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Running Head: INPUT ON BIOLOGICAL CONCEPTS

What does it mean to 'live' and 'die'?

A cross-linguistic analysis of parent-child conversations in English and Indonesian

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Abstract

Previous work on children's intuitive knowledge about the natural world has documented their difficulty in acquiring an overarching concept of biological life that includes plants as well as humans and non-human animals. It has also suggested that the acquisition of fundamental biological concepts like ALIVE and DIE may be influenced by the language used to describe them, as evidenced by differences between English- and Indonesian-speaking children's performance in tasks involving these concepts. Here we examine one particularly important source of linguistic information available to children during this acquisition process: everyday conversations with their parents. We take a cross-linguistic approach in analyzing the evidence available to English- and Indonesian-speaking children as they acquire meanings for words corresponding to the concepts ALIVE and DIE. Our analysis illustrates that young children acquiring English and Indonesian are faced with distinct problems, but that parental input in both languages does little to support the acquisition of broad, inclusive biological concepts.

Keywords: cross-cultural developmental psychology; language development; science; conceptual development; folkbiology

What does it mean to 'live' and 'die'?

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Overview

Developmental research into children's intuitive understandings of biological concepts like ALIVE and DIE suggests that acquiring these foundational concepts represents a distinct challenge (Carey, 1985; Hatano & Inagaki, 1999; Inagaki & Hatano, 1993, 1996; Nguyen & Gelman, 2004; Nguyen & Rosengren, 2004; Opfer & Siegler, 2004; Piaget, 1929; Poling & Evans, 2004; Richards & Siegler, 1984; Slaughter, Jaakkola, & Carey, 1999; Slaughter & Lyons, 2003; Springer & Keil, 1989, 1991; Waxman, 2005; among others). Consider for example that a rhododendron, which bears little perceptual relation to animals and is incapable of self-generated motion, is nonetheless alive, but that a mechanical monkey, which may bear striking perceptual relation to a live monkey and may appear to move its own, is nonetheless not alive. Therefore, as children discover which entities are alive and which are not, certain perceptible features (e.g., animacy, self-generated motion) may serve as a starting point, but children must be able to go beyond perception alone. Their acquisition must also be shaped by other sources of input about biological concepts, including the input available from the language and culture in which they are immersed. Indeed, current evidence reveals that although these core biological concepts are universally relevant, there are cross-cultural and cross-linguistic differences in their patterns of acquisition (Anggoro, Waxman, & Medin, 2008; Hatano, Siegler, Richards, Inagaki, Stavy, & Wax, 1993; Stavy & Wax, 1989).

Most of the past research on the acquisition of biological concepts has been aimed at characterizing children's knowledge, with considerably less attention devoted to the sources of

information available to children in the process of acquiring this knowledge. Although the acquisition of biological concepts is undoubtedly shaped by myriad factors, including the child's direct exposure to the natural world, to nature-focused media, etc., in the work reported here we focus on one key source of information: everyday conversations between children and their parents (Beals, 1993; Callanan & Sabbagh, 2004; Crowley, Callanan, Tenenbaum, & Allen, 2001; Harris, 2006; Harris & Koenig, 2006; Jipson & Callanan, 2003; Gelman, Coley, Rosengren, Hartman, & Pappas, 1998; Snow & Kurland, 1996; Thompson, 2006). Spontaneous conversations, where children have an opportunity to learn at their parents' knees, provide a rich potential source of information to children about a wide range of concepts.

Our goal was to discover what information, if any, these parent-child conversations might offer regarding the fundamental biological concepts ALIVE and DIE. One possibility is that parents support the acquisition of biological concepts by making them salient in conversations with their children. After all, parents commonly introduce other concepts like color and number in conversations with their children, drilling them on colors and counting routines; perhaps they also spontaneously infuse their conversations with information about biological phenomena. On the other hand, perhaps parents provide little direct information about the biological concepts ALIVE and DIE, just as they rarely engage in conversations about grammatical rules.

To address these issues, we examine how parents express information about biological concepts in conversations with their children. At issue is how the information provided by parents articulates with other foundational concepts like animacy or agency that children may already have in place (see Johnson, 2000; Poulin-Dubois, 1999; Spelke, Phillips, and Woodward, 1995 for reviews). We focus on interactions that were not specifically designed to elicit conversation about biological phenomena (e.g., interactions during a trip the zoo or a nature

museum), to examine the one source of information that is most readily available to children from the youngest ages (that is, conversations in their home). We consider two language communities, native speakers of English in the US, and native speakers of Indonesian in Indonesia, where previous research has documented intriguing cross-linguistic differences in the way that fundamental biological concepts are named, and developmental differences in the developmental timecourse underlying children's mastery of these concepts (Anggoro, Waxman, & Medin, 2008). In short, we aim to characterize the parental input in everyday conversation as a first step in discovering whether it provides information to support children's acquisition of knowledge about the natural world.

What related concepts might children have in place?

Children begin the process of acquiring knowledge about the natural world with at least one particularly relevant core concept in place: the concept ANIMATE. Infants are especially interested in animate entities, and are sensitive to several factors that distinguish animate from inanimate objects, including the presence of eyes or a face (Carey, Diamond, & Woods, 1980; Johnson, Slaughter, & Carey, 1998), or the capacity to engage in autonomous motion or goal-directed behavior (Berthenthal, 1993; R. Gelman, 1990; R. Gelman, Durgin, & Kaufman, 1995; S. Gelman & Gottfried, 1996; Opfer, 2002, Opfer & S. Gelman, 2001; Poulin-Dubois & Shultz, 1990; Woodward, 1999; Woodward, Sommerville, & Guajardo, 2001). As such, this concept may provide an early wedge for distinguishing living and nonliving things.

Although we suspect that an early appreciation of a fundamental concept like animacy plays a role in children's reasoning about biology, it is also clear that children must go beyond considerations of animacy if they are to establish the full scope of biological concepts that include inanimate living things like plants. This observation is consistent with decades of

research suggesting that it is especially difficult for young children to integrate plants into their concept ALIVE (Carey, 1985; Hatano, et. al, 1993; Klingberg, 1952; Klingensmith, 1953; Laurendeau & Pinard, 1962; Leddon, Waxman, & Medin, 2008; Opfer & Siegler, 2004; Piaget, 1929; Richards & Siegler, 1984; Russell & Dennis, 1939; Stavy & Wax, 1989; Waxman, 2005; Waxman & Medin, 2006). It is also consistent with evidence that children's appreciation of this broader concept is shaped importantly by the input they receive, including their direct contact with the natural world (Atran, Medin, Lynch, Vapnarsky, Ucan Ek', & Sousa, 2001; Proffitt, Coley, & Medin, 2000; Ross, Medin, Coley, & Atran, 2003), the belief systems of their communities (Astuti, Solomon, & Carey, 2004; Atran & Medin, 2007; Bang, Medin, & Atran, 2007; Medin, Ross, Atran, Cox, Coley, Proffitt, & Blok, 2006; Waxman & Medin, 2007; Waxman, Medin, & Ross, 2007), and the way their language labels biological concepts (Anggoro, Waxman, & Medin, 2008; Hatano, Siegler, Richards, Inagaki, Stavy, & Wax, 1993; Stavy & Wax, 1989).

