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Brief article

Thyme to touch: Infants possess strategies that protect them from dangers posed by plants

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ABSTRACT

Plants have been central to human life as sources of food and raw materials for artifact construction over evolutionary time. But plants also have chemical and physical defenses (such as harmful toxins and thorns) that provide protection from herbivores. The presence of these defenses has shaped the behavioral strategies of non-human animals. Here we report evidence that human infants possess strategies that would serve to protect them from dangers posed by plants. Across two experiments, infants as young as eight months exhibit greater reluctance to manually explore plants compared to other entities. These results expand the growing literature showing that infants are sensitive to certain ancestrally recurrent dangers, and provide a basis for further exploration.

1. Introduction

In modern Western circumstances, plants are often peripheral to daily life. They may be encountered only in well-manicured lawns and parks, or as already-harvested fruits and vegetables in the grocery store. Even people who spend lots of time outdoors do not need to know the names or underlying properties of the trees and shrubs along the trails; they are simply part of the scenery. However, across the entirety of human history these circumstances are rare—a consequence of the WEIRD societies (i.e., Western, Educated, Industrialized, Rich, and Democratic; Henrich, Heine, & Norenzayan, 2010) in which we live.

Throughout human evolution (extending to well before we were human), and in the conditions of modern hunter-gatherers, plants have been essential to human existence. Gathered plant resources provide food (Cordain et al., 2000; Ungar & Sponheimer, 2011), raw materials for building shelters and artifacts (Lee, 1993), and medicines (Begossi, Hanazaki, & Tamashiro, 2002). Yet, for all of these benefits, plants have always posed very real dangers. Plants produce toxins as defenses against predators that can be harmful, or even deadly, if ingested (Keeler & Tu, 1983; Palo & Robbins, 1991). Some plants also employ physical defenses, such as fine hairs, thorns, and noxious oils, that can damage tissues and cause systemic effects (Kingsbury, 1983). Hunter-gatherer populations across the world exploit these botanical facts by using toxic plant chemicals in rituals (van Andel, Ruysschaert, Van de Putte, & Groenendijk, 2013), to make poison arrow tips (Marlowe, 2010), and to poison rivers as a fishing tactic (Ringhofer, 2009).

The costs associated with plant defenses have shaped the physiology and behavior of many non-human animal species. These include purging mechanisms (e.g., vomiting) and mechanisms to break down toxins in the gut (Kingsbury, 1983), specific aversions based on taste or adverse experience (Rozin & Kalat, 1971), and behavioral strategies such as sampling small quantities of an unknown plant, and eating a variety of plants to minimize consumption of any one toxic compound (Freeland & Janzen, 1974). There is some evidence that humans may possess similar purging mechanisms and taste aversions to protect against plant toxins at vulnerable stages of development (e.g., pregnancy sickness; Profet, 1992; and children's aversion to vegetables; Cashdan, 1998). Further, because heating breaks

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down many toxins, it has been suggested that cooking arose in part to mitigate the effects of plant toxins (Stahl, 1984; Wandsnider, 1997).

Infants exhibit sensitivities to other ancestrally recurrent dangers, such as snakes and spiders (DeLoache & LoBue, 2009; Rakison & Derringer, 2008). Here we examine whether infants possess behavioral strategies that reduce their exposure to hazards posed by plant defenses. There are no morphological features that reliably signal which plants contain dangerous toxins (Keeler & Tu, 1983), making trial-and-error experimentation a costly proposition. Nevertheless, plant defenses can be easily avoided by minimizing physical contact with plants in the absence of social information that a plant is safe.[1] Therefore, we predicted that infants may possess behavioral strategies that reduce their exposure to hazards posed by plant defenses by minimizing their physical contact with plants. Accordingly, in Experiment 1 we tested whether infants show a reluctance to reach out and touch plants, relative to other kinds of objects.

2. Experiment 1

2.1. Methods

2.1.1. Participants

Forty-seven 8- to 18-month-old infants (23 female; M_{age} = 13 months, 18 days; range = 7;17–18;24) were tested in the Infant Cognition Center at Yale University. Three additional infants were run but excluded due to procedure error (2) and fussiness (1).

2.1.2. Stimuli

Our stimuli were two real plants, two realistic-looking artificial plants, and two artifacts. The real plants were basil and parsley plants in green plastic pots purchased from a grocery store. Because the real plants varied slightly over the course of data collection (i.e., they grew or wilted and needed to be replaced) we included two artificial plants in the stimuli set that were similar to the real plants. One of the artificial plants was made with large fabric leaves similar to the basil plant, the other was made from small plastic leaves similar to the parsley plant. Both were arranged in clay pots with "pot-toppers" that made it look like the pots were filled with soil.

