

THE EFFECTS OF PREDATORY STATUS ON DEVELOPING UNDERSTANDING
OF MENTAL STATE FUNCTIONING SUBSEQUENT TO DEATH

by

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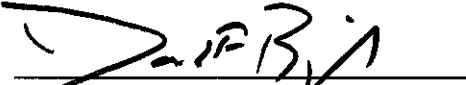
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This dissertation was prepared under the direction of the candidate's dissertation advisor, Dr. David F. Bjorklund, Department of Psychology, and has been approved by the members of his supervisory committee. It was submitted to the faculty of the Charles E. Schmidt College of Science and was accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

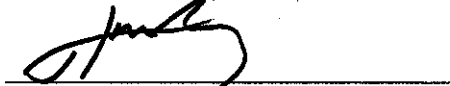
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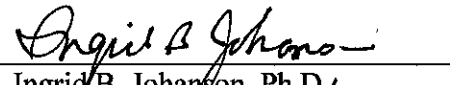
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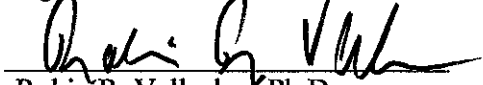
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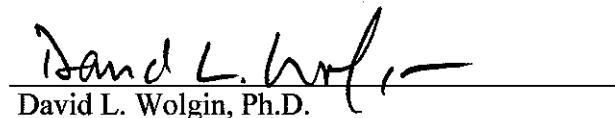
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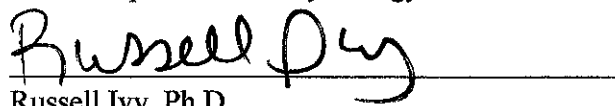
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ABSTRACT

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Bering and colleagues (2004, 2005) reported that the expectation that conscious mental states cease with the onset of death (discontinuity reasoning) emerges developmentally, and discontinuity reasoning for some states (emotions, desire, epistemic) remains lower than for others (psychobiological, perceptual). Cormier (2005) reported very similar findings for the context of sleep and proposed a modular explanation of these effects (“intentional persistence”) and suggested that intentional persistence represents an evolved adaptation designed to maintain vigilance and behavioral preparedness while in the presence of animals of ambiguous agency status (e.g., death, sleep, hibernation, feigned death). The current study extended this line of research to realistic animal characters. Although results revealed patterns of discontinuity reasoning and intentional persistence that were consistent with those of previous studies, the prediction that intentional persistence would be more pronounced for predators was

not fulfilled. A newly proposed evolutionary product, “Cooptation,” was introduced to further explain the results.

DEDICATION

To my beautiful and beloved wife, Vanessa, whose unwavering belief in me and whose steadfast presence have made the completion of the doctoral program and this dissertation possible. Also, to my angelic and wonderful children, Jeffrey Jonathon, Timothy James, and my “Petunia,” Vanessa Christina, for whom my love, in addition to that for my wife, drives me onward against all odds. Also, to my mother, Harriet, who remains with us in spirit and who provided very real and practical support just when it was needed; to my sister, Debi, who encouraged me to return to school when all hope for doing so seemed lost; and to my good friends, Bill McElderry and James Munoz, whose guidance and personal support have been invaluable. This dissertation also is dedicated to all divorced dads who have struggled mightily to achieve their academic dreams while suffering the perverse and systemic injustices of the family court systems of this nation. Finally, this dissertation is dedicated to glorious God himself, Jesus Christ, who, I can only assume, must have laughed and felt a bit sorry for me as I reentered the doctoral program with a burning passion for atheism and the single-minded life goal of scientifically revealing what I had assumed to be the (merely) cognitive basis of all religious beliefs – and for which this dissertation was intended to be the “opener!” Given my general stubbornness and sometimes rank stupidity, God, fortunately, decided to go “old school” and “knocked me off my horse” quite forcefully, unmistakably, and

sometimes maddeningly. For this I am eternally grateful, and now dedicate all of my efforts, scientific and otherwise, to him in the hopes that they will be judged as leading to truth.

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INTRODUCTION

Research on children's understanding of the mind (theory of mind, or ToM) has typically focused on children's developing knowledge of "basic" mental states such as belief, desire, knowledge, emotion, etc., as well as the relationship of these phenomena to perception, behavior and other mental state phenomena (Avis & Harris, 1991; Bjorklund, 20012; Flavell, 1999; Sabbagh, Xu, Carlson, Moses & Lee, 2006). Understandably, this research has been primarily concerned with children's understanding of these states as they occur in conscious, normally functioning individuals - for how else could someone conceivably be expected to experience beliefs, desires, emotions and the like (i.e., if they are not conscious)? Perhaps counterintuitively, a small handful of studies (e.g., Bering & Bjorklund, 2004; Cormier, 2005; Flavell et al, 1999) have explored children's developing understanding of the fate and nature of mental states as they are experienced by individuals who have undergone some significant transformation of consciousness, e.g., as occurs with the onset of sleep or death.

The central empirical question at the heart of these studies is "Do children and adults believe that mental states (such as emotions, desires, knowledge and the like) somehow continue to exist within an individual despite the onset of unconsciousness or even death (continuity reasoning), or do they perceive that such mental contents cease under these conditions (discontinuity reasoning)? Additional important questions have included: 1) Does age matter, producing differences throughout development (as would be the case, for example, if one observed age-related increases or decreases in

continuity/discontinuity reasoning)?; 2) Do differences exist between different mental states, i.e., might some states be more subject to continuity or discontinuity reasoning than others?; and 3) Are different transformations of consciousness (e.g., the onset of death vs. sleep), associated with different kinds or levels of continuity or discontinuity reasoning (e.g., Cormier, 2005)?

In addition to generating novel and interesting empirical data (to be reviewed in some detail below), the results of these studies have enabled their authors to view both traditional areas of intense interest and debate within cognitive development (e.g., the fundamental nature of intuitive human understanding of the mind, as in the theory theory/simulation debate) and areas left almost completely unexplored previously (e.g., the origins of afterlife beliefs) from new and promising empirical and theoretical vantage points. Particularly interesting are questions that derive from speculation on the potential evolutionary origins of theory of mind as applied to nonconscious agents, e.g., “Is theory of mind as applied to nonconscious agents simply the byproduct of theory of mind as typically applied to conscious agents, or has evolution provided specific adaptations that are ‘designed’ for addressing unique problems that arise when predicting the behaviors of nonconscious/deceased (or potentially nonconscious/deceased) entities?” If the latter is the case, what are these unique problems, and how are their corresponding adaptations designed to solve them?

Cormier (2005) proposed that some aspects of ToM as observed in studies of their application to nonconscious entities may indicate the presence of special evolutionary adaptations that are designed to address problems associated with risk management in encounters with entities of ambiguous agency status, such as an immobile and potentially

dead animal lying quietly in the bush (see Barrett & Behne, 2005 and Haselton & Buss, 2000). One of the primary goals of the current study is to examine this possibility by exploring potential developmental differences in reasoning about the mental states of deceased animals that differ in terms of predatory status. But before the current study can be adequately presented, a brief review of multiple themes within developmental and evolutionary psychology are needed and are presented below and in the following order: theoretical accounts of children's developing understanding of the nature of the mind (i.e., theory theory, simulation theory, modularity theory and information-processing theory), the emerging experimental literature on the development of reasoning about the mental states of nonconscious (sleeping, deceased) agents, evolutionary psychology (and evolutionary implications of theory of mind as applied to nonconscious agents), error management theory, and the human tendency to engage in anthropomorphism.

Theoretical Accounts of Developing Understanding of the Mind

Theory Theory

Three general classes of theory have been developed to account for children's developing understanding of the nature of mind (see Flavell, 1999 for an excellent overview): *theory theory* (from which the more general term encompassing all three, theory of mind, is derived), *simulation theory*, and *modularity theory*. Theory theorists suggest that everyday (i.e., nonscientific) notions of mind are largely constituted by an implicit (or *naïve*) psychological theory. Although nonscientific by definition, naive theories are analogous to scientific theories in that, most generally, both represent the outcome of distinctly human efforts to comprehend the nature of the world and are shaped over time in the minds of individuals as a result of the ongoing interaction of

current theoretical structures and experience. In other words, they are both characterized by development (Gopnik & Wellman, 1994). As knowledge and experience are gained, relatively crude and generally less successful theories are replaced by those that are more conceptually sophisticated, differentiated and successful, i.e., those that allow for more successful explanation, interpretation and prediction of relevant phenomena.

More specifically, although both scientific and naïve theories are produced in relation to experience and evidence, they share a level of coherence and abstractness that is not found in mere generalization from experience (empirical generalization). To use a familiar example, predicting that an object thrown into the sky by hand will return to earth along an intuitively predictable trajectory on the basis of numerous similar experiences (an empirical generalization) is a far cry from developing a conceptually abstract, coherent and (in this case) explicit theory of gravity and its associated qualities (such as its characteristic force and other unique physical properties). It is these properties – coherence and abstractness – that result in the unique explanatory power of theories, their characteristic patterns of prediction, and unique interpretations of evidence (Gopnik & Wellman, 1994).