Contributions of naming to biological concepts

Thus far, we have suggested that the input children receive about biological concepts will be crucial as they establish a biological framework that includes plants as well as humans and non-human animals. Here, we focus on one type of input – the names for biological concepts – that may be especially informative. After all, naming serves as a powerful cue to categorization, for infants and adults alike (see Waxman and Lidz (2006), for a review of developmental evidence, and Goss (1961); Rossman and Goss (1951) for evidence from adults). Providing a common name (e.g., “animal”) for a set of otherwise distinct entities (e.g., a dog, horse, fish) highlights the commonalities among them and promotes the establishment of an inclusive object

category. For this reason, naming is especially powerful in situations in which the relation among the entities is abstract, or difficult to glean from perceptual inspection alone.

The acquisition of abstract biological concepts, therefore, may well be influenced by the names that adults provide for biological entities. There are strong hints that this may be the case. A cross-national study revealed differences in the age at which children from Israel, Japan and the US mastered the concept ALIVE, and revealed that these differences have parallels in the naming practices associated with these abstract biological concepts in each language (Hatano, et al., 1993; see also, Stavy & Wax, 1989). Building upon this insight, Anggoro, Waxman, and Medin (2008) took as their starting point a key difference in the naming system in English versus Indonesian. While the concepts HUMAN, ANIMAL, and PLANT all are named with dedicated nouns in both English and Indonesian, English also uses the word “animal” to name the category that encompasses both humans and non-human animals, or animate entities. Indonesian, in contrast, has no dedicated noun for this category (Figure 1). English-speaking children must therefore contend with learning two nested categories that have the same name: “animal.”

FIGURE 1 ABOUT HERE

How might these different naming practices bear on children’s acquisition of the biological concept ALIVE? Waxman and her colleagues (Anggoro, Waxman & Medin, 2008; Waxman, 2005; Waxman & Medin, 2006) proposed that because the ANIMATE concept is named in English, and moreover is named with the very same lexical item as one of its most powerful constituents, children acquiring English are faced with an interpretive problem: the same name (“animal”) calls up two different nested categories. Previous research shows that children avoid polysemy, and prefer to assign different names to different categories (Callanan & Sabbagh,

2004; Markman, 1990; Merriman & Bowman, 1989; also see Clark, 1997). Waxman and colleagues hypothesized that to avoid mapping the same name to two nested categories, children might erroneously map the word “alive” to the ANIMATE concept, leaving “animal” to refer to the concept NON-HUMAN ANIMAL. One consequence of this misappropriation is that when presented with the term “alive”, children might focus on the concept ANIMATE, rather than the overarching concept LIVING THING. For Indonesian-speaking children, who face no such interpretive challenge (since the concept ANIMATE remains unnamed), there is no misappropriation of “alive”, and as a result, they should more readily include plants along with humans and animals when asked about things that are “alive”.

To test this hypothesis, Anggoro, et al. (2008) conducted a sorting task with 4- to 10-year-old monolingual children acquiring either English or Indonesian. Children were presented with a set of photographs depicting entities both living (humans, non-human animals, plants) and non-living (non-living natural kinds, artifacts) items, and instructed to sort the cards into piles several different times, each time on the basis of a different biological concept (e.g., DIE, ALIVE, GROW, NEED FOOD). For example, to probe their understanding of the term “alive,” children were instructed to sort the pictures into two piles, one pile “for everything that’s alive, and another for everything that’s not alive.”

The results revealed strong cross-linguistic commonalities, and a few intriguing differences. The youngest children in both language communities largely excluded plants when sorting on the basis of “alive” and “die,” including only humans and non-human animals in their categorizations. By age 9, however, a key difference between the language groups emerged: when sorting on the basis of “alive”, Indonesian-speaking children were more likely to include plants than English-speaking children. This difference is consistent with the hypothesis that

English-speaking children (but not Indonesian-speaking children) map “alive” to the concept ANIMATE.

The evidence from Anggoro et al. also revealed important commonalities, including those concerning “die”: Here, by six years of age, both English- and Indonesian-speaking children successfully included plants, revealing their sensitivity to a category that includes all and only living things. (Interestingly, however, the youngest English-speaking children were more likely to include plants in this category than were their Indonesian-speaking counterparts).

Notice that Anggoro, et al.’s sorting task is based on an implicit assumption about the relation between words and their underlying concepts: that words (e.g., “alive”, “die”) can function as probes to tap into children’s underlying concepts¹. In the current experiment, we consider this alignment between words and concepts from a different, but complementary vantage point: that parents’ use of words (e.g., “alive” (or “live”) and “die”), and the range of entities to which they apply them, may constitute an important source for the young child about the scope of these biological concepts. It is for this reason that an examination of parental input is crucial for understanding children’s emerging biological knowledge.

Current Study

We focused on the input that parents from the US and from Indonesia provide about the biological concepts “alive” and “die” in informal conversational contexts at home, before formal instruction in biology begins. We examined parents’ use of these terms in spontaneous adult-child conversations, and in adult-adult conversations that children might reasonably overhear. However, before analyzing these conversations, we first interviewed an independent set of adult native speakers of each language to gather their intuitions about the meanings of the terms “alive” and “die”. This permitted us to examine whether the full range of adults’ explicit

intuitions about these meaning are reflected in their use of these terms in conversations with young children.

To foreshadow, the results suggest that the input that English- and Indonesian parents provide their children in spontaneous conversation under-represents the full scope of these biological concepts. In both languages, parental input on ALIVE and DIE focuses predominantly on animate entities, and applications of the word “alive” to plants are vanishingly rare. In short, in neither language does parental input offer strong support for the establishment of overarching biological concepts that include plants as well as humans and non-human animals. In addition, we identified some intriguing cross-linguistic differences in the use of both “alive” and “die”, differences that might bear on children’s discovery of the underlying biological concepts.

