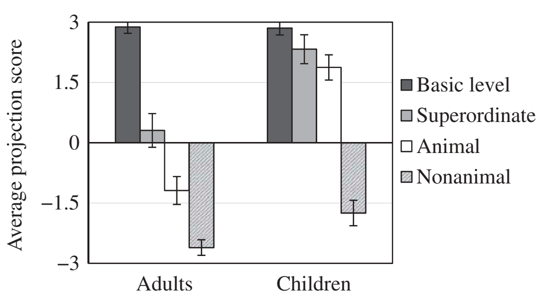

Figure 4. Average projection scores across all targets for adults and children in Experiment 4. Error bars represent ± 1 standard error from the mean.

Comparison between Experiments 3 and 4. The final analyses compared responses from the sequential condition in Experiment 3 to the responses in Experiment 4. An Experiment (3, 4) × Age (adults, children) × Target (basic level, superordinate, animal, nonanimal) ANOVA yielded an Age × Experiment interaction, $F(1, 71) = 7.72$ $p = .007$, $d = 0.66$. Follow-up analyses showed that children demonstrated higher projection scores in Experiment 4 than in Experiment 3, $F(1, 36) = 5.37$, $p = .02$, $d = 0.77$, but projection scores for adults were not different in the two experiments. Additional analyses revealed that for children, there were higher projections scores in Experiment 4 than in Experiment 3 for basic-level targets, $F(1, 36) = 4.86$, $p = .03$, $d = 0.68$, but not for any other targets (all Fs < 2.70, *ns*). Supplemental analyses revealed that for adults, there were no differences in projection scores between Experiments 3 and 4 for any of the targets (all Fs < 2.80, *ns*).

Results from this experiment indicate that removing each evidence exemplar immediately after presentation increased the strength of children's, but not adults', inductive projections. The effect was isolated to basic-level targets, perhaps suggesting that the task dynamics in Experiment 4 provided better support for highlighting the category represented in the evidence sample. However, it is not clear why, under these conditions, children continued to generalize broadly or why children exhibited an increase in projections across the experimental manipulations in Experiments 3 and 4 and adults did not. These matters are discussed in greater detail in the General Discussion.

General discussion

Children and adults are flexible inductivists insofar as they modify their inferences in light of *what* conceptual and perceptual information is available for generalization (Gelman, 1988; Heit & Rubenstein, 1994; Medin, Coley, Storms, & Hayes, 2003; Sloutsky & Fisher, 2008). The current studies explored the extent to which inductive generalizations are influenced by *how* evidence is presented. The results from four experiments revealed that presentation method had a significant influence on property projection. Participants exhibited a broader range of projections when three evidence exemplars were presented simultaneously (i.e., at the same time) than when they were presented sequentially (i.e., one by one), at least when the evidence exemplars remained visible during induction (Experiments 1 and 2). These presentation effects were absent when evidence items were not available for comparison with targets (Experiment 3), and sequential presentation had the most robust effects on children's inductive inferences when participants were not able to compare exemplars within samples of evidence (Experiment 4). The remainder of this discussion considers the mechanisms that may account for these findings and addresses the implications of these results for theories of inductive reasoning.

Overall, these results are consistent with the idea that presentation format influences the comparison processes used to generate inductive decisions. From this perspective, it is interesting to consider why projections in the simultaneous presentation were least effected by various manipulations to task structure—this presentation format always elicited a high rate and broad range of generalizations (Experiments 1–3). One explanation for why simultaneous presentation elicited high rates of positive projections is that it yielded greater attention to the conceptual, or "deep," relations between the sample and target items (Gentner & Namy, 2006; Gentner & Namy, 1999; Son et al., 2011) and thereby established a stronger inductive base from which to generalize. Furthermore, under simultaneous presentation, the provision of shared labels might have encouraged children to project properties to a wide range of targets. Labels are especially useful in the context of comparison (Namy & Gentner, 2002) and may trigger the expectation that available evidence refers to a particular category (Waxman & Markow, 1995; though see Sloutsky & Napolitano, 2003). The process of identifying common features for three "animals" might have facilitated projections to a broad range of targets believed to be representative of the animal category. This interpretation suggests that the simultaneous presentation, and perhaps not the sequential presentation, encouraged children to rely on their prior expectations about the labeled category ("animal") when determining the range of targets to which to generalize.

While the simultaneous presentation had a relatively consistent effect on projections, the effects of sequential presentation were strongly influenced by the structure of the inductive problem. The specific manipulations provide insight into the distinct ways in which the differentiation between items, a process facilitated by this presentation format (e.g., Lipsitt, 1961; Rescorla, 1980; Williams & Ackerman, 1971), can effect property induction. When items were presented one by one and remained visible during generalization, children and adults exhibited a narrower range and lower rate of positive projections compared with when the same items were presented simultaneously (Experiment 1). The depressed rate of projections suggests that the opportunity to differentiate between the evidence sample and targets limited the range of targets to which individuals were willing to generalize. Consistent with this idea, adults showed greater consistency in predicting that targets did not have a property (i.e., negative projections) in the sequential condition compared with the simultaneous condition. Evidence from Experiments 3 and 4 provides further support for this differentiation explanation. First, the strength and breadth of generalizations was inflated when evidence exemplars were not available for comparison during induction, thereby limiting the opportunity to discriminate between samples and target items (Experiments 3 and 4). Second, the sequential presentation format yielded a lower rate of projections when the presentation format permitted differentiation between exemplars (Experiment 3) compared with when participants were not able to differentiate between exemplars (Experiment 4).

