Running head: UNMASKING CHILDREN'S CONCEPT OF LIVING THINGS

Unmasking "Alive:" Children's Appreciation of a Concept Linking All Living Things

Erin M. Leddon, Sandra R. Waxman, and Douglas L. Medin

Northwestern University

Corresponding Author:
Erin M. Leddon
Department of Psychology
Northwestern University
2029 Sheridan Road
Evanston, Illinois 60208
e-mcmahon@northwestern.edu
Fax: (847) 491-7859

Acknowledgements
This research was supported by grants from the National Institutes for Health (R01 HD41653-01) and the National Science Foundation (BCS 0132469) to the second and third authors. The authors wish to express their gratitude to Flo Anggoro, Andrzej Tarlowski, Sara Unsworth, Patricia Hermann, Jessica Umphress, Melissa Luna, Will Bennis, and Olivier LeGuen for discussion of this work, and especially to Jennifer Woodring for contributions every step along the way. We also thank the principal, teachers, and students at Walt Disney Magnet School.

Abstract

Decades of research have documented in school-aged children a persistent difficulty apprehending an overarching biological concept that encompasses animate entities like humans and non-human animals, as well as plants. This has led many researchers to conclude that young children have yet to integrate plants and animate entities into a concept LIVING THING. However, virtually all investigations have used the word "alive" to probe children's understanding, an ambiguous term that technically describes all living things, but in practice is often aligned with animate entities only. We show that when "alive" is replaced with less ambiguous probes, children readily demonstrate knowledge of an overarching concept linking plants with humans and non-human animals. This work suggests that children have a burgeoning appreciation this fundamental biological concept, and that the word "alive" paradoxically masks young children's appreciation of the concept to which it is meant to refer.

Key Words: conceptual development; children; folkbiology; animacy; science education

Unmasking "Alive:" Children's Appreciation of a Concept Linking All Living Things

The relation between a word and the concept to which it refers lies at the very heart of successful communication. While often taken for granted, we heavily rely on the shared alignment of words and concepts between speaker and hearer. For example, a hearer will only be able to correctly attribute new information that they hear about "dogs" to all dogs if the word "dog" and concept DOG are aligned. But this alignment is not always perfect. On the one hand, it may be responsive to the context or mode of communication. For example, in an engineering context, "fluid" maps to a concept including both liquids and gases, while in common parlance, it would likely be understood to map to liquids only. Beyond context, misalignments may occur due to problems with the concept-word mapping itself. Hearers may simply lack the underlying concept corresponding to a particular word, for example, abstract concepts like JUSTICE or ATOM. Alternatively, they may have the relevant concept firmly in place, but have not yet aligned it with the corresponding word.

The discussion above is more than hypothetical, as misalignments between words and concepts have real consequences for children's learning. In this paper we focus on a particularly important example, the relation between the word "alive" and the concept LIVING THING – a core biological concept that encompasses animate entities like humans and non-human animals, as well as plants. Children's well-documented difficulty in tasks designed to elicit this concept, and in particular their difficulty judging plants to be alive, is often taken as evidence that the concept LIVING THING remains elusive for young children. In contrast, we propose an alternative interpretation: It is not that children lack a unified concept linking all and only living things, but rather they have failed to align the word "alive" with it. We suggest that this misalignment

occurs due to the ambiguity of the word "alive," which often maps to an animate interpretation in colloquial speech. This ambiguity may contribute to children's difficulty in demonstrating their burgeoning appreciation of the underlying concept LIVING THING well into their school-age years. The current study therefore underscores the powerful links between language and conceptual representations.

Decades of research into children's appreciation of the concept LIVING THING have primarily relied on a categorization task, which elicits judgments on the life status of a series of entities, both living and non-living. In this task, children are typically asked, "Are X's/Is the X (the entity) alive?". Because this task has been the metric against which children's appreciation of the concept LIVING THING is measured, and because this concept is so fundamental to science education, the evidence merits close examination.

