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Children's understanding of death as the cessation of agency: a test using sleep versus death

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Abstract

An important problem faced by children is discriminating between entities capable of goal-directed action, i.e. intentional agents, and non-agents. In the case of discriminating between living and dead animals, including humans, this problem is particularly difficult, because of the large number of perceptual cues that living and dead animals share. However, there are potential costs of failing to discriminate between living and dead animals, including unnecessary vigilance and lost opportunities from failing to realize that an animal, such as an animal killed for food, is dead. This might have led to the evolution of mechanisms specifically for distinguishing between living and dead animals in terms of their ability to act. Here we test this hypothesis by examining patterns of inferences about sleeping and dead organisms by Shuar and German children between 3 and 5-years old. The results show that by age 4, causal cues to death block agency attributions to animals and people, whereas cues to sleep do not. The developmental trajectory of this pattern of inferences is identical across cultures, consistent with the hypothesis of a living/dead discrimination mechanism as a reliably developing part of core cognitive architecture.

Keywords: Cognitive development; Agency; Death understanding; Intuitive ontology; Evolutionary psychology

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1. Introduction

Nearly a century of research has documented that death is a concept that is difficult for children to grasp (Carey, 1985; Nagy, 1948; Piaget, 1929; Speece & Brent, 1984, 1996). That this is so should not, perhaps, be surprising, because death is an ontologically strange phenomenon that poses difficult perceptual and conceptual challenges (Boyer, 2001). Perceptually, the challenge lies in the vast number of cues that living and dead things share. The transition from life to death is momentary, and may be perceptually quite difficult to detect. Conceptually, the challenge lies in the fact that death is one of the few cases in which an object crosses a major ontological boundary: in this case, the boundary between living things and non-living things. Given these considerations, the data documenting children's struggle to grasp the ontological nuances of death, a struggle that lasts well into late childhood and perhaps into adulthood, make sense (for reviews, see Slaughter, Jaakkola, & Carey, 1999; Speece & Brent, 1984, 1996).

From a theoretical perspective, prolonged and individually variable trajectories of conceptual development are expected in domains for which there is no core architecture, i.e. for which there are no mechanisms dedicated to the development of a conceptual apparatus according to a reliable developmental schedule (Leslie, 1994, 1988). In such cases, possession of the appropriate principles necessary for inference in the domain depends critically on acquisition of relevant knowledge (Johnson & Carey, 1998). This is often described in terms of "theory change" (Carey, 1985; Gopnik & Meltzoff, 1997). Carey and colleagues (Carey, 1985; Johnson & Carey, 1998; Slaughter et al., 1999) have proposed just such a theory change account of death understanding. Under this account, young children begin with no core architecture to provide them with the relevant inferential principles for understanding death. This is because children do not yet possess a folk biology, i.e. an understanding of the causal mechanisms, or biological functions, that sustain life.

There are a variety of studies consistent with the theory change view. For example, Johnson and Carey (1998) found that individuals with Williams syndrome, who are developmentally impaired in their acquisition of a mature folk biology, perform poorly relative to controls on measures of death understanding that rely on folk biology, including standard tests of understanding of the four classical components of the death concept (see Speece & Brent, 1984, 1996). Several other studies support the proposal that understanding biological processes as having a life-sustaining function is important for later-developing aspects of death understanding (Carey, 1985; Slaughter et al., 1999; Slaughter & Lyons, 2003; see also Inagaki & Hatano, 2002, for a discussion of the development of a "vitalist" folk biology).

The understanding of death has many facets. Here, we do not wish to dispute the proposal that acquisition of theory-like knowledge may be important for understanding death specifically as the cessation of the biological processes that sustain life. Rather, we wish to propose that at least one aspect of death understanding—the understanding of death as the cessation of agency—is subserved by early developing core architecture: namely, the *agency system*, an early-developing inference system dedicated to understanding and predicting the behavior of intentional agents (Johnson, 2000; Leslie, 1994). This proposal differs from previous proposals that have suggested that there is no core architecture specifically subserving death understanding (Carey, 1985). We suggest, on the contrary, that the agency detection system (Johnson, 2000; Leslie, 1994; Rakison & Poulin-DuBois, 2001; Scholl & Tremoulet, 2000) contains, as part of its proper domain, procedures for discriminating living animals (agents) from dead ones. Here we sketch the principle features of this proposal, and offer an empirical test of some of its key predictions.