Method

We examined the input concerning ALIVE and DIE from two perspectives. First, we considered *possible* applications of these terms, interviewing adult native speakers of English and Indonesian to ascertain the full range of meanings that native speakers assign to each word. Next, we examined the *actual* applications of these terms in a corpus analysis of spontaneous parent-child conversations in the US and in Indonesia, gathering off-the-cuff, real-world uses of these words.

Adult interviews

To begin, we interviewed adult informants to gather intuitions about the meanings associated with biological terms like “die” and “alive”. Two native speakers of each language served as primary informants. All were PhD candidates at Northwestern University in Evanston, IL. In a structured interview, each informant was asked to evaluate whether “die” and “alive/live” could apply to a range of people, animals, plants, natural kinds, or artifacts. In

addition, they were asked to generate a definition of each term. Because the Indonesian informants were also fluent speakers of English, they also offered explicit insights into differences in the application of these terms in Indonesian and English.

Parental input: Corpus analysis

Armed with native speakers' intuitions, we turned our focus to transcribed parent-child conversations from the CHILDES corpus of child-directed speech (MacWhinney, 2000). This corpus includes databases of conversations in various languages, including American English and Indonesian. We selected databases from each language based on their length and method of collection, in order to ensure that the conversations in each language represented naturalistic contexts over an extended period of time, and that the corpora for each language were of comparable size (1.4 million words for English, 1.5 million words for Indonesian).

Corpus selection. The conversational databases included in our search were selected because they represent large samples of speech between parent-child dyads over a period of several years ($M=33$ months), thus increasing the likelihood of encountering conversations related to biology, and providing a representative picture of typical parent-child interactions. They were also selected because the conversations were recorded during play sessions in the home, and therefore were more likely to represent typical daily interactions between the parents and child than sessions recorded in a laboratory or school environment. None of the databases were collected for the purposes of examining conversations related to biology. Parents were given no special instructions during the sessions, which often involved playing with toys and/or reading books. The experimenter was sometimes involved in conversations, and was considered along with the parents as an adult interlocutor for coding purposes.

For English, we identified transcribed interactions between eight parent-child dyads taken from five databases: Brown (Brown, 1973), Clark (Clark, 1982), Kuczaj (Kuczaj, 1976), Sachs (Sachs, 1983), and Snow (MacWhinney, 2000). Interactions in these databases were recorded every few weeks for periods ranging from 9 months to 4 years ($M=26$ months), and took place in urban or suburban areas, generally near research universities in the United States. The children were 5 boys and 3 girls ranging in age from 1;1 to 5;1.

For Indonesian, we included five distinct parent-child dyads selected from a single database (Gil & Tadmor, 2007). Interactions in these databases were recorded every few weeks for periods ranging from 1 to 4 years ($M=42$ months), and all took place in Jakarta, the capital and largest city in Indonesia. The children were 3 boys and 2 girls ranging in age from 1;6 to 6;1. The databases included the original utterance in Indonesian, a word-by-word literal translation into English, and a gloss in English.

Data collection and coding. Corpora were searched for uses of any form of the terms “alive/live” and “die” (“live, lived, lives, living,” “die, died, dies, dying, dead” etc.). Utterances containing an instance of either term were collected and analyzed by a trained coder along several parameters, including: analyzability (whether the utterance contained enough information to be further analyzed²), speaker identity (child or adult), and the entity that the term was applied to (e.g., who was being described as living or dead, categorized as Human, Non-Human Animal, Plant, Natural Kind, Artifact, or None of the Above). Because there were very few applications to Natural Kinds or None of the Above, these were collapsed along with Artifacts into a category labeled Other in the analysis below. The analysis includes child speech as well as adult speech. While our focus is on the input to children, and therefore parental speech, child speech was included to identify any gaps between adult and child usage.

All results were tabulated by the same trained coders, to ensure consistency across the samples³. The search for utterances containing “die” and “live” in Indonesian was first conducted on the translations and glosses provided in the corpus. While it may have been preferable to have a native speaker of Indonesian extract the results from the Indonesian, several steps were taken to ensure the accuracy of our results. First, after consulting our Indonesian-speaking informants, we conducted an additional search for “hidup” and “mati” (“live” and “die” in Indonesian) on the Indonesian utterances themselves. This was done to locate any utterances that escaped the initial search, due to the translation using a word other than “live” or “die” to convey the same meaning (e.g., using “perish” for “die”). We likewise evaluated the results of the English search to exclude any utterances containing words translated as “live” or “die” that did not correspond to the Indonesian biological terms “hidup” and “mati” (e.g., when the utterance contained an idiom that was translated as “die”).

Together these steps served to align the Indonesian and English coding criteria. In both languages, the search should reveal all uses of the biological terms “live” and “die” (and the corresponding Indonesian “hidup” and “mati”), and therefore the evidence about their meanings available to children.

Results

The results reveal several important convergences, as well as divergences between English and Indonesian. Consider first the convergences. First, adult informants’ intuitions underscore that in both languages, “alive/live” and “die” have several different meanings. The corpus analyses reveal that these different meanings are conveyed in spontaneous parent-child conversations. Second, the distribution of parental uses of these terms generally centers on humans and non-human animals, and rarely includes plants. This is important not only because

of the convergence between English and Indonesian, but also because it suggests that the evidence children receive from parental conversations does not provide the kind of information that could, in principle, guide them to establish the full scope of these terms' biological meanings. Specifically, because parental usage of these terms reflects the already privileged ANIMATE category, it offers little in the way of supporting the full scope of the biological concepts ALIVE and DIE. There were also differences in the applications of “alive” and “die” in English and Indonesian, differences that highlight the unique challenges facing young children in each language community as they seek to acquire meanings for these terms. We consider possible and actual applications of each term, in each language, in turn below.

Analysis of “alive”

An examination of “alive” (and “live”) in English, and their Indonesian counterpart “hidup,” suggests several convergences, as well as distinct challenges facing children in the two language communities.

English. Adult intuitions about “alive,” and the closely related “live,” reveal abundant ambiguity. For “alive,” the adults reported that a meaning related to activity or animacy is most salient. This narrow sense may best be described as connoting liveliness (e.g., “look alive!”). It crucially does not encompass the broader, biological sense of “alive” that extends to inanimate living things like plants. Moreover, the parent-child corpus analysis suggests that this narrow, animate-aligned interpretation is also favored by parents in conversations with young children.

In the corpora, “alive” appeared rarely, with only 62 total uses (36 for adults and 26 for children) among more than 1.5 million words. Moreover, when the term was used, it overwhelmingly concentrated on applications to animate entities, in both child and adult speech (Figure 2).