In classic work on this topic, Piaget (1929) described children as "animistic," documenting in children as old as 12 years of age a pervasive tendency to deny that plants are alive, but to attribute life status to certain non-living objects (typically those that apparently move on their own) (see also Klingberg, 1952; Klingensmith, 1953; Laurendeau & Pinard, 1962; Russell & Dennis, 1939). Difficulty establishing the scope of the concept has been documented more recently in various populations (e.g., Anggoro, Waxman, & Medin, 2005; Carey, 1985; Opfer & Siegler, 2004; Richards & Siegler, 1984 for American children; Stavy & Wax, 1989 for Israeli children; Hatano, Siegler, Richards, Inagaki, Stavy, & Wax, 1993 for Japanese, American, and Israeli children). In general, these studies have underscored that children are overwhelmingly accurate at attributing life status to animate entities, and are often adept at denying life status to nonliving entities. However, plants, being inanimate living things, have presented a particular challenge.

Children's persistent difficulty is especially striking in light of evidence that when queried about other biological properties, even 4- and 5-year-olds can successfully identify the set of all living things -- including plants but excluding non-living entities (e.g., Anggoro, 2006; Backscheider, Schatz, & Gelman, 1993; Hatano, et al., 1993; Inagaki & Hatano, 1996; Opfer & Siegler, 2004; Springer & Keil, 1989, 1991; Waxman, 2005). Anggoro, Waxman, & Medin (2007) clearly illustrate this paradox in a categorization task similar to the one described above. Children were asked to sort a series of cards depicting both living and non-living entities based on various predicates, including "is X alive," "can X grow," and "can X die." Despite a high level of accuracy for "grow" and "die," even 9- to 10-year-olds failed to include only and all living things when categorizing based on "alive," and often excluded plants.

Interestingly, then, although children do apply certain predicates to a group that includes humans, non-human animals, and plants, they have not mapped this category to the word "alive." Anggoro, Waxman, & Medin further show that this difficulty may be particularly pronounced in English-speaking populations, as Indonesian children were significantly more likely to include plants along with animate entities in their "alive" categorization. This result is attributed to differences in the naming practices in English and Indonesian for biological entities, suggesting a crucial role for language in the acquisition of biological concepts.

Focusing in on language, certain investigators have noted that children's performance in the "alive" categorization task may be explained in part by their failure to interpret the word "alive" as adults do (Carey, 1985; Nguyen & Gelman, 2002; Piaget, 1929; Slaughter, Jaakkola, & Carey, 1999). Therefore perhaps these studies are best interpreted as probing children's interpretation of the word "alive," and not their appreciation of an overarching concept linking all living things (Carey, 1985). Despite this suggestion for a more nuanced view of previous

results, children's persistent difficulty is more often taken as evidence that they "…simply do not understand that both animals and plants are living things (i.e., that they belong to the same category), and that children therefore…have difficulty finding a reasonable referent for the word 'alive.'" (Slaughter, Jaakkola, & Carey, 1999, p. 79).

We propose an alternative explanation, that children have a burgeoning appreciation of an overarching concept linking humans, non-human animals, and plants, but use of the word "alive" masks their appreciation of it. A possible source of difficulty is the ambiguity of the word, as "alive" in English does not uniquely or even primarily map onto the Western science-inspired biological interpretation that is the focus of research on this topic. Although "alive" technically applies to humans, non-human animals, and plants, in practice its use is often aligned with animate beings only, thus excluding plants. Its entry in Merriam-Webster's Online Dictionary illustrates this well. Among the 6 definitions listed, the primary definition, "having life," seems apt because it picks out all (and only) living things. But this definition is immediately qualified with "not dead or inanimate," thus explicitly excluding inanimates and therefore plants. This clearly reveals the tension between the technical meaning of "alive" and a more colloquial animate sense. The other Merriam-Webster entries underscore this animate meaning, as they generally relate to liveliness ("look *alive*," "his face came *alive* at the mention of food") or degree of activity ("streets *alive* with traffic," "keep hope *alive*").