In other words, theories, of both the explicit-scientific and naïve varieties, are uniquely and powerfully suited to the task of explanation and characteristically allow for prediction that is far removed from the simple empirical data of experience resulting in the construction of interpretations and predictions that just wouldn't be possible on the basis of simple and theoretically uninformed experience. Returning to my previous example, predicting from simple experience that rocks, babies, kitchen sinks, etc. will not remain aloft under their own powers doesn't help one explain or predict the contingent

movements of planetary bodies or the specific effects of distance or mass on such movements. A reasonably accurate (and in this case, scientific) theory of gravity, however, allows one to do all of these things with relative ease.

Wellman and colleagues offer the following theory-theory model of early-developing, naive (non-explicit) conceptions of mind. Probably as early as infancy, and at least by two years of age, children attribute psychological states to others (Wellman & Woolley, 1990). However, this early theory of mind is essentially limited to an understanding of two internal states: perception and desire. Importantly, these states are believed to be experienced by children of this age in *nonrepresentational* terms, with desires perceived as simple drives towards objects, and perceptions understood to simply be perceptual awareness of objects (Flavell, 1988). By age 3 children begin to verbalize a broader range of cognitive terms (e.g., think, know, remember; Shatz, Wellman & Siber, 1983) and display an understanding of fictional mental states (e.g., pretense, dreams; Woolley & Wellman, 1992, 1993). Although awareness of the representational nature of fictional mental states is apparent by this age (age 3), the emergence of a general concept for “belief” that also begins to develop at this age is essentially nonrepresentational in nature, i.e., that the contents of any given “belief” are implicitly assumed to reflect reality (i.e., that no concept exists for “false beliefs”). It is not until the age of 4 or 5 that children demonstrate apprehension of the concept that a person can possess a belief that is inconsistent with reality (i.e., is wrong), such as understanding that the belief that an unfamiliar cookie jar contains cookies may be wrong, as in a case where it contains spare change or is empty.

The most frequently cited evidence for the nonrepresentational nature of the belief concept for 3-year-olds is their (unsuccessful) performance on classic false-belief tasks. Originally developed for use with chimpanzees (Premack & Woodruff, 1978), successful execution of such tasks requires a basic mastery of the notion that beliefs may misrepresent any given factual state of affairs in the world. In the original variant developed for use with children (Wimmer & Perner, 1983), a child watches as a special treat is concealed in a specific location (e.g., Box A) in full view of another “person” (fictional doll character named “Maxi”). This other “person” is then observed by the child to “leave” the testing room (i.e., is removed by the experimenter), subsequent to which the experimenter moves the treat to another location (e.g., Box B), and then asks the child “When Maxi returns, where will he look for the treat?” Three-year-olds consistently fail this task by stating that Maxi will look in the second location (Box B).

Another popular variant of the false-belief task, the “Smarties” task (Hogrefe et al., 1986), is superficially different from the original “Maxi” task but conceptually identical. In this task, children are shown a container associated with a candy popular with children (“Smarties” in the original British sample) and asked what it contains, just prior to being shown the actual contents. The natural answer, “Smarties” in this case, is demonstrated to be incorrect when some other contents are subsequently revealed, e.g., pencils or ribbons. Children are then asked to predict what some other and uninformed observer might guess is in the container, as well as to report what they themselves originally thought was in the container. Consistent with findings from the Maxi task, 3-year-olds incorrectly report “pencils” to both questions.

It is not until 4 or 5 years of age that children begin to develop a representational understanding of belief, as indicated by successful performance on false-belief tasks. Similarly, by this age most children have developed a model of the mind that recognizes the representational nature of almost all mental states (i.e., desires and perceptions, beliefs, pretense and images;; Perner, 1991; Avis & Harris, 1991; Bjorklund, 2012; Flavell, 1988, 1999; Sabbagh et al., 2006). Critically, this unified understanding of mind (i.e., recognition of the representational nature of all mental states) not only results in the realization of new types of predictions, explanations and interpretations of mental states, but significant emendation to representations of phenomena previously afforded by the earlier (nonrepresentational) desire-perception theory of the nature of mind (Gopnik & Wellman, 1994).

Simulation Theory

An alternative account of children's developing awareness of the nature of mind, *simulation theory* (Harris, 1991, 1992), suggests that children's understanding of mind is not fundamentally mediated by internal and implicit theoretical constructs, but rather, by a kind of role-taking process or "simulation" of the mental states of others, the fundamental basis of which is the capacity for introspective self-awareness of one's own mental states (i.e., first-person psychological experience). In other words, one's ability to understand the mental states of another individual most fundamentally requires being able to determine or imagine what oneself would feel, believe, think, etc., if one were to exist within the other's circumstance and be subject to their experience. With development, children become increasingly skilled at this process, and therefore able to make increasingly substantial simulatory leaps (from self to other), as measured by the

number of adjustments required to what Harris refers to as “default settings” – which correspond to the current reality and intentional state of a simulator. As suggested by Flavell (1999), successful performance on the false-belief task (Smarties task) would necessitate, according to simulation theory, being able to suspend relevant aspects of current reality (“I now know the candy box has pencils and not candy”) and successfully imagine what one would think was in the candy box given knowledge only of the exterior, and not the actual contents of the container, as would be the case for an uninformed other (“If I could only see the outside, and didn’t have knowledge of the actual contents, I would think there was candy inside.”).

Modularity Theory and Information-Processing Accounts

An alternative to both theory theory and simulation accounts of the development of ToM have been proposed by theorists who invoke the neurological maturation of what are proposed to be “innate,” dedicated (i.e., domain-specific) information processing structures within the mind, originally dubbed (as a general class of such structures functioning within diverse cognitive domains) *modules* by Fodor (1983). Theorists supporting a modular view of ToM development (e.g., Baron-Cohen, 1995; Leslie, 1994) suggest that the social milieu of ancestral humans presented a powerful selective force in the evolution of the species. Successful navigation and manipulation of the complexities of social existence results in both greatly enhanced access to resources and reduction of myriad forms of threat, and an understanding of the beliefs and desires of others is invaluable in this regard. As postulated by evolutionary psychologists (e.g., Buss, 1995; Cosmides & Tooby, 1992), such selective forces have produced cognitive mechanisms (modules) that directly subserve capacities associated with ToM. As such, these modules

produce their outputs (e.g., “Joey will think that there is candy in the box”) in a relatively direct and automatic manner – one that is elicited by stimulus features and context (e.g., false-belief task), and not as the result of the development of the sorts of theoretical constructions proposed by theory theorists (e.g., a representational theory of the mind).

One such modular account of the development of ToM has been proposed by Baron-Cohen (1995), who posits four interacting ToM modules that come online in a developmentally prescribed sequence. The first of these, the *intentionality detector* (ID), becomes operative in early infancy and enables detection and attribution of volition (intentionality) based on specific qualities of object motion (e.g., “That object (dog) is deliberately moving away from/towards me/another object”). The second, the *eye-direction detector* (EDD), becomes operative before 9 months of age and has multiple functions: 1) to detect the presence of eyes (eye-like stimuli); 2) determine whether a set of eyes are looking toward oneself or another object; and 3) infer the presence of knowledge based on visual percepts (e.g., “The eyes of that agent are directed at me and therefore that agent *perceives* me”). The third module (which becomes operative between 9 and 14 months) is the *shared-attention mechanism* (SAM). It expands upon the dyadic orientation and limitations of the previous two modules to allow for representation of triadic interactions (“I can tell by looking at your eyes, and what I infer they currently perceive, that you and I are both looking at and perceiving the same object”). The fourth and final module, the *theory of mind module* (TOMM), allows for the representation of states corresponding to those required by and indexed by successful completion of false-belief tasks (described above), such as belief-desire reasoning.

A similar modular model of ToM development has been proposed by Leslie (1994) who posits an early appearing *Theory of Body* mechanism (ToBY) that recognizes the internal nature of energies that propel agents, and two *theory of mind mechanisms* (ToMM-sub1 and ToMM-sub2). ToMM-sub1 allows infants to generate construals of agent perceptions and goals, whereas ToMM-sub 2, which is proposed to develop during the second year of life, allows children to represent the propositional nature of mental states, including those needed to successfully execute the various false-belief tasks (e.g., “knowing” or “believing” a given fact, “imagining” a particular circumstance, “desiring” a particular state of affairs, etc.).