2. The cessation of agency hypothesis

The concept of agency has been discussed widely in the cognitive development literature (Csibra, Bíró, Koós, & Gergely, 2003; Gergely, Nádasdy, Csibra, & Biró, 1995; Johnson, 2000; Leslie, 1994). Agents, for our purposes, are objects capable of acting in a goal-directed fashion (Leslie, 1994). From an adaptationist perspective, the concept of agency, and a system of inferential principles in which this concept plays a role, are of crucial importance to survival, and to successful interaction with the animate world, from conspecifics, such as parents, siblings, and various social interactants, to heterospecifics such as predators and prey (Barrett, in press).

One important function of the agency system is *agency detection*: discriminating between those things in the world that are capable of goal-directed action, and those that are not. There are benefits associated with success and costs associated with failure (e.g. realizing or failing to realize that what appears to be a log is really a crocodile), and these, summed statistically over time, have shaped the evolution of agency detection systems that are present in all or most animal species. The benefits of an agency detection system are that it allows the activation of different behavioral decision-making procedures for different categories of object in the world. The ability to do one thing when faced with a live crocodile, and to do something else when faced with a dead crocodile or a piece of wood, has clear advantages for survival and reproduction.

In the cognitive development literature on agency detection, the kind of problem that is usually considered is the problem of discriminating between animate living things and non-living things such as artifacts (Gelman & Opfer, 2002; Massey & Gelman, 1988; Rakison & Poulin-Dubois, 2001). A substantial body of literature has documented both that infants are able to make such discriminations from a fairly early age, and that particular cues are used to do so (Johnson, 2000). Here, we would like to consider a discrimination problem that is potentially even more difficult: the problem of discriminating between living and dead agents. These are objects that are, unlike animals versus artifacts, both members of the same superordinate kind category (animals), but have very different properties than can be difficult to detect.

Specifically, we would like to propose that there has been selection in the past on young children's ability to discriminate between living and dead things in terms of agency. To see why this might be the case, consider several examples. Imagine a child encountering a snake, scorpion, or other such dangerous animal. Is it alive, or is it dead? If it is alive, precautions must be taken: move away, alert an adult, perhaps kill it. If it is dead, precautions may still be in order, but the urgency is not nearly as severe. In situations such as this, the costs of different kinds of errors are asymmetric (Guthrie, 1993; Haselton & Buss, 2000; Öhman & Mineka, 2001). In signal detection terms, a miss—assuming that the animal is dead, when it is in fact alive—could clearly have severe costs. A false alarm—assuming that the animal is alive, when it is in fact dead—would, in most cases, have much lower costs.

However, there are also costs to false alarms. One kind of cost is unnecessary vigilance. The detection of a dangerous agent in one's perceptual field normally monopolizes attention, overriding other priorities (Öhman & Mineka, 2001). An emergency mode should be deactivated once a dangerous agent is determined to be dead. Additionally, failure to realize an agent is dead might result in lost opportunities. For example, in societies where children regularly see animals killed and prepared for food, it would be highly disadvantageous to fail to realize that the animal, once dead, now lacks agency and is safe to eat without fear of harm.

Based on this reasoning, we hypothesize that the agency system contains a "switch" that functions to remap an object from one ontological category, ANIMATE OBJECT, to another major ontological category, BIOLOGICAL SUBSTANCE, within the over-arching category of living kinds (for "objects" vs "stuff" as an ontological distinction, see, e.g. Prasada, 1999; Prasada, Ferenz, & Haskell, 2002). We expect this switch to be "sticky," or difficult to flip, because of the asymmetry of costs of different kinds of errors. Misses—failures to detect that an agent is alive—are arguably much more costly than false alarms. For this reason, we expect the agent to non-agent remapping mechanism to be "skeptical," and to require positive evidence of death before remapping the object to the category of dead things.

3. Information-processing features of the living/dead discrimination system

The hypothesized features of the living/dead discrimination subroutine of the agency system are summarized in Fig. 1.