Of course, we are not suggesting that children learn word meanings from dictionary definitions. Nonetheless, these entries are telling because they likely reflect something about adult usage, and therefore provide a glimpse of the cues to meaning that adults provide spontaneously, and unwittingly, to children. As children seek to establish the meaning of "alive," therefore, they are likely to encounter a plethora of evidence for its sense that is aligned

with animacy: a corpus analysis of child-directed speech suggests this is indeed the case (Leddon, Waxman, & Medin, 2007). The fact that "alive" is often used in this animate sense may be related to children's difficulty including plants when questioned about this concept. Young children appear to map "alive" to the concept ANIMATE, instead of the concept LIVING THING. This observation would also explain why children tend to accurately attribute life status to animate entities, and deny it to nonliving things, but have difficulty with inanimate living things like plants.

In this paper we consider the source of the misalignment between the word "alive" and the underlying concept to which it refers. To foreshadow, we show that young children can indeed integrate plants into an overarching concept LIVING THING, but that the word "alive" paradoxically masks their appreciation of the concept to which it is meant to refer.

Experiment 1

The goal of this experiment was to discover whether children's difficulty including plants together with animate entities when asked to categorize based on the word "alive" was due to an effect of context, as in the "fluid" example above. It tests the hypothesis that children's performance in previous categorization tasks arises because they interpret "alive" in a colloquial sense, rather than in the scientific, biological sense. In this study, we invoke an explicitly scientific context before asking children to perform an "alive" categorization. If children have access to an alternative sense of "alive" that maps to this inclusive scientific, biological concept, then they should successfully categorize plants along with the animate entities.

Method

Participants. Children were recruited from a large public magnet school in Chicago, IL, which draws from throughout the city to achieve racial and ethnic diversity (in 2006-2007, the student population was 40.7% Black, 18.6% Hispanic, 17.0% White, 15.1% Asian, 8.2% Multi-Racial, .5% Native American). Forty-four children participated: 14 4- to 5-year-olds (M=5.21, SD=.56), 15 6- to 7-year-olds (M=6.69, SD=.33), and 15 9- to 10-year-olds (M=9.97, SD=.28). Of the 44 children, 24 were girls.

Procedure. Children participated in a short testing session at their school. As the experimenter led the child to the testing area, she explicitly focused the child's attention on science, explaining "…today we are going to talk about science. I just love science; it was always one of my favorite subjects and I still love learning about it. Do you like science?" She went on to ask what the child had been learning in science class lately, whether they had ever looked through a telescope or a microscope, and if they had ever done a science experiment.

Older children readily engaged in this conversation, describing their current science activities, which typically included cell biology (learning and diagramming parts of cells, etc.). Perhaps not surprisingly, the youngest children were often unsure what science was. For them, the experimenter followed up with a conversation about the sun, moon, planets, etc., explaining they would learn about these things in science someday. In all cases, an attempt was made to steer the conversation away from explicit discussions of living things, to avoid revealing the intent of the study.

After the warm-up, the experimenter introduced the categorization task. It was explicitly described as an activity "about science." Children were presented with 17 laminated cards, each depicting a photograph of an object on a white background (see Appendix for the animate entities, plants, and nonliving things depicted). To begin, the experimenter explained that the

child would be asked to make two piles, "…one pile for everything that's alive, another pile for everything that's not alive." After shuffling the cards, the experimenter presented them one at a time, asking "What's this?" Then, using the name provided by the child, the experimenter asked, "Are X's alive?" Each card was placed in the pile designated by the child. The experimenter noted the child's responses; items judged alive and not alive were scored as 1 and 0, respectively. We then calculated each child's mean response for the animate, plant, and non-living targets.

Results

Although children were presented within an explicitly scientific context, their performance nevertheless mirrored decades of previous research, revealing children's persistent difficulty including plants (Figure 1). We conducted an ANOVA using category (3: animate, plant, nonliving) as a within-participants factor, age (3: 4 to 5 years, 6 to 7 years, 9 to10 years) as a between-participants factor, and children's responses as a dependent variable. This analysis revealed only a main effect for category, $F(2, 82)=46.59$, $p<.001$. Pairwise comparisons revealed that children included animates in their categorization at a greater rate than plants, and included plants at a greater rate than nonliving things, both p's$<.001$.