The artifacts were constructed to match features of the artificial plants. The first artifact was constructed from two blue cardboard cylinders painted with a yellow stripe. Fabric leaves, identical to those on the artificial fabric plant, were dyed black and arranged to hang down from the top of the cylinder. The second artifact was designed to imitate the green color and movement of the plastic plant. It was made out of pipe cleaners covered in green beads attached to the top of a plastic cylinder. See Supplementary (SI) Section 1.1 and Fig. S1 for further details and measurements.

2.1.3. Procedure

Infants sat on their parents' laps across a table from an experimenter who placed six objects, one at a time, in front of the infant while saying "Look what I've got" (see Movie S1). Parents kept their eyes closed throughout and the experimenter looked down at the table and maintained a neutral expression while each object was before the infant. The objects were grouped into two sets of three objects each according to overall shape (see Fig. S1). Presentation order of the two sets, and the items within each set, were counterbalanced. Because we were interested in infants' actions towards the plants (and not the pots in which they were presented), we defined the "top part" of each object as the area of interest. This was the leaves and stems of the real and artificial plants, and the black fringe and beaded pipe cleaners on the artifacts (see Fig. S1). The experimenter only touched the bottom part of each object throughout the experiment.

Trials terminated (i) when the infant touched the top part of the object, (ii) 10 seconds after the infant touched the bottom part of the object and failed to touch any other part (to prevent digging in the dirt/knocking objects over), or (iii) after 30 seconds elapsed without a touch. A touch was counted as the moment that any part of the infant's hand came in contact with the object. A second coder evaluated a randomly selected 25% of the videos; coder agreement was 99%.

2.2. Results

2.2.1. Reluctance to touch plants

Infants showed a striking reluctance to reach out and touch plants. A repeated measures ANOVA on infants' mean trial duration for each object type (real plants, artificial plants, and artifacts) revealed a main effect of object type ($F(2,92) = 16.89$, $p < .0001$, partial $\eta^2 = .27$; see SI Section 1.2 for details) such that trial durations were much longer for the plants than the novel artifacts (real plants: $t(46) = 4.39$, $p < .0001$, d = .51; artificial plants: $t(46) = 5.61$, $p < .0001$; d = .61); there was no difference in trial duration between real plants and artificial plants ($t(46) = -.86$, $p = .40$; Fig. 1).[2] In fact, forty-five of our forty-seven infants took longer to touch the plants than the novel artifacts (binomial $p < .0001$; Fig. 2).

This effect was not driven by the rarity of the artifacts in a stimulus set comprising mostly plants; the difference obtained even with infants' first trial duration ($M_{real\ plants}$ = 15.30 s, SD = 14.99, $M_{artificial\ plants}$ = 10.50 s, SD = 11.70, $M_{artifacts}$ = 3.79 s, SD = 7.78; $F(2,44) = 3.40$, $p = .04$, partial $\eta^2 = .13$). Nor was it driven by specific features of the objects (materials, movement, color, height, or width; see SI Section 1.3). The effect was not driven by age; linear regressions showed no effect of age on trial duration for real plants ($\beta = .03$, $t = .22$, $p = .83$), artificial plants ($\beta = .005$, $t = .04$, $p = .97$), or artifacts ($\beta = -.07$, $t = -.49$, $p = .63$). Infants at 8 months were as reluctant to touch plants, relative to artifacts, as were infants at 18 months (Fig. 2).

[1] In other work we have shown that infants use relevant social information to guide their subsequent interactions with plants (e.g., selectively identifying plants as food sources; Wertz & Wynn, under revised review).

[2] Although the trial termination criteria were focused on infants' interactions with the top parts of the objects, follow up analyses showed that infants' treatment of the stimuli held for the bottoms of the objects as well (see SI Section 1.2).