FIGURE 2 ABOUT HERE

Adult uses were concentrated heavily on animals (50%), but did include humans (17%) and even some plants (11%). Interestingly, these applications of “alive” to plants represented only 4 utterances in the entire sample, all of which came in the context of book-reading, and not from spontaneous speech. Children’s uses reflected the animate sense of the term even more strongly, with applications to humans (35%) and non-human animals (46%), and no applications to plants. The Other uses for both children and adults generally reflected applications to monsters or other toys representing animate entities (e.g., stuffed animals). See the Appendix for examples.

We have focused on the term “alive” because most previous studies have used this word to probe children’s concept of living things. It is important to note, however, that in English the word “live” also corresponds to this concept⁴. Adult informants noted that like “alive,” “live” is also ambiguous. More specifically, “live” has a particularly salient alternative to its biological sense: the meaning “reside” (e.g., “Jane lives in Chicago”). Adults reported that this “reside” sense is the most salient meaning for this term. Although “live” is used much more frequently than “alive” in the corpus sample, with a total of 574 uses (355 by adults, 219 by children), both the adult and child distributions mirror each other quite closely, and again center strongly on animate entities (Figure 3). The high percentage of applications to humans for both adults (51%) and children (46%) reflects uses of “live” intended as “reside,” which overall amounted to 92% of the total uses.

FIGURE 3 ABOUT HERE

Of course children receiving this input have no advance warning of the ambiguity of “live.” But even assuming that they could distinguish the biological uses from the “reside” uses, the distribution remains human-centered (of the biological uses of “live,” 46% of adult uses were applied to humans, and 35% of child uses were). Moreover, there were very few applications to plants, with a total of 2 for adults (1%), and 4 for children (2%).

Indonesian. Turning to Indonesian, the analysis of adult intuitions reveals that like its English counterpart, “hidup” (“live”) means “has life,” and can in principle be applied to humans, non-human animals, and plants. Indonesian has no distinct word for “alive” versus “live,” and indeed both are translated in the corpus as “hidup.” Thus while the state of affairs at first glance appears simpler than the situation facing English-acquiring children, with only a single word to acquire, it is complicated by ambiguity. In addition to a meaning aligned with English “alive/live”, “hidup” also has a sense which means “on” (e.g., “the light is on”). As a result, it may be applied to a variety of electronic and mechanical artifacts (e.g., lights, fans, televisions, computers, video games, etc.). Both adult Indonesian informants agreed that this meaning has to do with activity or the functioning of certain objects, especially inanimate objects.

Interestingly, despite its multiple meanings, the corpus analysis reveals that “hidup” was rather rare in parent-child conversations, with a total of only 102 uses among more than 1.4 million words (73 for adults, 29 for children). The distribution of adult and child uses again mirrored each other quite closely (Figure 4).

FIGURE 4 ABOUT HERE

Uses for adults and children were focused on animate entities, with most applications to non-human animals (48% for adults, 45% for children), and some applications to humans as well (14% for adults, 21% for children). There were no instances of “hidup” being applied to a plant. Interestingly, the “on” sense, reflected in Figure 4 as Other uses, was quite rare, with only 9 total uses. Like the pattern observed in the English sample, the distribution of uses of “hidup” is aligned with animacy, as it is applied to animate entities, along with other artifacts that are at least in some sense capable of activity. See the Appendix for examples.

Discussion

These results demonstrate significant challenges facing children acquiring a meaning for “alive” or “hidup” in the two language communities. In both cases, the ambiguity of the relevant terms does little to help children with this abstract and difficult-to-acquire concept. Instead, the range of possible uses reported by native speakers, and the distribution of uses in the corpus, serve to highlight animacy-aligned interpretations.

The learning problem facing English-speaking children acquiring a meaning for “alive” begins with its ambiguity. The analysis of speaker intuitions revealed a salient animacy-aligned sense of “alive” highlighting liveliness, in addition to its more inclusive biological sense. The learning problem is complicated by the fact that the concept that “alive” also maps to another word, “live,” which is itself ambiguous. To the extent that children are aware of the relation between “alive” and “live,” this may serve to reinforce the animacy-based interpretation of “alive,” underscoring an already strong concept. But even if children maintain a clear distinction between “live” and “alive,” the evidence they receive about “alive” does little to support the inclusion of plants in the category. The dearth of applications to plants, coupled with children’s

already strong concept of animacy, may contribute to their mapping “alive” to animate entities while excluding inanimate living things, and therefore plants.

Indonesian-speaking children likewise face challenges to acquiring a biological meaning for “hidup.” As noted above, “hidup” is also ambiguous, and has an alternative sense meaning “on.” This sense may serve to highlight an interpretation for “hidup” aligned with activity, posing a challenge to incorporating inanimate entities that generally do not exhibit obvious activity, like plants, in a biological concept. Moreover, the corpus analysis reveals a distribution of use for “hidup” that is focused on animals, and that again underscores the already strong ANIMATE concept.

Analysis of “die”

Children in both language communities face distinct, though related, challenges in interpreting the meaning of the term “die”. As with “alive”, parental input generally reflects only a subset of the full biological scope of the underlying biological concept DIE, which includes humans, non-human animals, and plants alike.

English. In contrast to “alive,” speaker intuitions about the meaning of “die” reveal little ambiguity. It can be applied to humans, non-human animals, or plants, and is generally understood as referring to biological death. It does have some metaphorical uses (e.g., “My car died,” “These batteries are dead”), but native speakers’ intuitions were that these were relatively rare. This intuition is borne out in the corpus data: these metaphorical uses never occurred in these corpora. Indeed, the corpus analysis showed “die” to be relatively rare: only 221 instances occurred, 76 for adults and 145 for children. Crucially, however, applications to plants were included in adult usage (Figure 5).

FIGURE 5 ABOUT HERE

While adult uses were concentrated on humans (42%), they also included many applications to plants (20%) and to non-human animals (28%). Children's uses revealed their application to humans (33%) and non-human animals (46%). In contrast to their use of "alive", children did apply "die" to plants (10%). See the Appendix for examples.

Indonesian. An examination of adult intuitions about "mati," the Indonesian word for "die," reveals quite a different state of affairs. As in English, speaker intuitions revealed that this term is applicable to humans, non-human animals, and plants, and refers to biological death. Nevertheless, both informants reported that like "hidup," "mati" has another sense as well, meaning "off." It is therefore used frequently to refer to turning off lights, televisions, and other electronic devices. It can also be used to mean "extinguish" (e.g., a candle). The adult informants reported that in general "mati" seems to refer to a cessation of activity.

These two senses of "mati" were likewise reflected in the corpus analysis. In contrast to English "die", "mati" was relatively more frequent in the Indonesian sample, with 904 total uses (581 for adults, 323 for children). However, more than a third (312) of these uses were intended in the "off" sense, and were translated as such. Overall adults' and children's uses of the word mirrored each other quite closely (Figure 6).