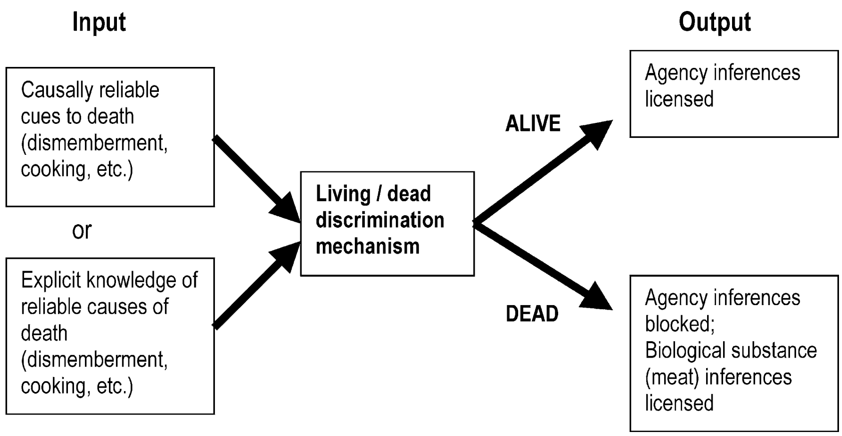

Fig. 1. Information-processing features of the living/dead discrimination system.

3.1. Inputs/cues

Upon encounter with an entity in the world, there are a variety of category judgments children might make about it. While some cues are useful for discriminating animals from non-animals, these will not all be useful for discriminating living animals from dead animals, because both are in the category ANIMAL. What kinds of cues might we expect the living/dead discrimination system to use?

At first glance, it might seem that *absence* of cues to agency (movement, etc.) would be useful, but an error management perspective suggests that such cues should only weakly trigger death inferences, if at all, because sleeping and torpid animals might fail to emit agency cues and yet still be dangerous. Given that the system will be tuned to be skeptical that a given animal is dead, it should rely instead on cues that are reliably associated, in a causal way, with death. These might include disruptions of the body envelope, dismemberment, and so on. Here there might be a hierarchy of cues, with the most reliable ones (such as the head being removed from the body, the body being crushed or in pieces, cooking/burning) being ranked highest.

The living/dead procedures of the agency detection system might take as input either cues received through the perceptual system (which should lead the most strongly to inferences of death), or non-perceptually linked knowledge of events that lead reliably to death, even if not directly observed. In the literature on children's understanding of death, it has been shown that even relatively young children are able to name types of events that lead reliably to death, such as being crushed, getting shot, and so on (Carey, 1985; Speece & Brent, 1984). If knowledge of causally relevant events is a type of input that the living/dead discrimination system accepts, then giving children relevant causal details, like "the chicken was cut up and put into the pot and boiled," should reliably trigger inferences of death, even if the word "dead" is never used.

3.2. Outputs

The output of the death discrimination system is a categorization decision: the object is assigned either to the category LIVING/AGENT, or DEAD/NON-AGENT/BIOLOGICAL SUBSTANCE. This category assignment, in turn, acts as a kind of tag which licenses or blocks further kinds of inference about the object: specifically, inferences about agency. In the absence of specific information about death, the default assignment of living, animate kinds will be to the category AGENT, which will license inferences about goal-directed behavior. When there are sufficient inputs to remap the object in question from ALIVE/AGENT to DEAD/NON-AGENT the inferential procedures of the agency system are de-activated, and it will be treated as a non-agent (substance), although still a member of a living kind category (CHICKEN). Agency inferences will be blocked.

4. The sleep/death distinction as a test

In the study reported here, we used the sleep/death distinction as a test of the cessation of agency hypothesis. Our goal was to determine whether children do, in fact, cease to license inferences about agency to objects that were once alive, but about which sufficient causal information has been provided to infer that they are dead. To do this, we used two experimental conditions: one in which a causal scenario is provided that leads to an animal's or a human's death, and another in which the animal or human goes to sleep.

The sleep/death distinction is useful for investigation of the cessation of agency hypothesis, and for investigation of children's understanding of death more generally, because children are widely held to confuse the two states. For example, Nagy (1948, p. 7) found that many young children (ages 3, 4, and 5) "attribute life and consciousness to the dead," and frequently think of death as "a departure, a sleep." Although the descriptive nature of Nagy's reported data makes it difficult to draw strong conclusions, it is clear that children do frequently refer to sleep when talking about death, and the confusion has since been mentioned by many other authors in the death literature (e.g. Carey, 1985; Slaughter et al., 1999; Speece & Brent, 1984). Children might confuse sleep and death for a variety of reasons, including using sleep as a source domain for making inferences about death because of greater familiarity with sleep than with death, perceptual similarity of sleep and death, and adults' likening of sleep and death in euphemistic talk about death. All of these predict conflation of sleep and death judgments, which makes the sleep–death comparison useful for a strong test of our hypothesis.