Comparisons to chance performance augment this interpretation. As predicted, children at all ages had no difficulty attributing life status to animate entities. Performance in this category differed from chance levels at every age, all p's $< .001$. Also as predicted, children reliably denied life status to non-living things; performance in this condition differed from chance levels at every age, all p's $<.05$. However, when it came to judging the life status of plants, children at all ages performed at the chance level. Importantly, then, even the 9- to 10-year-olds failed to include plants in their categorization of things that are "alive."

FIGURE 1

Discussion

Placing the categorization task explicitly within the context of science did not alter the general pattern found in decades of previous research. Indeed, children as old as 9 to 10 years of age failed to reliably attribute life status to plants. Children's performance in this task suggests that their difficulty is not an effect of context, but rather reflects a more deep-seated ambiguity of the word "alive."

Of course, it is possible that our manipulation failed to signal a scientific mode of construal in children. This point is well-taken, especially for the younger children, who often did not know what science was. But the older children readily discussed their current science activities, and often gave detailed accounts of learning about cell biology, including parts of plant and animal cells. Even these children, who clearly engaged in a scientific conversation and discussed issues relevant to living things immediately prior to the categorization task, largely failed to include plants in their categorization. It is clear, therefore, that children have failed to align the word "alive" with a concept that corresponds to the biological concept including animate entities as well as plants. What is less clear is whether children might be more likely to tap into an overarching concept of living things in a categorization task that did not include the ambiguous term "alive." This question is examined directly in Experiment 2.

Experiment 2

To examine whether children have an overarching biological concept that includes plants as well as animate entities, we probed children's knowledge but avoided the word "alive" entirely. This experiment tests the hypothesis that children indeed appreciate a concept linking plants and animate entities as living things, but their apprehension of it is masked by the word "alive," which is fraught with ambiguity. To do so, we conducted a categorization task,

substituting the semantically equivalent "living thing" for "alive". Although this may appear on the surface to be a more technical and demanding concept, "living thing" has few (if any) alternative senses, and no senses that systematically exclude plants. Using this term also allowed us to directly probe for children's knowledge of the overarching abstract concept, previously hinted at with children's performance on tasks questioning other biological properties (like "grow" or "die").

Method

Participants. Ninety children participated, from the same school as Experiment 1: 30 4- to 5-year-olds (M=5.18, SD=.59), 29 6- to 7-year-olds (M=6.90, SD=.53), and 31 9- to10-year-olds (M=9.81, SD=.40). Of the 90 children, 50 were girls. None of the children had participated in Experiment 1.

Procedure. The method mirrored that of Experiment 1, except that there was no scientific discussion preceding the categorization task. Children were led to a quiet testing area in their school and immediately introduced to the categorization task, with no specific preceding context set. The categorization question itself was re-phrased "Are X's living things?".

Results

When asked about "living things," children demonstrate a very different, and more precocious, appreciation of the overarching biological concept and of the place of plants within it (Figure 2). An ANOVA revealed a main effect of category, $F(2, 174)=210.82$, $p<.001$, and a marginal effect of age, $F(2, 87)=2.98$, $p=.056$, both of which were mediated by a category by age interaction, $F(4, 174)=7.36$, $p<.001$. Post hoc analyses indicate that this interaction stemmed primarily from developmental differences in children's attribution of life status to plants. Pairwise comparisons revealed that 4- to 5-year-olds and 6- to 7-year-olds were both more likely to include animates

than plants in their categorization, both *p*'s < .01, and also more likely to include plants than non-living entities, both *p*'s < .001. In contrast, 9- to 10- year old children were just as likely to include plants as animates in their categorization, ns; and their tendency to include nonliving things was reliably lower than each, both *p*'s < .001.