FIGURE 6 ABOUT HERE

Both adults and children applied "mati" to humans (25% for adults; 20% for children) and non-human animals (12% for adults, 9% for children), while applications to plants were virtually absent (1% for each, or a total of 3 utterances for adults and children). This may simply reflect differences in the particular conversations searched, but nevertheless it is suggestive, especially

given the considerably higher number of total uses of “mati” in the Indonesian sample more generally. The high percentage of Other applications reflects the “off” sense of “mati.” See the Appendix for examples.

Discussion

These findings, which characterize an important source of input available to children as they construct a meaning for “die” or “mati,” point to several challenges, especially for Indonesian-speaking children. For English “die”, the input appears to support a broad concept applying to humans, animals, and plants, at least more than it did in the case “alive/live”. The analysis of speaker intuitions reveals that “die” is relatively unambiguous, and the corpus analysis shows a pattern of input that is skewed towards humans and animals, but that crucially does include plants. Children therefore receive support for the inclusion of plants in this concept.

In contrast, for Indonesian, both the speaker intuitions and the corpus analysis reveal that children’s input supports a meaning for “mati” having to do with cessation of activity. The prevalence of “off” uses, coupled with the fact that the remaining biological uses were strongly aligned with animates, suggests that children receive little support for a broad biological concept DIE that includes plants along with humans and non-human animals.

Adult-adult conversations

While naturalistic parent-child conversations provide children with an important source of information, children’s input is not restricted to their conversations with their caregivers. Many other sources of information are available to them as they establish biological concepts (i.e. books, TV, movies, etc.), including conversations that they may reasonably overhear, but are not directly a part of. Previous research indicates that children are indeed attentive to such

conversations and can learn word meanings through overhearing, especially for object categories (Akhtar, Jipson, & Callanan, 2001). This observation motivated us to consider adult-adult conversations. At issue was whether these conversations might reflect a different, and perhaps more comprehensive and biologically-oriented application of biological terms. In other words, examining adult-adult conversations may permit us to assess whether the parent-child corpora above reflect an idiosyncrasy of child-directed speech that is not matched in conversations that children may overhear. (If this were the case, it would raise the possibility that children might benefit especially from adult-adult conversations as a source of information as they acquire biological concepts.)

To examine this possibility, we analyzed a corpus of English-speaking adult-adult phone conversations (Godfrey & Holliman, 1997). The results revealed a pattern of use for “alive,” “live,” and “die” even more skewed towards humans than child-directed speech (see Appendix Figures A1 and A2). While this may reflect the nature of the corpus, it seems unlikely that typical adult-adult conversations in everyday contexts would be much more informative about the meaning corresponding to biological terms. Therefore, conversations between adults that children may observe or overhear likely do little to support the full scope of the biological term being acquired. If anything, such conversations serve to reinforce the patterns observed in child-directed speech.

General Discussion

Taken together, these results underscore the complexity of the task facing children as they develop fundamental biological concepts ALIVE and DIE. At first glance, it may appear that we have simply learned that the terms for these concepts are ambiguous in both English and Indonesian, a fact that in itself would pose a significant challenge for children. However, that

first glance represents a very considerable over-simplification, one which ignores the systematicities in linguistic evidence available to children acquiring these terms and their underlying concepts. The terms “alive” and “die” are not only ambiguous; they are also used in such a way as to highlight certain aspects of their meaning over others. In short, the pattern of use observed in adult speech generally fails to provide children with the type of information that could support broad, inclusive biological concepts.

Our analysis offers more than the ambiguity of the terms “alive” and “die” in both English and Indonesian. It also bears on the alignment (or misalignment) between these words and concepts in everyday use. We asked whether parents’ use of these words and the range of entities to which they applied these words might resolve some of the difficulty that young children encounter in establishing the scope of these terms and the biological concepts they name. The current results offer little evidence that this source of input would help children surmount these interpretive difficulties.

Examining this source of information allows us to consider the development of biological knowledge from a unique vantage point. It provides an interesting window into the type of support these concepts *do* receive in parent-child conversations, and mirrors the findings reported in Anggoro, et al. (2008) on children’s acquisition of biological categories. While we cannot claim a causal link between the information available to children and their performance in the categorization task, the fact that the two so closely reflect each other is certainly suggestive. The parental input examined here in both languages reinforces the inclusion of animate entities in biological concepts, but offers less support about inanimate living things like plants. Therefore, for children to acquire overarching biological concepts that include plants as well as human and non-human animals, they must successfully integrate information from other sources.

Questions for future research

Future work must take a close look at the full range of information available to children acquiring fundamental biological concepts. While our goal in undertaking this analysis was to consider what insights children might glean about these concepts from their everyday conversations with their parents, in future work, it will be important to consider more a diverse range of contexts and concepts. For example, it will be important to consider concepts that go beyond ALIVE and DIE (e.g., GROW, BREATHE, NEED FOOD, NEED WATER, etc.), and to consider the information that adults convey in contexts in which conversations about biology are explicitly prompted, or in contexts where nature-related topics are more salient (i.e., museums, botanical gardens, arboretums, etc.). We suspect that in these conversations, adults will offer richer information about biological entities and processes. What remains to be seen is whether even in these contexts, the adult input will support the overarching biological concepts that include plants as well as human and non-human animals.

Future work should also continue to build on research that considers the impact of children's and parents' direct experience with the natural world. One route is to compare conversations in families living in rural and urban environments (Atran et al., 2001; Ross, et al., 2003; Proffitt, Coley, & Medin, 2000; Medin & Waxman, 2007; Tarlowski, 2006; Waxman & Medin, 2007); families with and without pets (Inagaki, 1990; Hatano & Inagaki, 1994). It will also be important to examine the input provided by sources other than parental input. In particular, an examination of the books, movies, and TV shows designed for young children should prove instructive (Medin & Bang, 2009). Finally, an examination of school curricula may clarify how the concepts and language that children bring with them to the classroom interact with the concepts and language that serve as the focus of formal education. Taken

together, an examination of these sources may shed light on children's difficulty integrating plants into the concept ALIVE well into their school-aged years.

The current study provides a first step toward these goals and offers a two-part cautionary tale for parents and science educators alike: (1) the input that young children receive before they begin formal schooling appears to do little to support the acquisition of the overarching biological concepts ALIVE and DIE, and (2) it is reasonable to assume that young children hold a different meaning (or a more limited scope of meaning) than adults do for the very same words, a state-of-affairs that may lead to miscommunication in the very contexts (science classrooms, nature activities) that we expect will be most instructive.