Often, proposals about evolved cognitive architecture are presumed to imply innateness of the entire structure. However, because natural selection acts on phenotypes, whether their development involves environmental input or not, we believe that a better criterion is *reliable development*. The cognitive skill in question, in this case living/dead discrimination, should exhibit a reliable developmental trajectory that is robust to a wide range of developmental circumstances, minimally encompassing those that would have been present in human ancestral environments. In the case of death understanding, we expect approximately the same developmental schedule across children from different cultures and with very different levels and kinds of exposure to both living things and death.

To test this, we performed parallel experiments with children in two very different cultures: German children living in Berlin, and Shuar children living in the Ecuadorian Amazon. We reasoned that if experience with the biological world and death matters, in a dose-dependent way, for the development of the living/dead distinction, then we should see performance differences between the populations. Shuar children, living in the Amazon rainforest, have substantially more experience with both living and dead animals, and more direct observations of death.

5. Method

5.1. Subjects

Children from two different populations participated in this study: 3-, 4-, and 5-year-old children from Berlin, Germany, and 3-, 4-, and 5-year-old Shuar children from the Amazon region of Ecuador. The Shuar are hunter-horticulturalists who are on the verge of the transition to a peasant, cash economy. Children live in a rural, forest environment where they have frequent encounters with live animals as well as animals being killed for food. Our German sample included city-dwelling children who have experience with animals as pets, in zoos, and on television. There are also, of course, many cultural differences between the populations, including differences in religious beliefs and attitudes towards death.

The German children were 20 3-year-olds (13 male, 7 female; age range 2;11–3;11, mean age 3;5), 29 4-year-olds (16 male, 13 female, age range 4;0–4;11, mean age 4;6), and 20 5-year-olds (12 male, 8 female, age range 5;0–5;11, mean age 5;5) from 13 inner city preschools in Berlin. The Shuar children were 12 3-year-olds (4 male, 8 female), 13 4-year-olds (7 male, 6 female), and 28 5-year-olds (15 male, 13 female; ranges and means not computed because exact dates of birth were not available for all children) from five Shuar villages. German children were interviewed in German in a quiet room in their school, and Shuar children were interviewed in Spanish in their homes.

5.2. Procedure

We used a within-subject design comparing a "sleep" condition with a "death" condition. Each condition was identical except for the details of the causal story, which either involved the protagonist getting tired and going to sleep, or being killed. Following the causal prime, children were asked a battery of target questions about the agency of the object.

Each causal story was depicted using realistic models of animals (human, chicken, and either lion for the German participants or jaguar for the Shuar participants). All subjects saw one human condition and one non-human condition, either lion/jaguar or chicken. The animal was presented and a series of warm-up questions were asked, including "what animal is this?", "have you seen one before?", "can it hurt you?" and "can it be afraid?" The warm-up questions were followed by two experimental conditions: in the "sleep" condition the animal was shown going to sleep, and in the "death" condition the animal was shown being killed by a person or other animal (the chicken was killed by a chef, to be cooked; the lion or jaguar was shot by a human hunter; the human was killed by a lion or jaguar while out walking in the woods). Following each condition-specific story text, there was a manipulation check in which children were asked to verify whether the person or animal was asleep or dead, prior to the target questions. The complete text of all conditions and questions is shown in Appendix A.

Presentation orders of the human/animal conditions and the sleep/death conditions were counterbalanced across subjects, with the sleep/death conditions constant between human and animal for any given subject.

5.3. Target questions

Following each manipulation, a set of target questions was asked. These questions assessed children's attributions of agency-related properties to the target object, including the ability to have mental states, to respond to stimulus, to move, etc. Each subject was asked these questions a total of four times: in the human sleep, human death, animal sleep, and animal death conditions, respectively. Because the same questions were asked in both sleep and death conditions, responses in each condition could be directly compared as a test of death understanding. The target questions, in the order asked, were:

1) “Can it move?”
2) “Can it be afraid?”
3) “Could it hurt you?”
4) “If you walked by and made a noise, could it know you were there?”
5) “Could it move if you touched it?”

6. Results

6.1. Data coding and analysis

In the analyses reported below we used percent correct measures, where percent correct for sleep questions is computed by dividing the number of “yes” responses by the total number of questions answered, and percent correct for death questions is computed by dividing the number of “no” responses by the total number of questions answered. Overall percent correct measures summed “yes” responses on sleep questions and “no” responses on death questions and divided by the total number of questions answered. Missing data, e.g. cases where there was no response due to participant inattention, were not counted. In addition, if a child responded “no” to the question “could it hurt you?” or the question “can it be afraid?” in the warm-up questions, indicating that the child did not believe the property should be attributed to the agent even when alive, the child’s responses to the question in the sleep and death conditions were not included in the analysis.