In direct contrast to modular (domain-specific) accounts of ToM, domain-general accounts suggest that the development of general information-processing mechanisms (e.g., inhibition, working memory, and general intelligence) account for the development of capacities associated with ToM (Carlson, Moses & Breton, 2002; Chiappe & McDonald, 2005; Flavell & Miller, 1998; Geary, 2005; Keenan, 2000). Domain-general theorists suggest that failure on false-belief tasks, for example, may be accounted for by an inability to withhold a prepotent response (i.e., immature inhibitory capacities, e.g., to blurt out the correct answer), incomplete understanding of the false-belief task (general intelligence), or inadequate motivation.

Theory of Mind Applied to Nonconscious Agents

Early Studies of Theory of Mind and Sleep

Flavell, Green, Flavell and Lin (1999) conducted a quartet of studies that examined children’s developing understanding of the nature of unconsciousness as well as the differences that exist in the psychological experiences of those who are awake and

fully conscious and those in a state of unconsciousness (specifically in this case, a deep, dreamless sleep). The general pattern of results indicated that increases in age were associated with improved understanding of the discontinuity of various consciously mediated psychological functions that occurs with the transition from the waking state to a deep and dreamless sleep. In other words, recognition that the flow of conscious experience is interrupted with the onset of deep sleep is not a given in childhood, but rather, emerges developmentally.

For example, in Study 1 (Flavell et al., 1999), 5-, 7-, and 8-year-old children, and adults were presented with line-drawings and descriptions of the activities and experiences of a fictional child who was initially awake (e.g., sitting in bed and looking at pictures, wanting ginger ale, etc.), but subsequently fell asleep. Participants were then asked if the child would continue to experience these various mental functions after falling into a deep, dreamless sleep. Results indicated that of the eight variegated states tested, 5-year-olds reported statistically significant levels of discontinuity (relative to chance) only for the perceptual experience of “seeing,” but not for the other perceptual experiences of “hearing” or “listening,” nor for the additional cognitive experiences of “pretending” or “thinking,” the emotional experience of “feeling sad,” the desire-based experience of “wishing,” or the epistemic experience of “knowing” she was asleep.

In contrast, the older groups displayed increasing levels of acquisition of the “discontinuity concept” (i.e., of the discontinuity of conscious functions that occurs with the onset of a deep, dreamless sleep). The patterns of statistically significant reports of discontinuity for the various functions were as follows: 7-year-olds, all three perceptual experiences; 8-year-olds, all perceptual experiences plus the cognitive experience of

“pretending”; and adults, all eight mental states. Flavell et al. (1999) interpreted the general pattern of results observed for this (and three similar, additional studies) as indicating that increased age is associated with increased ability to report discontinuity for states involving what they termed *reflective consciousness*, i.e., the metacognitive aspects of psychological experience (e.g., the experience of “knowing” that one is “hearing the rain” or “thinking about toys,” and *volitional states* such as thinking that one may “choose” to roll over (as in bed). Interestingly, the results of Study 3 indicated that although 6-year-old participants reported as a group that fully awake individuals are more likely to engage in various psychological activities than those who are asleep, they nonetheless failed in follow-up questioning to correctly assert that individuals in a deep, dreamless sleep may not engage in “wondering,” “listening” and “self-reflection.”

How is one to account for children’s persistent attributions of various psychological capacities that simply and clearly do not exist – by definition – during deep, dreamless sleep? In other words, how do children come to posit, in a developmentally predictable fashion, the presence of nonexistent psychological functions for those who are in a deep, dreamless sleep – functions that they themselves have never experienced within this context, observed in others, or presumably been taught to exist? This question becomes even more perplexing in light of findings reported by Flavell, Green and Flavell (1993, 1995) that indicate a childhood propensity for gross *underestimation* of the amount of mental activity that occurs in *conscious* minds. Quite simply, children underestimate the amount of activity that occurs in conscious minds (where it would seem quite natural to posit an endless stream of conscious and consciously accessible mentation), and yet, in contrast, posit multiple forms of

consciousness dependent mentation in individuals who have been unambiguously identified as unconscious.

Flavell et al. (1999) suggested that a lack of recognition of the true nature of unconsciousness (as the lack of consciously mediated psychological experience) accounts for children's reports of continuity of conscious psychological activity during deep sleep. They further proposed that developmentally, early intuitions may characterize unconsciousness as a state in which only conscious perception of external phenomena is lacking, and only later, through subsequent development, as a state in which nonperceptual or "internal-perceptual" activities such as thinking, feeling and the capacity for reflective-consciousness cease to exist. They further suggested that the basis for this hypothetical developmental sequence may be accounted for by multiple factors, including: information gained from outside sources such as parents and the media; children's own observations over time; developments in meta-memorial capacity (e.g., Schneider & Borkowski, 1998); improved introspective capacity and other discoveries regarding the nature of conscious experience, e.g., that it contains a stream of consciousness and involves self-awareness (Flavell et al., 1993, 1995); and that stimuli cannot be processed without conscious awareness (Flavell et al., 1995). In other words, as knowledge is gained throughout development regarding the nature of conscious experience, the understanding that periods of nonconsciousness occur (as well as the nature of these periods) becomes easier to apprehend.

Theory of Mind and Death

An additional and perhaps even more potent context for assessing children's understanding of the "nonconscious mind" is death. Although this suggestion may at first

seem oxymoronic given the absolute cessation of all biological and psychological functions that define death, the cultural ubiquity, historic (and likely pre-historic) prevalence of afterlife beliefs is suggestive of the possibility of a naïve and implicit human propensity for the direct and untutored attribution of mental states to the dead (Bering & Bjorklund, 2004).

Bering and colleagues examined this possibility directly. For example, Bering and Bjorklund (2004; Experiment 3) presented 5- and 11-year-old children and adults a videotaped puppet story in which a juvenile, anthropomorphized mouse character takes a walk in the woods during which he is explicitly described as experiencing numerous mental states that correspond to the following experiential categories: 1) *psychobiological*, e.g., thirst; sleepiness; 2) *perceptual*, e.g., gustation, audition; 3) *emotion*, e.g., fear, anger; 4) *desire*, e.g., wanting to go home; and 5) *epistemic* experience, e.g., knowing that he is smarter than his brother. At the conclusion of the vignette, the mouse character is fatally “consumed” by a puppet alligator. Participants were subsequently questioned about the post-death status of the mental states that had been “experienced” by the protagonist just prior to death. They were also questioned regarding the post-death status of some basic aspects of biological functioning.

Despite the clearly articulated context of death, the results were nonetheless similar to those obtained by Flavell et al. (1999) for the context of sleep in that discontinuity reasoning was observed to emerge only gradually throughout development, both in relation to age and question category. Specifically, kindergarteners displayed the highest levels of discontinuity reasoning for the category of biological states, and lower and equivalent levels of discontinuity reasoning for all other categories (i.e.,

psychobiological, perceptual, emotion, desire and epistemic states, with the exception of higher reported discontinuity for perceptual questions than emotion or desire questions). Greater application of the discontinuity concept was observed for the two oldest age groups (late elementary and adult), in that both groups displayed high and statistically equivalent levels of discontinuity reasoning for the categories of biological, psychobiological, and perceptual questions and lower (and also equivalent) levels of discontinuity reasoning for the categories of emotion, desire, and epistemic functions.

The observation of gradualism in the development of discontinuity reasoning within this study (Bering & Bjorklund, 2004) is unlikely to be the result of confusion over the context (i.e., death) by the kindergarteners, for even they displayed relatively high levels of discontinuity reasoning for the biological questions, suggesting at least a basic mastery of the biological implications of death by this age. Previous research by Barrett (1999) similarly demonstrates attainment of a relatively coherent understanding of the biological implications of death by preschool age (at least within the context of predator/prey relationships, as was the case for this study by Bering & Bjorklund). Surprisingly, however, only 40% of the adult participants displayed fully consistent discontinuity reasoning across all question types – a finding that is unlikely to be an artifact associated with the personal philosophies or religious orientations of the adult participants of this study, as similar results have been observed for college-educated, self-proclaimed extincivists, (those who explicitly endorse the belief that death corresponds to the cessation of all life functions; Bering, 2002). Importantly, the general findings of Bering and Bjorklund have also been observed cross-culturally, as reported by Bering

Hernández Blasi and Bjorklund (2005) for samples of Spanish children of both public and Roman Catholic (religious private school) educational backgrounds.

An Additional Study of Theory of Mind and Sleep

Cormier (2005) conducted a study in which the methods of Bering and Bjorklund (2004, Experiment 3, described above) were essentially replicated, with the exception of modification of the narrative vignettes such that the protagonist character fell into a “deep and dreamless sleep” at the end of the stories (as opposed to dying) and the addition of one experimental subject age group (2nd/3rd grade). The two primary patterns of results of the study were highly similar to those of Bering and Bjorklund in that: 1) increased age was associated with increases in *overall levels* of discontinuity reasoning (i.e., averaged across all mental state types); and 2) the mental state categories of emotion, desire and epistemic functions were generally associated with lower levels of discontinuity reasoning (in comparison to psychobiological and perceptual functions) by late childhood (5th/6th grade), a pattern that was maintained into adulthood. These findings are important in that they support the generalizability of the findings of Bering and Bjorklund beyond the narrow context of death (to, at the very least, the context of sleeping agents, and perhaps, to all forms of nonconscious agents) and are also consistent with the findings of Flavell et al. (1999).