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Figures

Figure 1. Schematic representation of English and Indonesian naming practices.

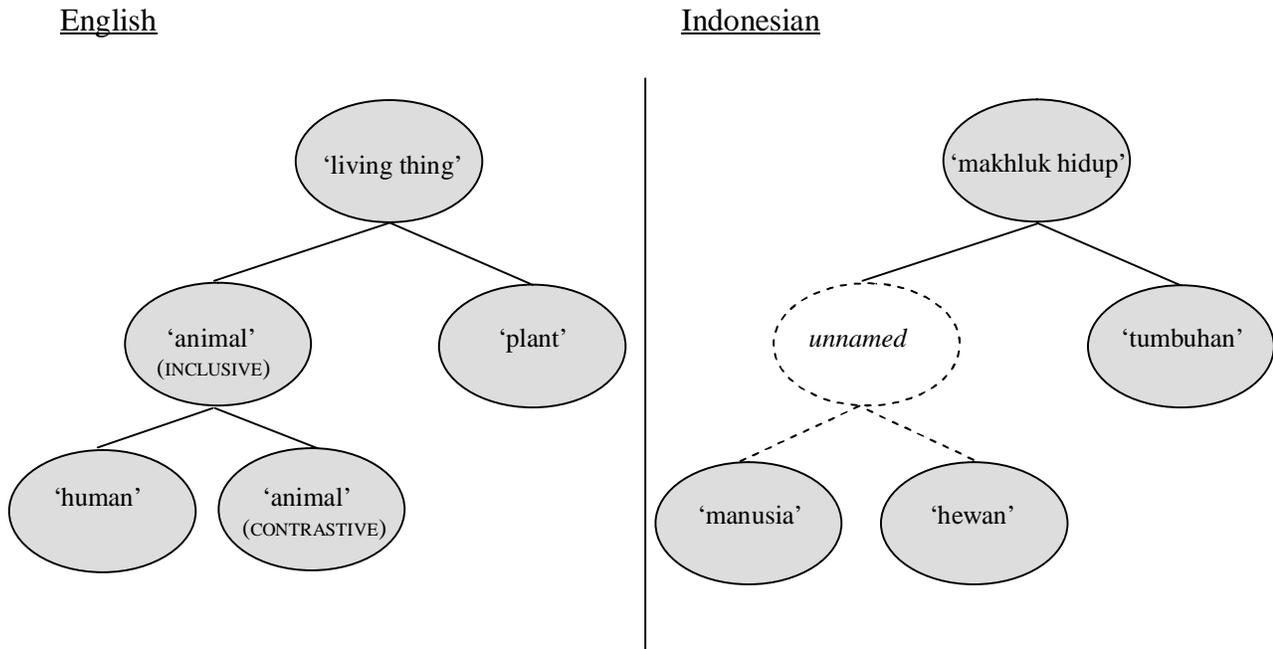


Figure 2. Distribution of applications of English “alive” in the corpus sample, for adults and children.

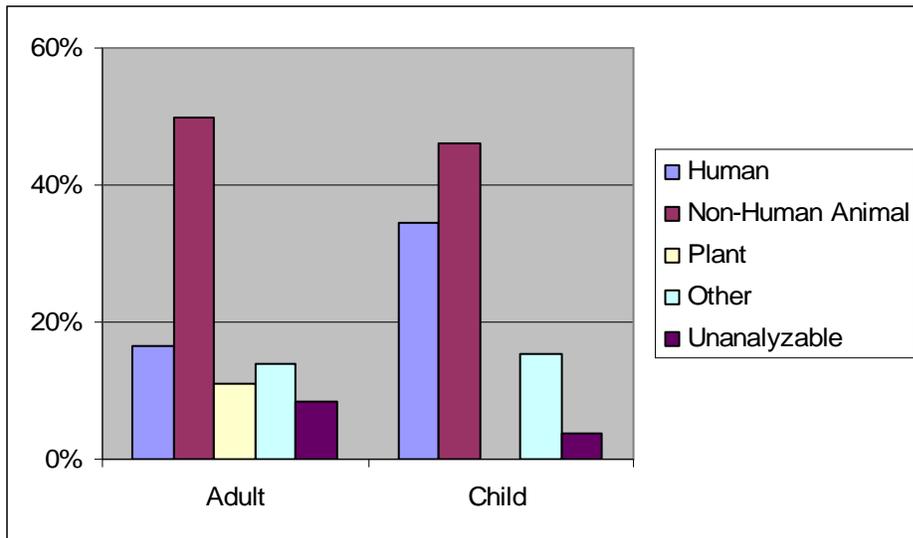


Figure 3. Distribution of applications of English “live” in the corpus sample, for adults and children.

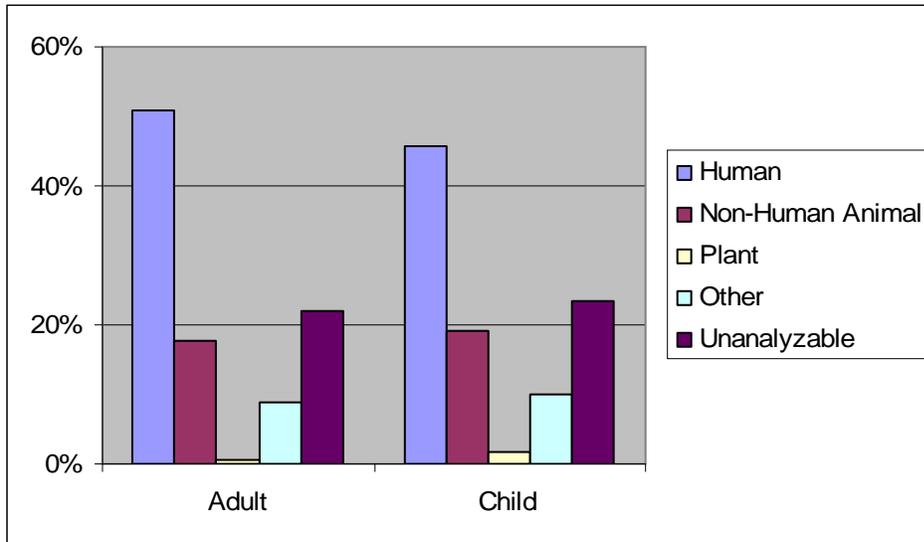


Figure 4. Distribution of applications of Indonesian “live” in the corpus sample, for adults and children.