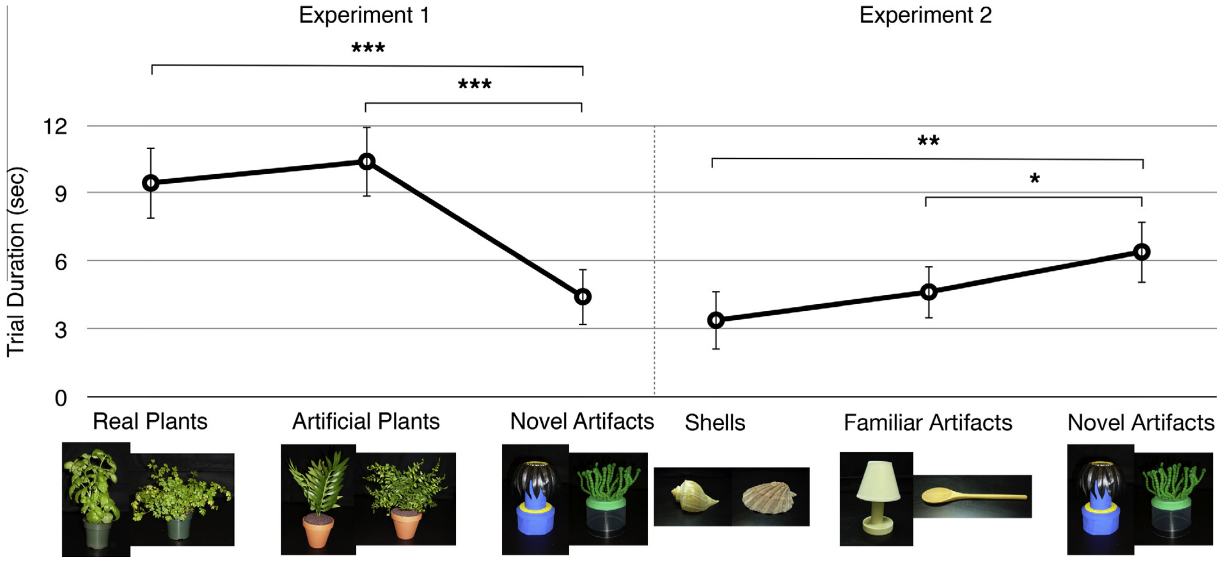

Fig. 1. 8- to 18-month-olds' mean trial durations in Experiments 1 and 2. Error bars represent ± 1 SEM. Significant post hoc *t*-test comparisons are noted. *** indicates $p < .0001$, ** indicates $p < .01$, and *indicates $p < .05$. Comparisons between real and artificial plants, and shells and familiar artifacts were not significant.

2.2.2. Parent questionnaire results

To examine the role of specific experiences, parents completed a questionnaire assessing how often (i) their infants saw them caring for plants, (ii) their infant tried to touch plants, and (iii) they stopped their infant from touching plants. There was no correlation between trial duration and measures (ii) and (iii) (SI Section 1.4). However, infants who saw their parents caring for plants more often took longer to touch plants (real plants: $r = .43$, $p = .008$, artificial plants: $r = .34$, $p = .04$), while there was no correlation with artifacts ($r = .03$, $p = .87$). It appears that increased exposure to parents' handling of plants actually increases infants' reluctance to touch them.

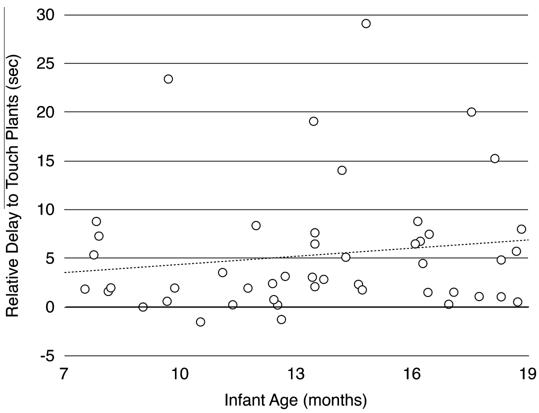

Fig. 2. Relative delay for touching plants compared to novel artifacts in Experiment 1 plotted by infants' age. Positive numbers indicate that trial durations were longer for the plants (real and artificial combined) than the novel artifacts. Forty-five out of forty-seven infants took longer to touch the plants than the novel artifacts (binomial $p < .0001$). There was no effect of age on the relative delay to touch plants ($\beta = .13$, $t = .86$, $p = .39$).

2.2.3. Intentional-touch coding

Because a trial ended once any part of the infant's hand touched the top part of an object, our trial duration measure may underestimate the time before infants intentionally touch plants. For example, if the back of an infant's hand accidentally brushed the leaf/top part of an object while he or she was reaching for the bottom part, it still counted as "touching" the top part and ended the trial. Similarly, trials could end without the infant ever touching the top part (see criteria (ii) and (iii) for trial termination above). To investigate this, a coder rated the videos for (i) whether the infant touched the leaf/top part of the object during each trial, and (ii) whether those touches were intentional or accidental. A second coder independently coded a randomly chosen 25% of the videos; coder agreement was 95.8%.