We first looked for effects of order of presentation. Finding none, we eliminated this from further analyses. An ANOVA with animal type as a between subjects variable showed no effect of chicken versus lion/jaguar conditions; these were therefore collapsed into a single variable (animal).

Fig. 2 shows percent of children responding yes for each target question in sleep and death conditions, broken down by population and human/animal condition. In this figure, differences in patterns of inference for the sleep and death conditions can be seen in the spread between the sleep and death curves, with greater distance between the curves indicating greater distinction between sleep and death in terms of agency (i.e. “yes” responses in sleep conditions and “no” responses in death conditions). Fig. 3 summarizes these results, showing the mean number of total correct responses per child, by age, population, and agent type (human or animal target).

6.2. Human condition

To test for knowledge of the difference between sleep and death, we used paired *t*-tests (one tailed) to compare the proportion of sleep questions and the proportion of death questions for which the participant replied “yes.” Performance was above chance for Shuar 4-year olds ($t(11)=4.2$, $P=0.001$), German 4-year olds ($t(26)=6.7$, $P < .0001$),

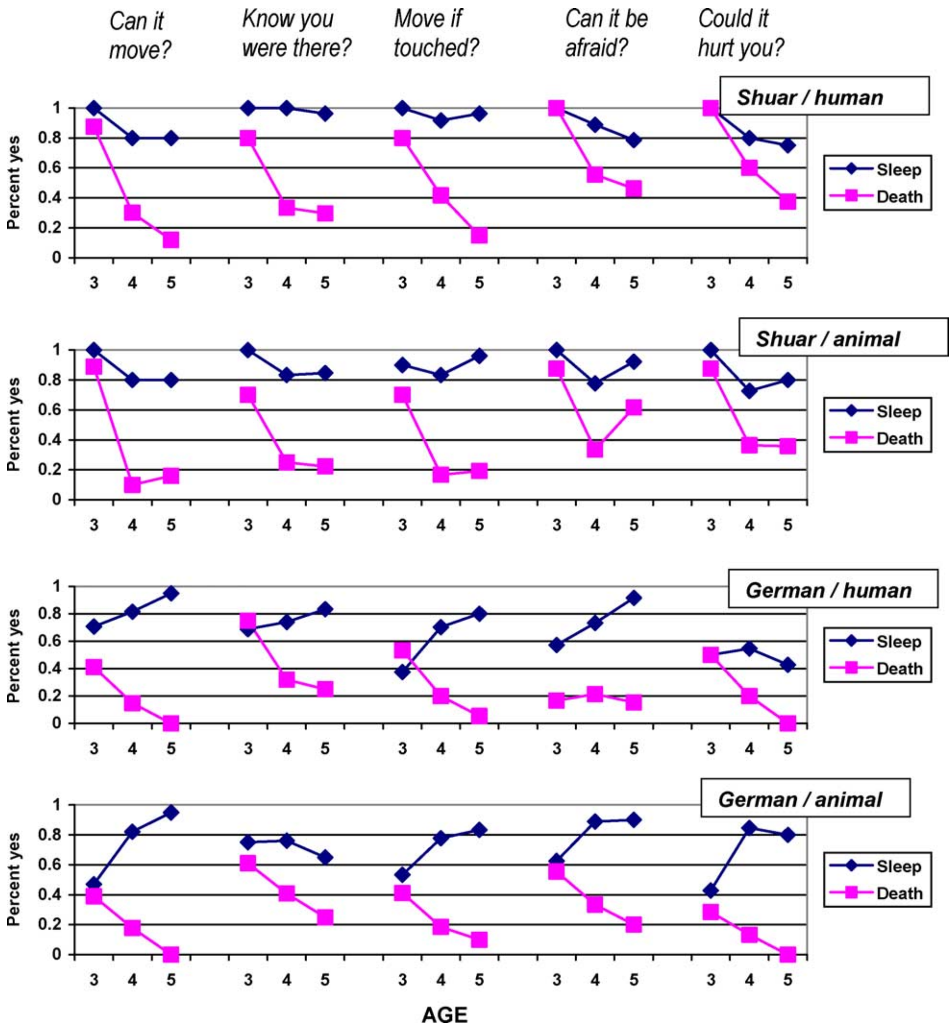

Fig. 2. Responses to sleep and death questions by population and condition.