Comparisons to chance levels of responding are also revealing. As in Experiment 1, children at all ages readily attributed life status to animate entities, and denied life status to non-living things; performance in these categories differed from chance levels at every age, all *p*'s < .001. However, children's tendency to attribute life status to plants displayed a different, and more precocious pattern than that of Experiment 1. While 4- to 5-year-olds attributed life status to plants at chance levels, by age 6- to 7, children attributed life status to plants at a rate greater than chance, *p*=.001, as did 9- to 10-year-olds, *p*<.001.

FIGURE 2

Discussion

Children's categorization when queried about "living things" reveals a relatively early appreciation of a core biological concept that includes plants as well as animate entities. This is consistent with the proposal that children appear to have mapped the word "alive" to the concept ANIMATE and not the concept LIVING THING. Indeed, children categorizing based on "alive" never attributed life status to plants at a rate greater than chance. In contrast, children categorizing based on "living thing" reliably attributed life status to plants by age 6 to 7, and distinguished plants from nonliving entities at age 4 to 5. This constitutes support for the hypothesis that the ambiguous "alive" is aligned with animacy and therefore masks children's appreciation of a biological concept of all living things.

If this hypothesis is correct, then children should readily attribute life status to animate entities and deny it to nonliving things in both Experiments 1 and 2, but they should be more likely to attribute life status to plants in Experiment 2, when the ambiguous term "alive" was avoided, than in Experiment 1. In a final analysis, we tested this hypothesis directly in a series of planned comparisons based on an ANOVA using category (3) as a within-participants factor, and age (3) and experiment (2) as between-participants factors (Figure 3). As predicted, there were no reliable differences in attributions of life status to animates (for Experiment 1, M=.94, for Experiment 2, M=.94, ns) or to nonliving things (for Experiment 1, M=.24, for Experiment 2, M=.19, ns). In contrast, performance on plant did differ across the two experiments (for Experiment 1, M=.54, for Experiment 2, M=.74, p<.01). This analysis therefore confirms children's greater tendency to include plants when categorizing based on "living thing" as compared to "alive," suggesting an animacy-aligned interpretation of "alive."

FIGURE 3

General Discussion

These experiments reveal that the word "alive" paradoxically masks young children's appreciation of the concept to which it is meant to refer. This is an important finding because decades of research demonstrating children's difficulty apprehending a biological concept including all and only living things have heavily relied on this term, yet the term "alive" interferes with their ability to access the very concept that it is intended to uncover. Moreover, when children are probed with the semantically equivalent, but less ambiguous, "living thing", they are more likely to attribute life status to plants, and to do so at an earlier age. We have proposed that the ambiguity of the word "alive", and its close alignment to animacy, may contribute to children's difficulty.

Integrating plants into the concept LIVING THING is clearly difficult for young children. As in previous work, children in the current study showed no reliable tendency to attribute life status to plants until their elementary school years, even when probed with "living thing." Nevertheless, their success including animals and humans, even at the youngest ages, suggests a privileged place for animate beings in this category. The privileged status of animate entities in comparison to plants was examined by Opfer and Seigler (2004), who showed children to judge life status based on animacy, or the capacity for teleological action. Once children were taught that plants also have this capacity (e.g., are able to move towards the sun), they were more likely to include them in the category. This and other previous work dating back to Piaget highlights the central role animacy plays in children's concept of living things.

The privileged status of animate beings in the category is likely reinforced by the ambiguity of the term "alive" in English, and the fact that it is used so often in an animate sense. This ambiguity therefore presents an added challenge to children acquiring the concept. Nevertheless, the results of Experiment 2 show that children can overcome this challenge, demonstrating knowledge of a concept that includes plants as well as animate entities when probed with the less ambiguous "living thing." This finding underscores the importance of considering the relation between words and concepts, especially if our goal is to discover the underlying conceptual representations of young children whose interpretation of words may not always straightforwardly map to the meaning adults intend. It also has implications for science education, as successful communication between teachers and students relies on shared word meanings. It is therefore important to characterize not only the scientific concepts children bring to the classroom, but how children encode these concepts in words, and where instruction may be needed to refine children's initial interpretations.