Infants never touched the top part on 33% of the plant trials compared to 15% of the artifact trials (McNemar's test of dependent proportions, $p = .0002$). Similarly, there were accidental top part touches during the plant trials, but none during the artifact trials (20% vs. 0% of trials; McNemar's test, $p < .0001$). Thus, our trial duration results may indeed underestimate infants' motivation to avoid touching plants.

3. Experiment 2

Experiment 2 addressed two alternative explanations for infants' reluctance to touch plants. First, it might reflect a novelty preference; infants may have been less interested in exploring the more familiar objects (the plants) than the novel artifacts we created, which could also account for the positive correlation between trial duration and plant exposure. Second, it might reflect a belief about artifacts, not plants: an expectation that artifacts are generally safe, while other types of objects should be avoided. To examine these possibilities, we presented infants with a different stimulus set: two novel artifacts, two familiar objects, and two seashells.

3.1. Methods

3.1.1. Participants

Forty-four full term 8- to 18-month-old infants (22 female; M_{age} = 13 months, 19 days; range = 7;16–18;28) were tested in the Yale Infant Cognition Center. Four additional infants were run but excluded due to video loss (3) and parent interference (1).

3.1.2. Materials and procedure

The novel artifacts were the same artifacts used in Experiment 1. The familiar objects were a small lamp and a spoon. A lamp was chosen because, similar to plants, infants see their parents touching lamps, but infants would be unable or discouraged from touching lamps themselves. Infants see their parents using spoons nearly every day, but unlike lamps, infants also have first-person experience using spoons. These assumptions were verified by a parent questionnaire (see Table S1). Seashells were chosen because they are naturally occurring forms (i.e., not man-made) that, like the plants, are inanimate. See SI Section 2.1 and Fig. S2 for stimuli details. For these experiments, we did not include animals because (i) infants' reactions to animals have been studied in other contexts and infants are drawn to animals over artifacts (LoBue, Bloom Pickard, Sherman, Axford, & DeLoache, 2013), and (ii) animals' self-generated movement would create a confound in this stimulus set.

The object presentation procedure was identical to Experiment 1 (Movie S2). However, because the spoon and shells lacked a clearly identifiable "top part," trials for these objects terminated (i) when the infant touched any part of the object, or (ii) after 30 seconds elapsed without a touch. A "touch" was again coded as any part of the infant's hand contacting the object. An offline coder determined trial duration. A second coder evaluated a randomly selected 25% of the videos; coder agreement was 99%.

3.2. Results

3.2.1. Trial duration results

Infants showed no reluctance to touch either familiar objects or shells. A repeated measures ANOVA on infants' mean trial duration for each object type (novel artifacts, familiar artifacts, shells) showed a main effect of object type ($F(2,86) = 5.35$, $p = .006$, partial $\eta^2 = .11$; see SI Section 2.2 for details). Infants took longer to reach out and touch novel artifacts than familiar artifacts ($t(43) = 2.27$, $p = .03$, d = .21; see also Shinskey & Munakata, 2005) or shells ($t(43) = 2.92$, $p = .006$, d = .34; see Fig. 1). The novel artifact duration was not different from Experiment 1 ($t(89) = -1.06$, $p = .29$). An ANOVA on the latency until infants' first touch[3] revealed only a marginally significant effect of object type on trial duration ($M_{shell\ first\text{-}touch}$ = 3.38 s, SD = 8.71; $M_{familiar\ artifact\ first\text{-}touch}$ = 3.36 s, SD = 7.38; $M_{novel\ artifact\ first\text{-}touch}$ = 4.96 s, SD = 8.79; $F(2,86) = 2.69$, $p = .07$, partial $\eta^2 = .06$), which was driven by infants being slower to touch the novel artifacts than the familiar artifacts ($t(43) = 2.64$, $p = .01$, d = .20). Regardless of which touch criterion was used, infants did not show a reluctance to touch familiar objects or other natural kinds, ruling out alternate explanations for the reluctance to touch plants found in Experiment 1.

[3] This "first touch" criterion reflects the time until infants made contact with any part of the object, including the bottom part, and applies a uniform trial termination criteria across the objects used in Experiment 2. Although this correction is not necessary for the objects used in Experiment 1, the original pattern of results holds using this criterion (see SI Section 1.2).

3.2.2. Parent questionnaire results

Parents completed a questionnaire about infants' experiences with shells, lamps, and spoons. In this case, infants' trial durations were not systematically related to any of the experience variables (SI Section 2.3).