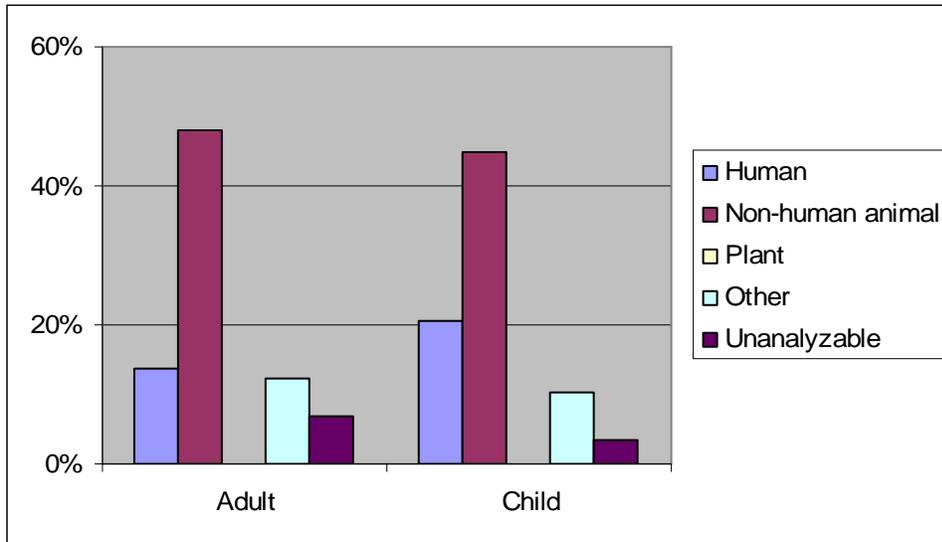


Figure 5. Distribution of applications of English “die” in the corpus sample, for adults and children.

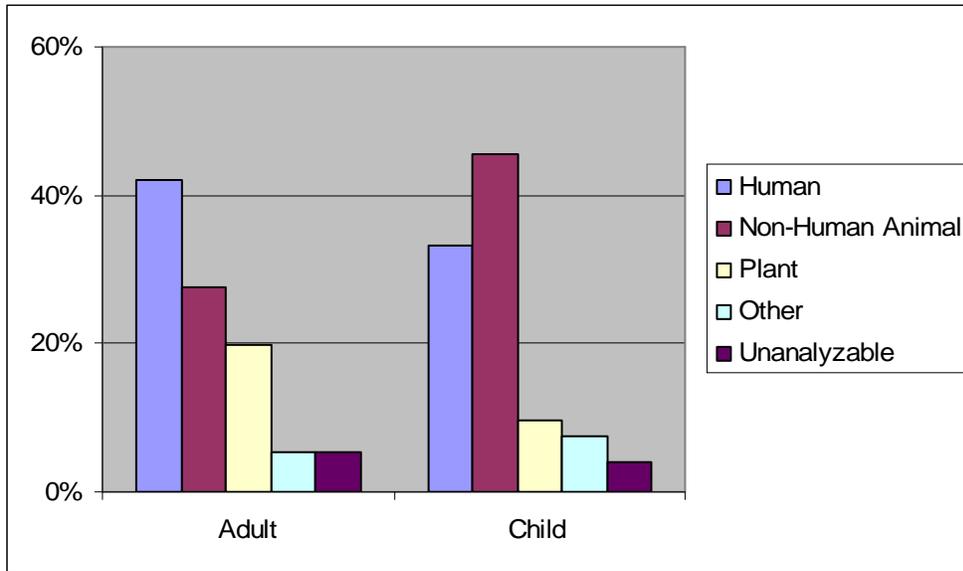
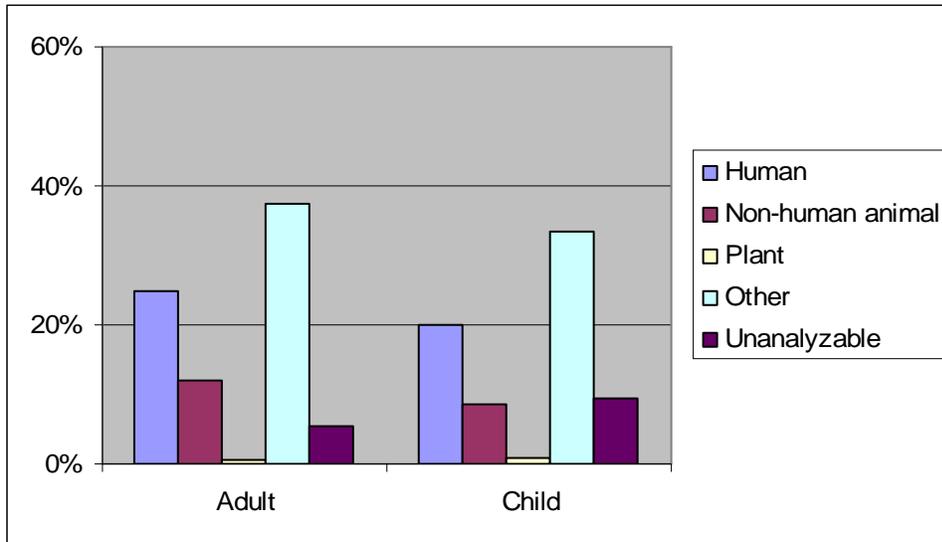


Figure 6. Distribution of applications of Indonesian “die” (“mati”) in the corpus sample, for adults and children.



Appendix

Examples of English “alive” from corpus analysis

From Kuczaj (1976), Abe182 lines 126-133

Child: Daddy # did you know that my beetle can move?

Child: I just saw it move it moved.

Father: it must be alive.

Child: uhhuh.

From Snow (MacWhinney, 2000), Nath26 lines 198-229

(+ indicates book reading)

Mother:+ " alive.

Mother:+ " Heehaw has two flowers in his flower pot.

Mother:+ " one is alive.

Mother:+ " it is living.

Mother:+ " the other one is dead.

Mother: which one's alive?

Mother: nope that's the dead one.

Mother: this is the alive one.

Child: dis [: this].

Mother: that's the dead one.

Child: eh where's de [: the] live one?

Mother: this is the alive one.

Mother: the one that's standing up and looking green and red and bright.

Mother: the dead one is all kind of hanging over # droopy.

From Kuczaj (1976), Abe110 lines 511-524

Father: I thought they were your friends.

Child: they are my new buddies and this house is my new buddy too and it's alive right?

Father: what's alive?

Child: our house and it's breathing look at the curtains.

Father: the blinds are moving # but the house isn't breathing # silly.

Examples of English “live” from corpus analysis

From Brown (1973), Sarah042 line 339

Father: if a policeman found you if you were lost # you'd tell him where you live # right?

From Brown (1973), Sarah094 lines 512-521

Child: Hippity.