References

Anggoro, F.K. (2006). *Naming and acquisition of folkbiologic knowledge: Mapping, scope ambiguity, and consequences for induction*. Unpublished doctoral dissertation, Northwestern University.

Anggoro, F.K., Waxman, S.R., & Medin, D.L. (2007). Naming practices and the acquisition of key biological concepts: Evidence from English and Indonesian. Manuscript submitted for publication.

Anggoro, F.K., Waxman, S.R., & Medin, D.L. (2005). The effects of naming practices on children's understanding of living things. In B. Bara, L. Barsalou, & M. Bucciarelli (Eds.) *Proceedings of the Twenty-seventh Annual Meeting of the Cognitive Science Society*, 139-144. Mahwah, NJ: Lawrence Erlbaum Associates.

Backscheider, A.G., Schatz, M. & Gelman, S.A. (1993). Preschoolers' ability to distinguish living kinds as a function of regrowth. *Child Development, 64*, 1242-1257.

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: Bradford Books.

Hatano, G., Siegler, R.S., Richards, D.D., Inagaki, K., Stavy, R., & Wax, N. (1993). The development of biological knowledge: A multi-national study. *Cognitive Development, 8*, 47-62.

Inagaki, K., & Hatano, G. (1996). Young children's recognition of commonalities between animals and plants. *Child Development, 67*, 2823-2840.

Klingberg, G. (1952). The distinction between living and not living among 7-10-year-old children, with some remarks concerning the so-called animism controversy. *Journal of Genetic Psychology, 90,* 227-238.

Klingensmith, S.W. (1953). Child animism: What the child means by "alive." *Child Development, 24,* 51-61.

Laurendeau, M., & Pinard, A. (1962). *Causal thinking in the child.* New York: International Universities Press.

Leddon, E.M., Waxman, S.R., & Medin, D.L. (2007, March). Talking about living things: What children learn about biological concepts in everyday conversations. Paper presented at the Society for Research in Child Development Biennial Meeting, Boston, MA.

Nguyen, S.P. & Gelman, S.A. (2002). Four and 6-year-olds' biological concept of death: The case of plants. *British Journal of Developmental Psychology, 20,* 495 -

Opfer, J.E., & Siegler, R.S. (2004). Revisiting preschoolers' living things concept: A microgenetic study of conceptual change in basic biology. *Cognitive Psychology, 49,* 301-332.

Piaget, J. (1929). *The child's conception of the world* (J. and A. Tomlinson, Trans.). New York: Harcourt Brace and Co.

Richards, D.D. & Siegler, R.S. (1984). The effects of task requirements on children's life judgments. *Child Development, 55,* 1687-1696.

Russell, R.W. & Dennis, W. (1939). Studies in animism: I. A standardized procedure for the investigation of animism. *Journal of Genetic Psychology, 55,* 389-400.

Slaughter, V., Jaakkola, R., & Carey, S. (1999). Constructing a coherent theory: Children's biological understanding of life and death. In M. Siegal & C. Peterson (Eds.), *Children's understanding of biology and health.* Cambridge, UK: Cambridge University Press.

Springer, K. & Keil, F. (1989). On the development of biologically specific beliefs: The case of inheritance. *Child Development, 60,* 637-648.

Springer, K. & Keil, F. (1991). Early differentiation of causal mechanisms appropriate to biological and nonbiological kinds. *Child Development, 62*, 767-781.

Stavy, R., & Wax, N. (1989). Children's conceptions of plants as living things. *Human Development, 32*, 88-94.

Waxman, S.R. (2005). Why is the concept "living thing" so elusive? Concepts, languages, and the development of folkbiology. In W. Ahn, R.L. Goldstone, B.C. Love, A.B. Markman, & P. Wolff (Eds.), *Categorization Inside and Outside the Laboratory: Essays in Honor of Douglas L. Medin.* Washington, DC: American Psychological Association.