Shuar 5-year olds ($t(26)=10.8$, $P < .0001$), and German 5-year olds ($t(19)=12.6$, $P<0.0001$). The patterns of responses of 3-year olds were in the predicted direction, but not significantly so at $\alpha=0.05$ (Shuar 3-year olds, $t(9)=1.4$, $P=0.11$; German 3-year olds, $t(16)=0.84$, $P=0.21$). An ANOVA on responses to human questions, with overall percent correct as the dependent variable and age and population as between-subject factors revealed only a main effect of age ($F(2,107)=21.1$, $P<0.0001$, $eta=0.53$), with no main effect of population ($F(1,107)=0.007$, $P=0.931$, $eta=0.0083$) nor a population by age interaction ($F(2,107)=0.123$, $p=0.884$, $eta=0.048$). An ANOVA using individual questions as repeated measures showed no effect of question type (i.e. differences between the five different agency questions).

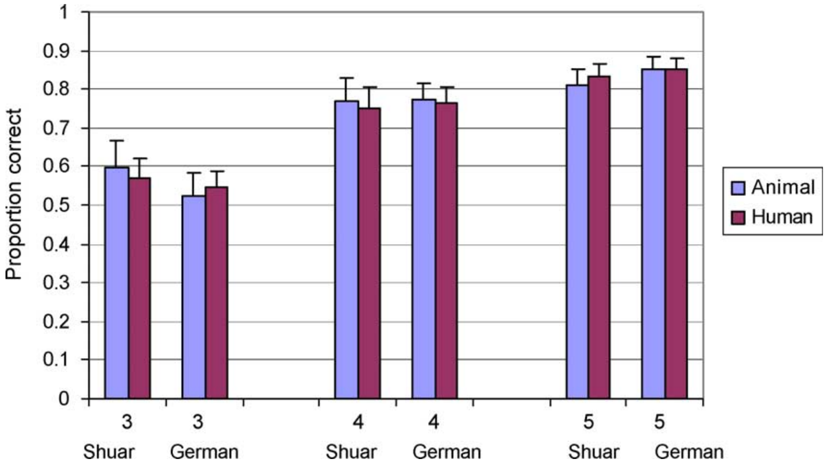

Fig. 3. Mean proportion of correct responses by population and age (bars indicate standard errors).

6.3. Animal condition

Performance was above chance for Shuar 4-year olds ($t(11)=4.7$, $P=0.0005$), German 4-year olds ($t(27)=6.4$, $P<0.0001$), Shuar 5-year-olds ($t(25)=7.6$, $P<0.0001$), and German 5-year olds ($t(19)=11.1$ $P<0.0001$). The patterns of responses of 3-year olds were in the predicted direction, but not significantly so at $\alpha=0.05$ (Shuar 3-year olds, $t(9)=1.6$, $P=0.08$; German 3-year olds, $t(16)=0.93$, $P=0.18$). An ANOVA on responses to animal questions, with overall percent correct as the dependent variable and age and population as between-subject factors revealed only a main effect of age ($F(2,109)=13.4$, $P<0.0001$, $eta=0.44$), with no main effect of population ($F(1,109)=0.064$, $P=0.8$, $eta=0.024$) nor a population by age interaction ($F(2,109)=0.625$, $P=0.54$, $eta=0.0011$). An ANOVA using individual questions as repeated measures showed no effect of question type (i.e. differences between the five different agency questions).

6.4. Comparing performance in human versus animal conditions

To determine whether children understood death in the case of animals better than for humans, or vice versa, an ANOVA was performed with percent correct on human questions and percent correct on animal questions as repeated measures, and with population and age as between-subjects factors. There was no main effect of animal vs. human condition, nor any interaction with population or age.

Finally, to determine whether there was an overall performance difference between populations in the youngest age group, we performed a planned comparison *t*-test between German 3-year olds and Shuar 3-year olds, collapsing human and animal conditions. The results showed that neither population had a performance advantage at this age ($t(26)=0.794$, $P=0.4$, two-tailed).

7. Discussion

These results support the hypothesis that children understand death as the cessation of the ability to act by age 4. By this age, providing causal information about death significantly and systematically changes the pattern of inferences children make about an animal. Agency attributions to dead animals are blocked, whereas attributions to sleeping animals are not. On our task, we found a reliable developmental trajectory that is the same across populations and conditions. That the developmental trajectory of inference patterns that we observed was identical for both Shuar and German children supports the hypothesis that the living/dead distinction is a reliably developing part of core architecture. Given the vast differences between city-dwelling German children and rural-dwelling Shuar children in exposure to death and dead animals, one would have expected population differences in performance if experience with death were driving the development of inference skills in this domain in a dose-dependent way.