Evolutionary Psychology

Modern evolutionary psychology (e.g., Barkow, Cosmides & Tooby, 1992; Buss, 1995; Chiappe & MacDonald, 2005; Cosmides & Tooby, 2002; Cosmides & Tooby, 2005; Daly & Wilson, 1988; Ellis & Bjorklund, 2005; Geary, 2005; Pinker, 1997) is a relatively new but uniquely powerful discipline within the psychological sciences that

explores the psychology of humans (and other species) from a perspective that spans “deep time,” i.e., the evolutionary history of a species. Derided by many not so long ago (and still resisted in some quarters today) as an upstart, overreaching discipline, the current reality is that evolutionary psychology represents a true paradigm shift within psychology (Buss, 2005). Just as Darwin’s theories of evolution by natural and sexual selection (1859 and 1871, respectively) have resulted in the integration of all the various subdisciplines of biology under one, cohesive metatheoretical framework, evolutionary theory, as wielded by modern evolutionary psychologists, is currently producing a similarly unifying transformation within psychology and related disciplines (Bjorklund, Cormier & Rosenberg, 2005; Bjorklund & Pelligrini, 2002; Buss, 1995, 2005; Duntley & Buss, 2008; Ellis & Bjorklund, 2005).

Evolutionary psychology is based most fundamentally on the theory of evolution by natural (and sexual) selection as originally described by Darwin and subsequently expanded upon by others. These theories propose that the basic biological and psychological features of organisms have been produced and shaped over geological time by evolution in response to the evolutionarily recurrent challenges faced by members of a species to survival and reproduction (Darwin, 1859, 1871). Darwin’s basic argument is cogently summarized by Gaulin and McBurney (2004): 1) natural populations, if left unchecked, could grow exponentially; 2) despite this potential for exponential growth, natural populations nonetheless are observed to remain at relatively stable levels; 3) many individual members of a species do not produce as many offspring as is theoretically possible; 4) individuals that are the most well adapted to their environments tend to leave the most offspring; 5) due to heredity (which was clearly recognized but remained

unexplained in Darwin's time), offspring tend to resemble their parents both biologically and psychologically; 6) over time and across many generations, natural selection produces individuals that are well adapted to their environment (i.e., individuals that are relatively well-suited to the tasks of survival and reproduction).

A critical assumption of modern evolutionary psychology is that the human mind did not evolve to function as a domain-general information processor and problem solver, but rather, as a collection of relatively domain-specific (modular) information processing mechanisms (Buss, 1995; Fodor, 1983; Pinker, 1997; Symons, 1995; Tooby & Cosmides, 1990, 1992, 2005) that emerged in response to evolutionarily recurrent problems (e.g., food acquisition, predator avoidance, mate selection, face recognition) faced by our ancestors in the environment of evolutionary adaptedness, i.e., the statistical aggregate of the evolutionary environments encountered by our species throughout its history (Tooby & Cosmides, 1992). This framework explicitly rejects the perspective almost universally endorsed within the social sciences throughout most of the 20th century which assumed a largely or almost exclusively domain-general mind that used the same information processing routines to solve all information processing demands (Tooby & Cosmides, 1992). Critically, a wealth of findings amassed within developmental and evolutionary psychology within the last few decades supports the claim for a large number of domain-specific adaptations within the human mind (see Buss, 2005, 2009).

Important but contested refinements to the relatively "canonical" tenets of evolutionary psychology, as just briefly described, above, and coming primarily from developmentalists, have included an increased recognition of the hierarchical nature and range of domain-specificity displayed by evolved cognitive mechanisms, including the

existence of some relatively domain-general mechanisms (see Bjorklund & Ellis, in press; Bjorklund & Pelligrini, 2002; Bjorklund & Rosenberg, 2005; Chiappe & MacDonald, 2005; Geary, 2005; Geary & Huffman, 2002; Geary & Bjorklund, 2000), as well as the “probabilistic” nature of all aspects of development, including the development of evolved cognitive mechanisms (Bjorklund, Ellis & Rosenberg, 2007). Although these proposals have been rejected by some as inconsistent with the more canonical modular perspective, these objections have been successfully rebutted (e.g., Bjorklund, et al., 2007).

Evolutionary Implications of Theory of Mind as Applied to Nonconscious Agents

As described above (see “Theory of Mind Applied to Nonconscious Agents”), humans display what may at first appear to be a very strange and persistent propensity for positing continuity of mental state functioning beyond the threshold of death and sleep (Bering & Bjorklund, 2004; Bering et al., 2005; Cormier 2005; Flavell, Green, Flavell et al., 1999), with acquisition of the discontinuity concept (i.e., the understanding or perception that some or all mental states cease with transition to nonconsciousness or death) occurring only gradually throughout development and remaining incomplete for a significant proportion of college educated adults - especially for emotion, desire, and epistemic states. These findings suggest two important questions: 1) why do humans, in developmentally regular fashion, intuit continuity of mental states beyond death (or other forms of nonconsciousness, such as sleep); and 2) why are people more prone to do this for some states, such as emotions, desires and epistemic states, than for others, such as perceptual and psychobiological states (e.g., sickness, tiredness, hunger) states?

Error Management Theory and Living/Dead Discrimination

Haselton, Buss, and DeKay (1998; see also Haselton & Buss, 2000) proposed an evolutionary psychological theory of error management which claims that evolved psychological mechanisms whose function is to make judgments under conditions of uncertainty are likely to be “designed” by evolution to be predictably biased when making judgments within domains for which the costs of various errors (false positives/Type I and false negatives/Type II) were asymmetrical, on average, across evolutionary history. This is because a decision-maker cannot simultaneously minimize both kinds of errors. Minimizing the chances of making one kind of error necessarily increases the likelihood of the other (Green & Swets, 1966).

In most kinds of psychological research involving hypothesis testing, for example, false positives (Type I errors) are usually considered more costly and undesirable than false negatives (Type II errors). Consequently, research psychologists bias their use of inferential statistics to reduce the probability of false positives to an acceptable level with the result that the probability of false negatives is necessarily increased. One can easily imagine, however, that in different research contexts, such as research on potential new drug therapies for a medical condition, that investigators may choose to bias their statistics in favor of increasing the risk of false positives (Type I errors) in order not to mistakenly reject potentially effective treatments by virtue of false negatives (Type II errors). Human engineered warning systems (such as fire alarms) are also biased in this direction (Haselton & Buss, 2000) because the costs of even one missed fire is generally greater than that of even many false alarms. Therefore, even though biases of the types

just described (whether of human or evolutionary “design”) might increase the overall error rate, the net effect should nonetheless reduce overall costs (Haselton & Buss, 2000).

Barrett and Behne (2005) suggested that the difficulties (uncertainties) associated with discriminating between living and dead agents have posed error management problems throughout the evolutionary history of our species. As Boyer (2001) has pointed out, death presents perceptual and conceptual impediments to a straightforward understanding of this unique phenomenon. Perceptual challenges follow from the fact that the transition from life to death may occur within moments and is often perceptually difficult to detect, as well as the fact that living and dead organisms share many perceptual features. Conceptual difficulties follow from the fact that death represents one of the few circumstances in which an organism crosses a major ontological boundary, in this case from “living things” to “non-living things” (Boyer, 2001; Barrett & Behne, 2005). Additional conceptual difficulties appear to be the result of (what appear to be) species universal cognitive biases, such as those that preserve attribution of mental state functions to deceased and sleeping agents (Bering & Bjorklund, 2004; Cormier, 2005; see “Theory of Mind Applied to Nonconscious Agents,” above).

That the development of a complete understanding of death (i.e., that it entails the cessation of all biological and psychological functions) is difficult (especially for children) has been well-established (Bering & Bjorklund, 2004; Carey, 1985; Nagy, 1948; Piaget, 1929; see Slaughter, Jaakkola, & Carey, 1999 and Speece & Bent, 1984, 1996 for reviews). Barrett and Behne (2005) and Barrett (2005) argue that the evolutionary ubiquity and relevance to fitness (in the evolutionary sense) of encounters with potentially deceased creatures has likely led to the evolution of cognitive

mechanisms that are specifically designed to make the living/dead distinction. Moreover, they argue that the ambiguity and uncertainties associated with these encounters, as well as error management constraints (that follow from the asymmetric nature of costs associated with false positives and negatives in these contexts), should have produced a system that is predictably biased in favor of false positives (i.e., mistakenly assuming an organism is alive when in fact it is not).