3.3. Discussion

Infants' reluctance to touch plants was not driven by familiarity, nor by a reluctance to touch natural kinds in general. Instead, infants seem to be equipped to handle the recurrent dangers plants pose by selectively delaying manual exploration.

4. General discussion

The findings presented here show that, in the absence of social information, infants from 8 to 18 months of age are reluctant to touch plants compared to other types of entities. This behavioral strategy would protect infants from the dangers posed by plants by decreasing the likelihood of ingesting plant toxins (by either consuming plant parts or ingesting toxins rubbed off on their hands from damaged plant parts), or incurring injuries from plants' physical defenses (e.g., fine hairs, thorns, or noxious oils).

How this strategy operates in naturalistic settings remains to be investigated. Caregivers play a crucial role in keeping infants safe, but our findings suggest that infants contribute behavioral responses of their own. Inhibited exploration may provide time for adult intervention before an infant makes contact with a particular plant, or guide infants to interact with objects less likely to be harmful. Whatever the case, the current results suggest that human infants, like other non-human animals (Freeland & Janzen, 1974; Kingsbury, 1983), possess strategies for mitigating the ancestrally recurrent dangers posed by plants.

The current results add to recent findings showing that infants and young children are sensitive to other recurrent dangers, such as snakes, spiders, and dangerous animals (Barrett & Broesch, 2012; LoBue, Rakison, & DeLoache, 2010) and to the literature on factors that affect infant reaching speed (e.g., infants reach faster for larger objects and for objects in the dark; Berthier & Carrico, 2010; Clifton, Rochat, Robin, & Berthier, 1994). Yet infants' responses to plants and animals differ in interesting ways. For humans and other primates, attention is more easily captured by snakes and spiders (e.g., LoBue & DeLoache, 2008; Rakison & Derringer, 2008). However, social information from conspecifics is required before these and other animals are treated as dangerous (Barrett & Broesch, 2012; DeLoache & LoBue, 2009; Öhman & Mineka, 2001).[4] In contrast, infants in the current studies treated plants as potentially dangerous in the absence of social information. To be clear, we are not suggesting that infants are actively afraid of plants. Rather we propose that once infants identify an object as a plant, they deploy a behavioral strategy of inhibited manual exploration, which serves to help protect them from plants' potential dangers.

The current findings are consistent with this proposal, yet there is certainly much that remains to be investigated. Future research can examine the circumstances in which such protective strategies fail. Plant poisoning does occur in young children (roughly 10% of calls to poison control centers in the US and Germany), yet few of these cases result in serious harm; and serious plant poisonings in the developing world (e.g., areas of South Asia, West Africa, and Central America) typically occur only in areas where food is scarce and poisonous plants are mistaken for edible plants (Eddleston & Persson, 2003). Future research could also explore whether there are alternate or additional explanations for why infants delay manual exploration of plants. Another task that remains is to elucidate the features infants use to identify an object as a plant. Adults can recognize trees from point-light displays of swaying movement (Cutting, 1982), but this cannot be the entire story. Our results indicate that infants do not appear to use specific features in isolation (e.g., green color, leaf shape), suggesting that they may rely instead on a probabilistic combination of different features that remains to be discovered.

Another critical future direction will be to explore the role of social information and social learning. A strategy of avoiding all plants indefinitely would be disastrous for any herbivorous or omnivorous species; humans are no exception, especially given the many other ways humans utilize plants outlined in the introduction. Given that there are no morphological features that reliably signal toxicity in plants (Keeler & Tu, 1983), we suspect that this initial avoidance may be a default strategy that can be overturned by social information indicating that a given plant is safe to eat or use for some other purpose. In other work, we have found evidence consistent with this idea: infants use social information about edibility to selectively identify and approach edible plants (Wertz & Wynn, in press). Future studies can also examine whether infants engage in more social referencing when confronted with plants relative to other entities, and how knowledgeable adults guide infants' interactions with plants.

Although plants may seem insignificant in modern circumstances, they posed life-or-death problems—learning what is food and what is fatal—throughout human evolution. Our results suggest that plants have left their mark on human cognitive architecture and that there is much to be gained by exploring this fundamental and understudied area of human cognition.

[4] This may be why studies of infants' responses to animals that do not include systematic social information show that infants are differentially interested in and willing to approach animals (Kidd & Kidd, 1987; LoBue et al., 2013; Ricard & Allard, 1993).

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cognition.2013.09.002.

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