The fact that 4-year olds exhibit little confusion in distinguishing sleeping from dead agents is striking, given the reasons for thinking that children might easily confuse these states, including their high degree of perceptual overlap, the possibility of reasoning about death through analogy to the more familiar state of sleep, and the comparison of death with sleep in adults' euphemistic speech. The cessation of agency hypothesis predicts that children should be quite good at distinguishing sleep from death, but *only* when presented with cues or causal information that reliably trigger the living-to-dead remapping mechanism. The results presented here support this hypothesis. By age 4, there was little confusion between sleep and death. In fact, the questions were stacked against the hypothesis, because many children could justifiably answer "no" to questions about sleeping animals' ability to move, etc.

We suspect that one reason that we obtained such cross-culturally robust results is that we used stimuli that effectively trigger children's death understanding in the micro-domain where this understanding should be clear and early-developing. Unlike many other studies, in which animals or people are merely asserted to be dead, or questions about death are asked without a causal context (see Speece & Brent, 1984, 1996, for reviews), in our scenarios we provided critical causal information which we predicted would trigger the living/dead remapping mechanism. We suspect that exposure to causally reliable cues or information is likely to be critical, because for error management reasons, any living/dead remapping mechanism should be difficult to trigger except by highly unambiguous cues to death. That cues are critical in triggering appropriate death inferences is suggested by several other studies. A study by Dolgin and Behrend (1984) used color photographs of living and dead animals (e.g. a cooked turkey, a cooked fish) and found that children 3 and up performed significantly above chance at correctly attributing various properties, such as ability to move, grow, see, etc, to living and dead things. A study by Brent, Speece, Lin, Dong, and Yang (1996) that used actual dead animals (fly, stuffed squirrel) as a warm-up found understanding of "nonfunctionality" (i.e. lack of biological functions) and irreversibility of death in over 80% of US and Chinese 3-year olds, suggesting a possible priming effect of realistic stimuli.

The error management perspective presented here suggests a possible interpretation of prior studies showing that children have particular trouble understanding *human* death

(Speece & Brent, 1984). In our study, there was no difference between children's understanding of human and animal death in either population. We suspect this is because we provided causal cues sufficient to trigger the death detection mechanism. In real life, children often do not have access to cues that would reliably trigger categorization of a human as dead, according to our proposal. Indeed, access to such cues is often intentionally prevented by well-meaning adults. For example, sometimes children are not able to see the body of a dead relative, the body is prepared in such a way as to minimize cues to death, or children are specifically told misleading or ambiguous statements (the relative "went away").

Might understanding of death as the cessation of agency develop even earlier than we found here? In other domains of cognitive development, processing demands of tasks used to probe cognitive skills might push the apparent age of acquisition of the skill upwards, even for core capacities such as theory of mind (Bloom & German, 2000; Leslie & Polizzi, 1998). Although we designed our study to minimize certain kinds of task demands—for example, by providing a causal scenario leading to sleep or death, so as to provide appropriate input for death-related inference mechanisms, as opposed to relying strictly on lexical labels for sleep and death states—the task was still cognitively demanding, relying on pretense and language skills. It would not surprise us if an even earlier developmental trajectory could be revealed if these task demands were lightened, and more ecologically representative inputs were employed.

7.1. Alternative hypotheses

Although we have proposed that death understanding is subserved by a specific, living/dead discrimination mechanism that is part of the agency detection system, there are several alternatives to this proposal that this experiment cannot rule out, and several ways in which this mechanism might be situated in the cognitive architecture.

One possibility is that death detection arises merely as the byproduct of the operations of non-death-specific mechanisms. For example, it could be that agency detection mechanisms continually "refresh" their judgments by monitoring objects for agency cues, and when these cues cease, agency judgments are turned off. While we cannot rule this out, we have stressed that there are error management reasons for organisms to monitor for more than mere *lack* of agency cues, as in, for example, deep sleep or torpor. If, as we suspect, death judgments are stronger when unambiguous cues to death are present, it is less likely that failure to activate the agency system alone is driving the inferences. On the other hand, the fact that real sleeping animals may emit agency cues, albeit subtle ones, might confound attempts to demonstrate this.