As Barrett and Behne (2005) and Barrett (2005) correctly point out, the inability to reliably distinguish between living and deceased agents would have resulted for our ancestors in either lost opportunities and wasted resources on one hand (in response to false positives), or in potentially dangerous or fatal risks on the other (in response to false negatives). Consider the case in which an otherwise potentially dangerous animal is incorrectly determined to be alive when it is in fact, dead (false positive). In this case, one may unnecessarily avoid this creature, thereby missing out on opportunities to harvest foodstuffs (meat, internal organs) and other valuable materials for tool-making, trading, self-adornment and gifting (e.g., bones, ligaments, hides, etc.), as well as wasted time and precious metabolic resources in maintaining unnecessary vigilance and avoidance (e.g., climbing into a tree and hiding for an extended period). Although this kind of error is potentially costly, its costs should pale, nonetheless, on average, in comparison to the converse error, i.e., a false negative.

In the event of a false negative, in which one incorrectly determines that a potentially dangerous animal is deceased when in fact it is alive, one may be likely to ill-advisedly approach the animal to harvest it in the manner described above (or simply fail to maintain a safe distance or approach with the proper caution), and thereby risk serious

injury or death as a result of an unanticipated predatory or defensive attack. Therefore, on average, false negatives (incorrectly determining that a living organism is dead) will have been much more costly than false positives (incorrectly assuming that a deceased creature is alive) to our ancestors. The most beneficial outcomes result (on average) of course, when correct determinations are made.

Barrett and Behne (2005) examined patterns of inferences about sleeping and dead organisms by German and Shuar (indigenous population of the Ecuadorian Amazon) children between the ages of 3 and 5 years. The German sample included city-dwelling individuals whose experience with animals was limited essentially to those encountered as pets, in zoos, and in electronic media (TV, movies, etc.). The Shuar sample was of hunter-horticulturalist society who lived in a rural forest environment in which animals were frequently encountered and hunted in the wild. The pattern of results revealed a single developmental trajectory – displayed within both samples – in which children, by 4 years-of-age, come to understand death in terms of cessation of agency (i.e., that an organism is no longer capable of engaging in goal-directed action) and that causal cues to death (such as dismemberment and cooking) but not sleep, elicit inferences of cessation of agency. The authors interpret these results as supporting their hypothesis of a cross-culturally universal living/dead discrimination mechanism that exists as a reliably developing aspect of core cognitive architecture.

Given the previously discussed error management constraints that such a system must frequently work under (i.e., frequent uncertainty and asymmetric costs of false positives and false negatives), the proposed system is unlikely to be calibrated to make strictly veridical determinations. Consequently, Barrett and Behne suggest that the

cognitive “switch” associated with remapping an object from the ontological category of “Animate Object” (living animal) to “Biological Substance” (deceased animal) will be “sticky,” i.e., that the agency system will be tuned to be “skeptical” of the occurrence of such transformations. Therefore, an agency detection system of this type should only very weakly trigger death inferences in the case of a mere lack of cues to agency (e.g., lack of movement) and should instead rely on cues that are more reliably associated in a causal manner with death, e.g., disruption of the body envelope, dismemberment, etc. In short, the system should be expected to be somewhat biased in favor of false positives (“it’s alive”).

Error Management Theory and Intentional Persistence

Cormier (2005) suggested that one of the proximal means by which the agency detection system (or, more specifically, the living/dead discrimination mechanism) may maintain the “stickiness” of the switch that remaps living objects (Animate Object) to deceased (Biological Substance) is be the bias towards continued attribution of consciously mediated mental state functions to animals that are either no longer fully conscious (Cormier, 2005; Flavell et al., 1999) or even explicitly identified as or observed to be apparently deceased (Bering & Bjorklund, 2004; Bering et al., 2005; see the section entitled “Theory of Mind Applied to Nonconscious Agents” above). Continued implicit attribution of mental states to organisms of ambiguous agency status (e.g., lying still with eyes closed) serves to maintain one’s vigilance at extremely high levels when approaching or interacting with such organisms. One would, in effect, be ready to respond very quickly and intensely, if necessary, to any species-typical, unexpected or potentially threatening behaviors (e.g., predatory or defensive attack,

startle response). One would also be prepared for organism-specific “expected” behaviors, such as continued intense kicking from a giraffe that was observed to display these behaviors just prior to being felled by a spear during the hunt.

The net effect of an agency detection system (Barrett, 2005) that functions in the manner proposed here is one of heightened behavioral preparedness and reduced overall personal costs (on average) associated with encounters with animals of ambiguous agency status. The fact that one may consistently experience unrealistic ideas about the mental state functioning of deceased or sleeping animals or human individuals, such as “Yea, you always love your Mom, even when you’re dead” (see Bering & Bjorklund, 2004; Bering et al. 2005; Cormier, 2005; Flavell et al., 1999), is essentially irrelevant from an evolutionary perspective. Therefore, although an agency detection system biased in the manner proposed here will display dramatically increased overall error rates in the form of false positives (Type I errors as evident in attributions of continued mental state functioning in organisms that are dead, for instance), it should nonetheless reduce the average costs (in the form of reduced rates of injury and death) experienced in encounters with animals of ambiguous agency status.

An experience from my youth demonstrates the simplicity of these ideas: My Uncle Sonny, a lifelong and avid hunter brought a kill (buck) home that was left in the garage for a day before being hung and gutted in preparation for subsequent consumption. Despite my having a clear-eyed understanding of physical death by this age (approximately 7 years) as a result of many previous encounters with my Uncle’s kills as well as the typical developmental accretions to biological knowledge concerning death that accrue by this age (Atwood, 1984; Barrett, 1999; Evans, Poling & Mull, 2001; Lazar

& Torney-Purta, 1991; Slaughter, Jaakola & Carey, 1999; Speece & Brent, 1984), my same-aged cousin and I found it almost impossible to walk anywhere near or even in the same general area (garage) as the carcass. Our fears prompted us to continuously dare each other to walk by, or even to touch the carcass, if we could. It took a full day for either of us to work up the courage to be able to quickly run by, but not touch or even stand near (i.e., within “striking distance” of) the carcass. Our fears were not about disgust (Rozin & Fallon, 1987; Rozin, Lowery, & Ebert, 1994), but rather, that the buck might suddenly spring to its feet and pursue us, perhaps bent on vengeance for its murder, or at least in desperate, wild efforts to fight for its life and freedom. In other words, we continued to implicitly experience the buck as an intentional agent despite having been clearly informed, having observed for ourselves, and intellectually recognizing that it was absolutely and unambiguously dead.

Although clearly irrational from the common-sense point of view, our responses and fears make great sense from an evolutionary perspective informed by error management theory (Haselton & Buss, 2000). Our fears primed us to be able to immediately and powerfully respond to any sudden action or movement on the part of the buck with immediate and almost unthinking flight on ours. Our responses were also consistent with the findings of Barrett and Behne (2005) who reported that mere lack of cues to agency (i.e., lack of movement) were insufficient to block attributions of agency. Interestingly, although my cousin and I did observe some causal cues to death (e.g., bullet entry wound to the neck and some blood around the wound site), we remained quite excited and fearful around the carcass. This is presumably because the observed neck wound and observed lack of motion were perceived as insufficiently reliable cues to

death (after all, the neck injury might have only have been a “flesh wound”). Something more substantial and reliable, such as being cooked or more significant interruption of the body envelope (e.g., decapitation) was required to trigger more complete and implicit death inferences; and this , in fact, was provided late in the afternoon of the second day, at which time the buck was hung by its ankles from a tree and gutted. At that point, my cousin and I could approach the carcass without fear but nonetheless remained at some distance due to onset of a disgust response (Rozin & Fallon, 1987; Rozin et al., 1994) elicited by the sight of the exposed, uncooked flesh and viscera. It is also telling that it was the “securing” of the motionless buck (which occurred when it was hung by its rear heels) that elicited feelings of personal security in its presence and the additional, implicit sense that it had at last been drained of all potential for feeling or action.