Appendix

Complete list of stimuli.

Item	Category
Person	Animate
Bear	
Squirrel	
Blue jay	
Trout	
Bee	
Worm	
Maple Tree	Plant
Cranberry Bush	
Dandelion	
Sun	Non-Living
Clouds	
Water	
Rock	
Bicycle	
Scissors	
Pencil	

Figure Captions

*Figure 1***.** Experiment 1. Proportion of life status attributions in each category, as a function of age.

*Figure 2***.** Experiment 2. Proportion of life status attributions in each category, as a function of age.

*Figure 3***.** Experiments 1 and 2 compared. Proportion of life status attributions in each category across experiments.

Figures

Figure 1.

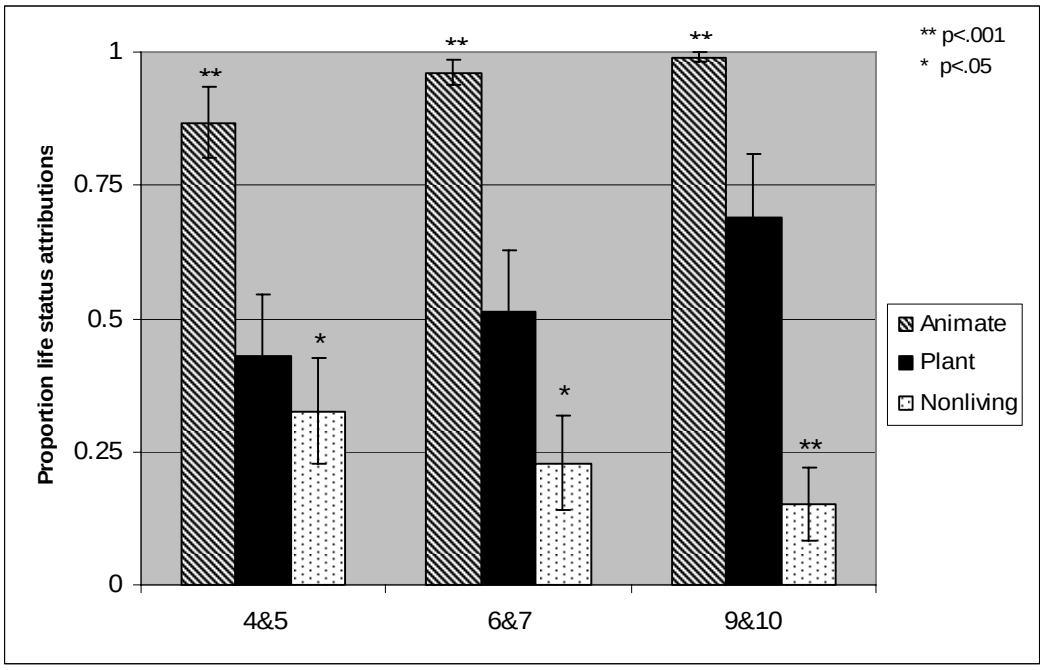


Figure 2.