Another possibility is that for at least some kinds of death judgments, the agency system is not involved at all. For example, systems for tracking object identity might come into play when one object is split in two (Hall, 1998). This is not a problem for the present study, in which objects remained intact. However, on tasks in which labels for individuals are used for the same object, cut into pieces, before and after death (e.g. "the chicken"), this could result in changes in inference patterns due to object tracking alone. Potentially, new objects have been created, which then need to be monitored for agency. If, however, some properties are judged to have survived the split, the system may be representing (partial) object continuity. Initial results of a follow-up study (Barrett, unpublished data) suggest that certain properties, namely substance properties, are judged to survive splitting of a living thing into two, whereas agency properties are not. This is consistent with the AGENT → SUBSTANCE remapping proposed here.

Finally, there is the question of where our proposed mechanism sits within the cognitive architecture. For example, it could lie "outside" of the agency system. Indeed, we have argued that it serves as a kind of gatekeeper, or switch, to turn on or off agency judgments about an object, so our proposal is merely that the mechanism is designed to interact with the agency inference system in a specific, functional way. On the other hand, given that only members of living kind categories can possess the properties LIVING or DEAD, our proposed mechanism might lie "downstream" of the mechanism that assigns objects to the category ANIMAL (which, in turn, might be independent of the agency system itself, and might rely more on static cues). Functionally, these designs would both produce the same results seen here, so narrowing down the exact relationship of this mechanism to other processing systems must await future work.

8. Conclusion

The results of this study support the hypothesis that death understanding is subserved by reliably developing, evolved mechanisms that enable children to distinguish between objects that are capable of acting and objects that are not, and to make inferences about each. That such an inference system exists makes sense if one considers that in ancestral environments, children's survival is likely to have depended on their abilities to reason about the consequences of interacting with various kinds of things in the world. There are things to avoid, if one wants to survive (e.g. predators); and things that cannot be avoided, if one wants to survive (e.g. food). Knowing which is which, and how and when to interact with them, would have been a crucial skill. In societies in which children cannot be supervised constantly, when on their own or left unattended for just a moment, the decision-making skills of a three, four, or five-year-old child can mean the difference between life and death.

The kind of analysis of cognitive skills in children undertaken here, i.e. an analysis of the functions that a particular cognitive competence would have served in ancestral environments, has implications for a wide range of normative theories in cognitive development, and can be used to predict what we may expect when we test children's cognitive skills. While some kinds of judgment skills almost certainly had survival consequences over the course of evolutionary history, others probably did not, and therefore, are not likely to be subserved by reliably developing, evolved cognitive mechanisms. In the case of death understanding, there are many aspects of death for which we should *not* expect a reliably developing understanding in children or adults, for example, the fact that death can result from lack of sufficient oxygen flow to the brain. Moreover, some aspects of death understanding—for example, that death is inevitable in humans—might develop only later or not at all, if there has been no selection to understand this.

We find it remarkable that the aspect of death understanding that we have investigated is so invariant across children from two very different cultures, despite the bewildering array of evolutionarily novel information sources, often providing contradictory, baffling, and intuition-violating information about death. In films, television, and cartoons, death is rarely, if ever, portrayed as it really is. Information about death in propositional form, e.g. information from well-meaning parents trying to soften harsh realities, and information from religious sources, can be equally confusing. Despite these facts, when it comes to the understanding of a very basic fact—that death ends the body's role as a vehicle of action—children are not confused.

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Appendix A. Text of interview

Warm-up questions
I am going to show you some animals and ask some questions.
What animal is this?
Have you ever seen it?
Can it get hungry?
What does it eat?
Can it speak?
Can it sleep?
Can it be afraid?
Would you touch it?
Can it hurt you?
Can it kill you?
Manipulations

Human/sleep. This woman has been working all day and running around. It's night now and she is very tired. She lies down and sleeps.

*Chicken, lion, jaguar/sleep***.** This lion/chicken has been running around all day. It's night now and the lion/chicken is very tired. It lies down and sleeps.

Human/death. This man is walking in the woods and a lion/jaguar comes and bites him. The lion/jaguar bites him a lot and the man dies. The man is now dead.

Chicken/death. This woman is a cook. She wants to eat this chicken, so she takes a knife and cuts the chicken's neck and the chicken dies. The chicken is now dead.

Lion/jaguar/death. This man is a hunter. He is walking in the forest and he sees a lion/jaguar. He takes his gun and shoots the lion/jaguar and the lion/jaguar dies. The lion/jaguar is now dead.

Is the animal dead/asleep?

Target questions

Can it move?

Can it be afraid?

Could it hurt you?

If you walked by and made a noise, could it know you were there?

Could it move if you touched it?

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