Importantly, the bias towards continued attribution of mental state functioning beyond the threshold of death or unconsciousness does not extend with equal force to all mental states. It is most evident for emotions, desires and epistemic states (as compared with psychobiological and perceptual states; Bering & Bjorklund, 2004; Bering, Blasi et al., 2005; Cormier, 2005) - mental states that Cormier (2005) suggested are closely linked to inferences about an organism’s intentionality. Although this proposed link (between emotions, desires and epistemic states on one hand, and global perceptions or intuitions about an organism’s intentionality, on the other), has not been empirically demonstrated, consider the following hypothetical scenario:

An individual reports that he is experiencing a migraine of such overwhelming intensity that natural light, low-level background noise and other typical perceptual stimuli give rise to the acute nausea and physical pain associated with this kind of

headache (psychobiological experience). You observe this person as he hurriedly trots indoors, lower the thermostat to 60°F, and goes into his bedroom where he closes the blinds and desperately duck under the covers. Although one would be generally correct in *explicitly* and intuitively interpreting these behaviors in terms of perceptual and psychobiological factors, the *implicit* theoretical functioning of your theory of mind system (see Gopnik & Wellman, 1994 for a description of the development of belief-desire reasoning referred to as theory of mind or “ToM”) would nonetheless have presumably processed this individual’s behavior in terms of the more fundamental states of emotion, desire and belief/knowledge. In other words, it would presumably attribute the observed actions in terms of a *desire* to run into the room, fueled by the intensity of the *emotional* experiences of desperation and fear, and in response to the *belief* that some measure of relief may be had by heading indoors to decrease perceptual stimuli to the lowest possible levels by turning down the thermostat, closing the blinds and ducking under the covers. In short, emotions, desires and epistemic (knowledge/belief) states appear to be the primary drivers of the ToM system, especially with regard to predicting the intentional states of organisms, whereas psychobiological experiences (e.g., migraine headache) and perceptual experiences (e.g., painfully bright sunlight) appear to serve as important predictors of these states.

In summary, Cormier (2005) proposed that the continued attribution of emotion, desire and epistemic contents, or, as in his proposed shorthand, *intentional persistence*, to an organism that appears inactive (as in the cases of sleep, death, hibernation, feigned death, injury, hypothermia, etc.) represents the safest course, from an error management perspective, in dealing with such creatures. Given the evolutionary ubiquity of such

encounters, as well as the extreme error management constraints on average outcomes, the evolution of this, and perhaps other, similarly oriented biases should not be surprising.

One such similarly oriented bias has been proposed by researchers working on the cognitive foundations of religion. Barrett and colleagues and others (Atran, 2007; Barrett, 2000; Barrett, 2001; Barrett & Keil, 1996; Barrett & Zahl, 2013; Guthrie, 1980; Guthrie, 1993; Guthrie, 2001; Lawson & McCauley, 1990), for example, have proposed the existence of what has been referred to as the “hyperactive agency detection device(s)” (HADD) or, similarly, a bias towards the anthropomorphism of nature, as a fundamental aspect of belief in supernatural agents. According to such proposals, humans display hypersensitivity towards perceiving human-like agency in the environment and are more likely to do so when data are sketchy or ambiguous. The evolutionary basis of this bias is very similar to that proposed for intentional persistence, namely, that, on average, the costs associated with failing to detect the presence of an actual agent are much greater than that associated with mistakenly perceiving an imagined agent. Consider, for example, that you are walking down a dark, quiet alley late at night. You suddenly hear some unexpected scuffling not far behind you. Your immediate internal reaction of “Oh, my God! There is somebody running up behind me!” can be extremely adaptive, especially if you are correct in your inference. If, on the other hand, you startle and turn only to discover that the wind has stirred a paper bag amongst some leaves, no harm is done. It is quite possible that hyperactive agency detection will prove, over time, to consist of an array of distinct but related cognitive biases, among which intentional persistence may be generally included.

An interesting implication of the current line of reasoning about intentional persistence is that it is likely to be more pronounced for creatures that are perceived as potentially predatory or relatively dangerous (e.g., a lion, buck, or wild boar) in comparison to those that are substantially less so (e.g., a sheep, rabbit, dairy cow, farm-raised pig). More specifically, children of various ages and adults should be more likely to infer continuity of relevant or previously occurring mental states (i.e., various emotions, desires and epistemic contents), subsequent to death or the onset of unconsciousness (e.g., a deep and dreamless sleep), for potentially threatening or predatory creatures than for those who are perceived as substantially less so. The testing of this hypothesis forms one of the important bases for the current study.

The current study is also distinguished by another important feature. Unlike previous research in this area (e.g., Bering & Bjorklund, 2004; Bering et al., 2005; Cormier, 2005; Flavell et al, 1999), which required participants to reflect on the mental states of highly anthropomorphized, essentially “human,” “Little Mouse” characters (as in the studies by Bering & colleagues, and Cormier), or the human child characters used in the studies by Flavell et al., the current study provides the first known study of the development of reasoning about the mental states of recently deceased animal characters engaged in ecologically relevant actions. Although the characters in the current study are intended to represent “true” animals, as opposed to fully anthropomorphized and essentially “human” animal characters, it is nonetheless true that humans respond to animals through an undeniably anthropomorphic perspective. Given the well-established human tendency to anthropomorphize nonhuman animals, a brief consideration of some of the literature on this topic is warranted.

Anthropomorphism

Dennett (1987) proposed that both children and adults take the “intentional stance” in their attempts to understand the behavior of people and animals (intentional agents or simply, “agents”), i.e., that they implicitly assume that behaviors can be explained and predicted on the basis of unobservable internal mental states (e.g., beliefs and desires) that bear a direct relationship to goal states (intentions). This view has been widely adopted by psychological researchers. Although currently and more commonly referred to as “theory of mind” (see “Theoretical Accounts of Developing Understanding of the Mind,” above), some researchers, such as Barrett (2005) use the somewhat broader term, the “agency system,” to refer to the inferential procedures used to make inferences about intentional agents.

There is some evidence that the ability to generate intentional schemas about agents is present as early as infancy (e.g., Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Gergely, Nadasdy, Csibra, & Biro, 1995). Gergely et al. (1995), for example, used a dishabituation paradigm in which 9-month-old infants were habituated to the sight of two balls contingently contracting and expanding in “response” to one another just prior to one approaching the barrier that separated them and jumping over it to reach the other. Although the infants in this study did not subsequently dishabituate in response to seeing one ball approach the other in a straight line when the barrier had been removed (a path of movement they had not seen previously), they did dishabituate (i.e., show surprise as indicated by longer looking times) in response to seeing one ball display the previously seen jumping motion when no barrier was present. The authors interpreted these findings as indicating the presence and activation of a social “approach schema” by infants in

which they expect that an agent will take the shortest path in attempting to make contact with another agent (in this case to reach the other ball). There is no reason to assume that this is the only intentional schema possessed by infants. Csibra, Gergely, Biro, Koos and Gergely (2003), for example, have demonstrated the existence of an early-developing “pursuit-evasion” schema that, as suggested by Barrett (2005), may represent the beginnings of the development of understanding of predator-prey relationships. (See Scholl & Tremoulet, 2000 for additional examples of likely intentional schemas.)

Importantly, multiple theorists have suggested that intention-related schemas and intuitive theories (such as theory of mind) are likely to have evolved to guide understanding and prediction of not only human behavior, but also that of animals (i.e., all agents), a proposal that casts the concept of “anthropomorphism” in a new light. As typically used, “anthropomorphism” refers to an interpretation of what is not human or personal in terms of strictly human or personal characteristics (especially human behavioral or psychological characteristics). This occurs in many contexts but is observed very frequently in human attempts to understand animal behavior (Barrett, 2005; Guthrie, 1993; Mitchell & Hamm, 1997).

Although often considered an “error” in the technical sense, it is widely recognized that so-called anthropomorphism can be quite useful. For example, Hebb (1946) noted that scientists who used anthropomorphic terms to describe chimpanzee behavior (as opposed to more “scientific” behavioral descriptions) were frequently more successful at predicting chimpanzee behavior. Similarly, Pinker (1997, p. 63) claimed that intuitive psychology remains the most useful and complete science of behavior, a sentiment echoed by German and Leslie (2000, p. 230) in their statement that several

generations of the best scientists have added relatively little to the ideas effortlessly grasped by all 4-year-olds in this domain. None of this should be particularly surprising, for as Barrett & Behne (2005) pointed out, the intentional stance (including theory of mind) exists as a core part of cognitive architecture in order to make predictions about the behaviors of living things. It makes sense that children and adults would spontaneously apply this apparatus in their efforts to understand animals and actually be more successful in doing so than those who limit themselves to more rigorously scientific and “objective” notions and language.

These observations have been made many times in the anthropological literature as well (Blurton Jones & Konner, 1976; Liebenberg, 1990; Mithen, 1996). As Mithen (1996, p. 168), points out, anthropomorphism is observed universally among modern hunters and substantially improves the prediction of animal behavior. Moreover, improved behavioral predictions occur despite the fact that animals are unlikely to “think about,” for example, their foraging and mobility patterns in the same ways as the humans who hunt them.