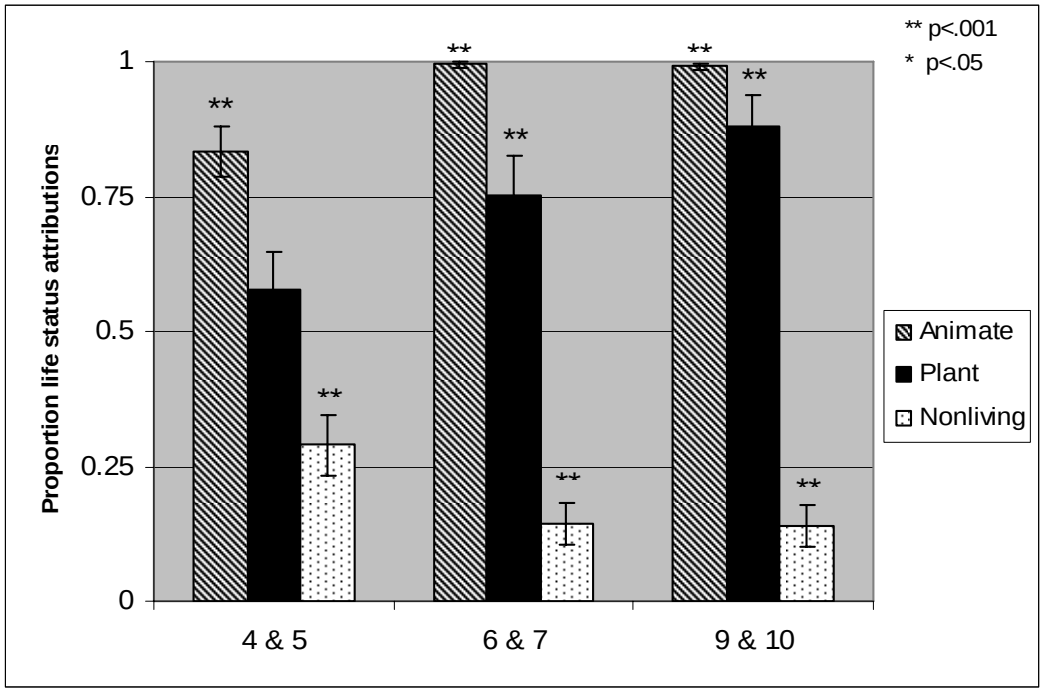
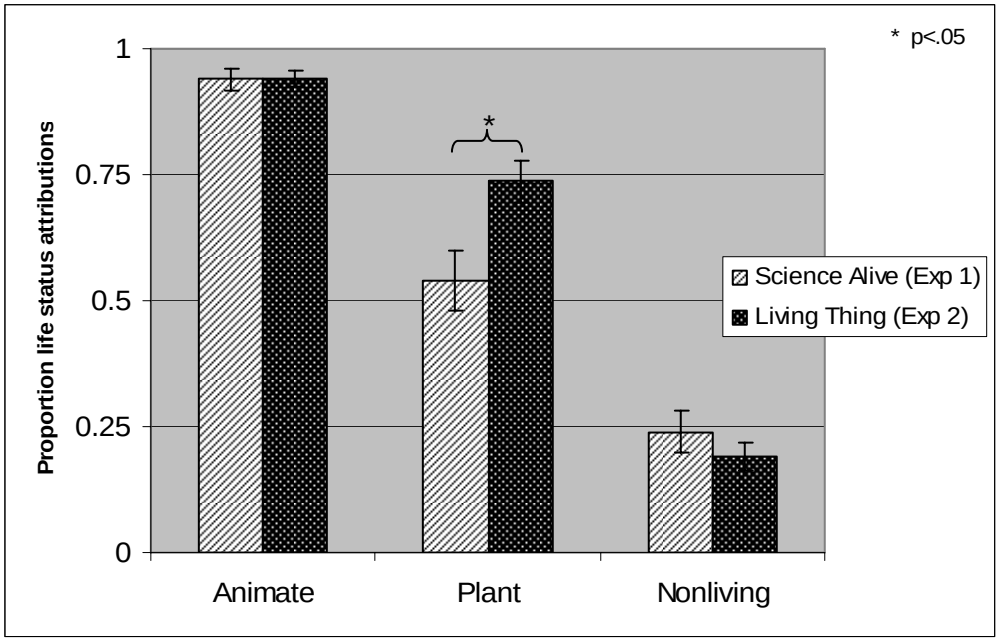

** p<.001
* p<.05
Proportion life status attributions
1
0.75
0.5
0.25
0
4 & 5
6 & 7
9 & 10
Animate
Plant
Nonliving
**

Figure 3.


* p<.05
Proportion life status attributions
1
0.75
0.5
0.25
0
*
Science Alive (Exp 1)
Living Thing (Exp 2)
Animate
Plant
Nonliving