Mother: yeah.

Mother: down the beach she had a grasshopper in a jar.

Mother: his name was Hippity.

Mother: and that darn thing lived for about four or five days # in a jar.

Examples of Indonesian “hidup” (“alive”) from corpus analysis

From Gil & Tadmor (2007), MIC_2000-09-11 lines 6279-6293

Child: dor.

English: bang. (pretending to shoot RIN with the Lego gun.)

Rini (adult): ah # ah # ah # ah.

English: ah... ah... ah... ah. (pretending to be dying because CHI shot her.)

Rini (adult): gak ada yang hidup lagi # Michael doang.
English: nobody is alive now... except Michael.

Examples of English “die” from corpus analysis

From Kuczaj (1976), Abe111 lines 106-115

Child: yeah see it's a dead tree # Mommy.

Mother: I know how can you tell it's dead?

Child: because it's white.

Mother: uhhuh it's not green and living # is it?

From Brown (1973) Sarah081 lines 373-375

Mother: yeah # our cat died.

Mother: we've never had very much luck with animals like that.

Examples of Indonesian “mati” (“die”) from corpus analysis

From Gil & Tadmor (2007), RIS_2001-08-14 line 65

Mother: tvnya matiin!
English: turn the TV off

From Gil & Tadmor (2007), PRI_2000-04-01 lines 10263-10282

Child: ini apa ni?
English: what's this? (Turning the page of a book)

Mother: tuh, mati tu gajahnya tuh.
English: look, the elephant is dead!

Child: mana?
English: where?

Mother: kena kelindes, tuh.
English: he has been crushed.

Figure A1. Distribution of applications of English “live” (including “alive”) in the CHILDES (parent-child conversations) and Switchboard (adult-adult conversations) corpus samples.

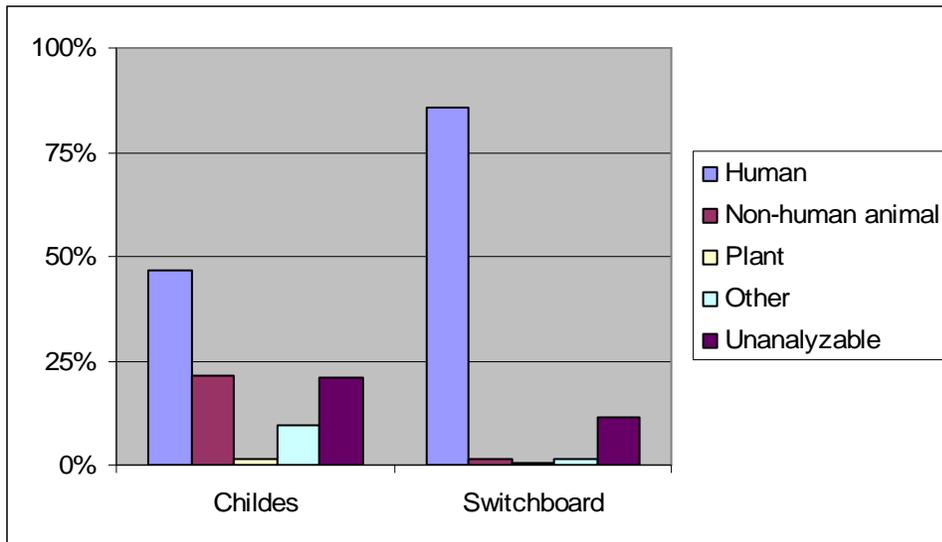
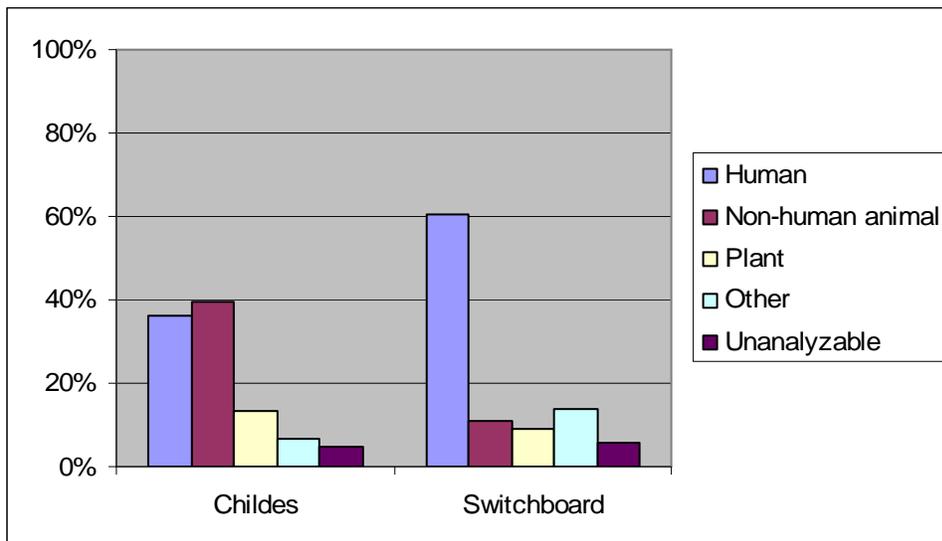


Figure A2. Distribution of applications of English “die” in the CHILDES (parent-child conversations) and Switchboard (adult-adult conversations) corpus samples.



Footnotes

¹ While a full treatment of the relation between word meanings and concepts is beyond the scope of this paper, few would object to the idea that the two are inexorably linked. We therefore assume a tight coupling between conceptual representations and word meanings: in short, words are labels for concepts.

² The original transcript was consulted for contextual information when necessary. Utterances consisting of a single word (e.g., “Alive.”) with limited or no supporting contextual information were considered unanalyzable.

³ With respect to coding, in certain cases where there were questions about the meaning of an utterance, we consulted an Indonesian-speaking informant. This was rare, however, as the translations and glosses typically contained sufficient information for purposes of our analysis.

⁴ While the morphological and semantic relation between “alive,” “live,” and “living” may be apparent to adults, it is unclear how obvious it may be to young children (see McBride-Chang, Wagner, Muse, Chow, & Shu, 2005, for review of children’s morphological awareness). What is clear, however, is that one step of the acquisition process facing children involves ferreting out the meanings of these words, and the relations among them.

⁵ On this view, it might be expected that Indonesian-speaking children would include artifacts when asked to sort “things that can die.” A look at the results from Anggoro, et al. (2008) does not reveal this tendency, but this may be due to the nature of the artifacts included in the task: a pencil, scissors, and a bicycle. Future work may examine the influence of the “off” sense of “mati” and how children may develop more than one meaning for a given term.