It is also true, however, that people (and especially children) often display what is clearly an overextension of the intentional stance, as in Piaget’s (1954) observations of childhood animism (seeing agency in the world where it doesn’t exist) and in Keleman’s (1999) observations that children extend teleological reasoning (which she argues is derived from their understanding of intentionality) to everything from clocks, tigers, clouds, and dog tails (“They exist so that dogs can wag them!”). The observation that people (and most typically children) display inaccurate extensions of the intentional stance to nonagents does not detract from the notion that evolved human psychological

architecture is likely to be designed to understand and predict the behaviors of agents (and not just humans) in terms of intentionality. In fact, the former (overextension of the intentional stance) may occur as an evolved byproduct of the latter, or, as argued by Guthrie (1993), is likely to be what I will describe as a co-occurring adaptation that evolved to manage error risk (in the sense proposed by Haselton, Buss & DeKay, 1998) in response to the potentially threatening presence of agents. An error of this type would occur, for instance, in immediately perceiving that the scuffling sound that occurs behind you in the dark is the result of human footsteps as opposed to the reality of it being caused by the movement of blowing leaves.

Current Study

The current study was designed to accomplish two primary goals: 1) to determine if the previously reported developmental patterns of reasoning about the functioning of mental states subsequent to death (and sleep) for humans and highly anthropomorphized animal characters will generalize to “true” animals; and 2) to provide a partial test of the theory that intentional persistence represents an evolved cognitive heuristic that guides understanding and responses to animals and humans of ambiguous agency status (as previously described). Given the theoretical perspective that intuitions about the continuity of mental states beyond the threshold of nonconsciousness represents the functioning of a system designed to maintain vigilance and behavioral readiness in the presence of entities whose agency status is perceptually ambiguous, the design of the current study rests on the logical inference that potentially threatening animals (and humans) will be likely to elicit lower levels of discontinuity reasoning by subjects

(especially for emotions, desires and epistemic states, *a la* intentional persistence) as compared to nonthreatening animals.

The degree of threat associated with a given animal type can presumably be the result of one or more dimensional or categorical factors. Dimensional factors include characteristics such as size, strength, speed, aggressiveness, degree of tameness, etc., with animals that are relatively large, strong, quick, aggressive, and wild posing a relatively greater threat than those possessing lower degrees of these characteristics. Categorical factors can include specific characteristics such as the presence (or lack) of sharp teeth and/or claws, or membership in a particular class, e.g., the classes of predator and nonpredator, or pack and solitary hunting types. Other less concrete or less immediately salient characteristics, such as general familiarity or degree of real-life exposure, or likelihood of an actual encounter (in either current or early environments), may also be relevant as assessed either consciously, or (unconsciously) by cognitive mechanisms designed to identify threat-level in the event of an actual or potential encounter with a particular creature. Given the interest for the current study in comparing responses to relatively threatening vs. nonthreatening animals, animals that display presumably large and highly salient differences in potential threat were chosen from the classes of predator and nonpredator. Importantly, previous research has demonstrated significant differences in the cognitive processing of mental state information in response to whether the task involved assessing mental states in the contexts of predator-avoidance or playmate-avoidance (e.g., Ellis, King, Csinday, Grotuss & Bjorklund, 2011; Keenan & Ellis, 2003)

The basic design of the current study is derived in straightforward fashion from Bering and Bjorklund (2004, Experiment 3) with two primary exceptions: 1)

experimental participants reported on the post-death continuity (or discontinuity) of mental states for realistic (but fictional) threatening and nonthreatening animals; and 2) as in Cormier (2005), an additional age group (2nd/3rd grade) was included. Predictions were as follows: 1) relatively high levels of discontinuity reasoning will be consistently observed for biological states, across both age and question type; 2) consistent with previous studies (e.g., Bering & Bjorklund, 2004; Cormier, 2005) it was expected that increased age will be associated with increased levels of discontinuity reasoning across all mental state types; 3) with increasing age, levels of discontinuity reasoning for emotions, desires and epistemic states will become increasingly distinct from and lower than that observed (within-age) for perceptual and psychobiological states; and 4) discontinuity reasoning for emotions, desires and epistemic states will be lower for the predatory, threatening animals as compared to the nonpredatory, nonthreatening animals for all age groups above preschool/kindergarten. Multiple child age groups were included in this study in order to: 1) replicate previous findings establishing the emergence of intentional persistence as a legitimate developmental phenomenon; and 2) identify the point of emergence of differences (in intentional persistence) that are predicted to be displayed in response to predatory and nonpredatory creatures, respectively

METHOD

Design

Participants viewed a video vignette conveying the actions and experiences of either a predatory or nonpredatory animal. Discontinuity reasoning following the “death” of the animal was investigated in a 4 (Age: Kindergarten vs. 2nd/3rd grade vs. 5th/6th grade vs. Adults) x 2 (Predatory status: predator vs. nonpredator) x 6 (Question-type: biological vs. psychobiological vs. perceptual vs. emotion vs. desire vs. epistemic) design, with repeated measures on the Question-type factor. To support generalizability, two vignettes featuring a predatory main character (Lion, Wolf) and two vignettes featuring a nonpredatory main character (Zebra, Sheep) were used. To additionally support generalizability, two different sets of items for each mental state type (psychobiological, perceptual, emotion, desire and epistemic) were also used.

Participants

Two hundred and fifty-four participants, divided into four age groups (matching those used by Cormier, 2005), participated in the study: 1) 63 preschool/kindergarten children, (34 boys, 29 girls), mean age = 5 years, 6 months (range = 3 years, 11 months to 6 years, 6 months); 2) 60 2nd/3rd graders, (36 boys, 24 girls), mean age = 8 years, 9 months (range = 7 years, 7 months to 10 years, 0 months); 3) 66 5th/6th graders, (33 boys, 33 girls), mean age = 11 years, 9.7 months (range = 10 years, 6 months to 13 years, 8 months); and 4) 65 adults, (34 males, 31 females), mean age = 19 years, 7 months (range = 18 years, 7 months to 25 years, 4 months). Juvenile participants were recruited from

two university-affiliated schools (elementary and preschool) in a suburban metropolitan area of South Florida with enrollment at the elementary school (K-8) based on community lottery, and enrollment at the pre-school based on open application. Adult participants were recruited from the Psychology Department subject pool (derived from the undergraduate General Psychology course) at Florida Atlantic University in Boca Raton, FL. The participation of adult participants was voluntary, but counted towards fulfillment of research participation obligations placed upon all students enrolled in the General Psychology course. Although not measured, a high and desirable degree of racial, ethnic and socioeconomic diversity was observed within participant groups.

Materials and Procedure

All participants were tested individually in a single session. Children were removed from either their classroom or aftercare program and accompanied by an investigator to a private testing room located in the school library. The experimental procedure was explained in age-appropriate language and verbal assent for participation was obtained prior to commencement with testing. Adults were tested in a room within the investigator's suite of laboratory offices, and were informed that although the experiment was designed to be manageable for children, the experimenter was also interested in the responses of adults.

Stimulus materials consisted of four brief (just under three minutes) videotaped animal stories, four 8" x 10" full color animal photographs (see Figure 1), and 12 questionnaires. Each of the four video vignettes (see Appendix A for two of the four vignette narratives) depicted the experiences of either a threatening, predatory creature (wolf or lion) or benign, nonthreatening, nonpredatory creature (sheep or zebra) acting in

relation to another creature that was needed to fulfill the requirements of the narrative. Individual sets (within the vignettes) consisted of a desk surface covered with a simple, single color cloth and small craft store set pieces (e.g., blue piece of foam corresponding to a river, small plastic green trees, and a synthetic cotton-like substance for snow) and characters were represented by small but realistic plastic toy figures. Character manipulation was conducted by a woman whose torso and arms were within view and narration was provided by an off-screen male voice. The four photographs presented images of real animals that individually corresponded to one of the four vignette protagonists (wolf, lion, sheep, and zebra). The sheep and zebra photographs presented close-up, benign facial images. In contrast, the wolf and lion photographs presented close-up images of threatening facial expressions (snarling, roaring) and were intended to be frightening.

Each of the video vignettes explicitly conveyed, via narration accompanied by manual character manipulation, the physical and psychological experiences of a protagonist character who was engaged in ecologically relevant actions, e.g., hunting prey (wolf, lion) or benignly seeking “greener pastures” (sheep, zebra) just prior to experiencing a fatal accident (e.g., drowning in the river), which was also depicted. All four narratives explicitly conveyed two specific mental state experiences for each of the following five mental state category types: psychobiological, perceptual, emotion, desire, and epistemic. To support the validity and generalizability of conclusions, two different sets of specific experiences for each of these five experiential categories (psychobiological, perceptual, emotion, desire, epistemic) were employed: the lion and zebra narratives used the experiences in “Set 1” (e.g., the psychobiological experiences in

this set were “sore” and “sick”) and the wolf and sheep narratives used the experiences in “Set 2” (e.g., the psychobiological experiences in this set were “sleepy” and “hungry”) See Appendix A for the specific mental state items associated with Sets 1 and 2, and for the narratives and corresponding questions for each animal character (Lion, Wolf, Zebra, Sheep).