Despite commonalities in the responses of children and adults, there were some important differences. Children generalized more broadly than adults and exhibited greater variation in their responses as a consequence of the experimental manipulations. One explanation for the broader pattern of generalization in children's responses is that shared labels carried more weight for them than they did for adults (e.g., Sloutsky & Fisher, 2012). It is also possible that for children, who tend to be more credulous (e.g., Mills, 2013), presentation format had a stronger pragmatic influence. For example, children may have expected the deliberate use of the label "animal" during simultaneous presentation was intended to be instructive about the entire class of animals. This interpretation might also help to explain why children rarely chose to not project properties; unlike adults, children may have expected that because the researcher asked them to judge the items that "have" and "do not have" the target property, those were the only two response options. The pattern of broad generalizations by children in Experiments 3 and 4 is also consistent with the idea that children are simply more disposed to search for similarities, rather than differences, between exemplars (e.g., Hammer et al., 2009; Rhodes & Liebenson, 2015). In the absence of task features that invite differentiation between samples and targets (Experiment 1), children, unlike adults, might have relied on the more familiar strategy of identifying similarities between evidence and targets.

Most previous work on children's inductive flexibility has demonstrated that children's conceptual knowledge determines which generalizations they are willing to endorse (Coley, 1995; Hayes & Thompson, 2007; Kalish & Gelman, 1992; Lawson & Kalish, 2006; Opfer & Bulloch, 2007). Children do not simply rely on their taxonomic knowledge as a basis to generalize properties but consider different types of relations (e.g., predator–prey, kinship, deontic, etc.) when determining which inferences are warranted. The present studies support the view that flexible inductive decisions are also rooted in general purpose mechanisms such as those that govern associative learning or deploy attentional resources to determine how to generalize properties from known cases to novel cases (e.g., Rakison & Hahn, 2004; Sloutsky & Fisher, 2004, 2008). In this way, perhaps the most parsimonious interpretation of these results is that they indicate that how evidence is presented impacts the degree to which we rely on different sources of information to make inductive judgments (e.g., Goldstone, 1996). Evidence presentation can play a critical role in bringing either perceptual or conceptual information to the foreground. From this perspective, because simultaneous presentation supports identification of unobservable or relational properties (Gentner & Namy, 2006) and places unique constraints on one's interpretation of labels (Namy & Gentner, 2002), this format might be more likely to engage individuals in conceptual-based processes associated with so-called category-based reasoning (e.g., Gelman, 2003). This interpretation would align with, for example, the idea that the simultaneous presentation caused children to believe they were learning about properties of *animals*. Sequential presentation, on the other hand, engages processes that support differentiation between presented cases, such as heightened attention to perceptual differences between exemplars, as well as those that support memory formation, all of which are important for induction (A. F. Fisher & Sloutsky, 2005; Hawkins, Hayes, & Heit, 2016; Rakison & Hahn, 2004; Sloutsky & Fisher, 2004; Smith & Jones, 1993). Framing the results in this way suggests that a fruitful approach for future research is to understand the degree to which various methods of evidence presentation—known to engage distinct cognitive processes—contribute to the development of inductive reasoning.

This paradigm might also be employed to explore other facets of early induction such as the development of inductive principles. For example, before about 8 years of age, children do not obey the sample size and diversity principles of induction—they fail to recognize that larger and more diverse samples of evidence provide a better basis from which to generalize compared with smaller and less diverse samples (Hayes, 2007). In the standard method used to examine these principles, individuals are presented with two samples simultaneously and then are asked to select the best sample from which to generalize (Lopez et al., 1992; Gutheil & Gelman, 1997; cf. Rhodes & Liebenson, 2015). Thus, it is possible that failure in prior tasks might have been a consequence of employing the simultaneous presentation method; participants may have been primed to search for common features shared by evidence samples when in fact the solution to these problems requires a focus on differences between samples. In support of this point, Lawson (2014) found that children as young as 3 years of age obeyed the sample size principle of induction (i.e., preferred to generalize from a sample of five cats rather than a sample of three cats) when items were presented sequentially but not when they were presented simultaneously. Examining the relative effects of each of these presentation formats on children's respect for the diversity principle and other inductive principles is important for future research.

The present studies were not without limitations. As indicated earlier, there are remaining questions regarding the influence of labels under different presentation formats. In the spirit of communicating relevant information, people tend to label targets at the basic level (e.g., "dogs"; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). The purpose of using the "animal" label, despite the evidence exemplars representing the same basic-level category, was to permit broad generalizations—this label covered most of the targets used in these studies (except the nonanimals) and therefore would not prohibit projections to these targets. However, it is likely that children's familiarity with the "animal" label contributed, at least to some degree, to the broad range of generalizations. Thus, it remains an open question whether the effects of evidence presentation on property induction would be observed with novel labels (e.g., Spencer et al., 2011).

Another limitation is that all the items were roughly at the same level of abstraction (e.g., basic level) and represented animals within the same superordinate class (e.g., mammals). It will be important to examine the effect of presentation format in other domains and for samples with greater variability. Also, the different formats place different temporal constraints on induction, some of which were controlled across the two conditions. Previous work has shown that simultaneous presentation and sequential presentation have the same effects on induction when exposure time is equated (Lawson, 2014). However, other temporal factors could influence generalization (e.g., delay between evidence presentation and projection phase; Vlach et al., 2012). It will be important to explore the extent to which these factors influence children's inductive projections under different presentation conditions.

In sum, the results from these studies indicate that the method of evidence presentation has a considerable impact on inductive reasoning in young children and adults. Overall, this work emphasizes the importance of viewing inductive reasoning as a dynamic process in which the mechanisms that govern our generalizations from known to novel cases are triggered in the moment by the methods used to present evidence.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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