The experimental procedures consisted of informing participants that they were going to be presented with a photograph and brief video vignette and subsequently asked a series of questions about the story. Once child assent or adult consent was obtained, each participant was immediately presented with two consecutive viewings of one of the four (randomly assigned) vignettes. Each presentation of the vignette was accompanied, near the beginning, by a brief presentation of the corresponding animal photograph. Participants were then asked a series of 12 standardized questions intended to elicit and briefly explore reasoning about the likely continuity or discontinuity of each the 10 individual psychological state experiences explicitly attributed to the protagonist character (e.g., for the perceptual experience of audition, “Now that the Lion is no longer alive, do you think Lion can hear the birds singing?”), as well as two that corresponded to implicit biological functions (e.g., “Now that the Lion is no longer alive, do you think Lion will ever need to drink water again?”). Experimenters responded to initial answers (which were almost invariably a straightforward “yes” or “no”) with a conversationally natural, non-leading verbal acknowledgement (e.g., “Okay” or “Alrighty”) and then a single, non-leading justification probe (e.g., “How come?” or “Why?”). (See Appendix A for all four video vignettes and corresponding question.) The answers to all questions were both manually and (if approved by both parent and child) electronically recorded by

the experimenter. The overall length of the test procedure was approximately 15 – 20 minutes.

Coding

All responses were transcribed by a research assistant and then coded by the first author and second coder. Answers to all individual questions for each participant were coded to reflect the presence of either *continuity* or *discontinuity* reasoning. Continuity reasoning was inferred when participants provided a reasonably clear assertion (operationally defined) that a particular function (mental state experience or biological function) continued beyond the death of the protagonist (e.g., Question: “Now that the Lion is no longer alive, do you think Lion can hear the birds singing?” Response: “Yea. He can still hear them because they were right by him.”). Discontinuity reasoning was inferred in response to a reasonably clear assertion (operationally defined) that a particular function (mental state experience or biological function) ceased in response to the death of the protagonist (e.g., “No, because he’s dead.”). Coding relied on assessment of both initial response (“yes” or “no”) and the subsequent justification provided. In cases where a reasonably clear determination of the presence of either discontinuity or continuity reasoning can not be inferred, or where a response was not provided, items were coded *unscorable*. Initial inter-rater reliability for response codes was 93.46%, and all initial discrepancies between codes for specific responses were resolved through subsequent discussion and evaluation of each discrepant item.

RESULTS

Preliminary Analyses

The criterion for significance for all statistical tests reported in this study is $p \leq .05$ unless stated otherwise. All reports on effect size are based on measures of Partial eta squared. Due to the robustness of analysis of variance methods for nonrepeated measures factors, no transformations were effected upon the data in response to significant results for the Levene test of the assumption of homogeneity of variance. For analyses that displayed a significant result for Mauchley's test of the assumption of sphericity, the results are reported using the Huynh-Feldt correction of degrees of freedom, and F - and p -values. Unless otherwise stated, post hoc analyses used the method of Bonferroni-correction to manage Type I error risk. Five subjects (out of 257, i.e., 1.9%), all within the youngest age group, whose responses clearly indicated lack of comprehension (e.g., a majority of nonresponses, providing justification of initial "yes" or "no" answers in the form of numbers) were excluded from the analysis.

Two measures were generated that summarized each participant's responses for each question type (biology, psychobiology, perception, emotion, desire, and epistemic): 1) percentage discontinuity of all scoreable responses; and 2) percentage discontinuity of all responses. All reported statistical tests used *percentage discontinuity of all scoreable responses* for the various dependent measures as no differences in the overall pattern of results between "scoreable responses" and "all responses" on analyses of primary interest were revealed during preliminary analyses. A preliminary analysis indicated no

significant effect attributable to sex, so all subsequent analyses were collapsed across this factor.

Predatory Status

Table 1 and Figure 2 presents mean percentage discontinuity responses by age and question type for the participants in the predator and nonpredator conditions. These data were analyzed in a 6 (Question Type) x 4 (Age Group) x 2 (Predatory Status) ANOVA with repeated measures over the Question Type factor. As predicted, the main effect for Question Type was significant, $F(3.65, 882.28) = 119.98, p < .001$, effect size = .331, as was the main effect for Age Group, $F(3, 242) = 40.38, p < .001$, effect size = .334. Contrary to initial predictions, the main effect for Predatory Status was nonsignificant, $F(1, 242) = .299, p = .585$, effect size = .001. Pairwise comparisons on question type revealed: biological > psychobiological, perceptual, emotion, desire, epistemic; psychobiological = perceptual, and psychobiological > emotion, desire, epistemic; perceptual > emotion, desire, epistemic; emotion = epistemic, and emotion > desire; and desire = epistemic. Pairwise comparisons on the age factor revealed: Pre-K/K < 2nd/3rd, 5th/6th, Adult; 2nd/3rd = 5th/6th, and 2nd/3rd < Adult; 5th/6th < Adult.

Two interactions were also significant: Question Type x Age Group, $F(10.94, 882.28) = 4.83, p < .001$, effect size = .057, and the Question Type x Predatory Status, $F(3.65, 882.28) = 4.50, p = .002$, effect size = .018. The three-way interaction (Question Type x Age Group x Predatory status), $p = .331$, and Age Group x Predatory Status interaction, $p = .404$, were nonsignificant.

Question Type x Predatory Status

Subsequent inspection of the significant Question Type x Predatory Status interaction contrasted performance between participants in the predator and nonpredator groups, separately for each question type using Bonferroni-corrected two-tailed t-tests (See Table 2). Lower levels of discontinuity reasoning were predicted for predators (as compared to nonpredators) for emotion, desire, and epistemic question types. Although the differences between the means for both desire and epistemic questions were in the predicted direction, only the difference for the epistemic questions was significant, $t = 2.40, p = .017$ (or, $p = .0085$ for a one-tailed test in the predicted direction); desire, $t = 1.29, p = .197$. The means at emotion were practically indistinguishable. As predicted, mean discontinuity responses did not differ between the participants in the predator and nonpredator conditions for the biological, psychobiological, or perceptual question types, all $ts < .26$, all $ps > .23$.

Question Type x Age Group

Means for the significant Age Group x Question Type interaction are presented in Table 3 (and see Figure 3). Inspection of the significant Age Group x Question Type interaction was conducted via two sets of analyses: a) analysis of the effects of question type at each age group; and b) analysis of the effects of age group for each question type. To accomplish the former, a one-way (6) ANOVA on Question Type with repeated measures over the factor was conducted separately for each of the four age groups. Results for the Pre-K/K group indicated a significant effect for Question Type, $F(4.40, 268.35) = 26.98, p < .001$, effect size = .307. The results of the planned comparisons among question type were as follows: biological ($M = 70.97\%$) = perceptual ($M =$

56.45%) > psychobiological (M = 37.90%), emotion (M = 25.00%), desire (M = 22.58%), and epistemic (M = 27.42%). Note also that psychobiological < perception; psychobiological = emotion and epistemic but psychobiological > desire; and desire = emotion = epistemic.

The results reflect the predicted within-age pattern of relatively low levels of discontinuity reasoning for emotions, desires and epistemic states, relative to biological, psychobiological and perceptual states. Note that responses for psychobiological states at this young age result in them occupying somewhat of an “intermediate” position between what can be inferred to be the more “purely” biological states (biological and perceptual, and which are associated with higher absolute levels of discontinuity responses) and the more purely “psychological” states (emotion, desire, and epistemic, and which are associated with the lowest absolute levels of discontinuity responses). When considered in light of reasoning about psychobiological states at later ages (to be presented below), this finding suggests that reasoning about psychobiological states remains relatively incompletely differentiated from reasoning about more purely “psychological” states (such as emotion, desire, and epistemic states) at this early age.

For the 2nd/3rd age group, there was also a significant effect for Question Type, $F(4.29, 244.56) = 40.64, p < .001$, effect size = .416. The results of planned comparisons for this group revealed a pattern that more closely approximated, as compared to the Pre-K/K group, the “classic” pattern in which levels of discontinuity reasoning for biological, psychobiological, and perceptual states were similar to each other, and, as a group, relatively higher than that associated with emotions, desires and epistemic states. This is largely the result of relatively higher levels of discontinuity reasoning for

psychobiological states, as compared to that observed for the Pre-K/K group, and reflective, presumably, of the increasing differentiation of psychobiological states from the more “purely” psychological states (emotion, desire, and epistemic). Specifically, biological questions (98.28%) = psychobiological (87.07%); and biological > perception (M = 81.90%), emotion (M = 50.86%), desire (M = 38.79%) and epistemic (M = 48.28%). Additionally, psychobiological = perceptual but psychobiological > emotion, desire and epistemic. Also, perceptual > emotion, desire, and epistemic states; and emotion = desire = epistemic.

For the 5th/6th grade group, the effect of Question Type was significant, $F(2.57, 164.52) = 39.68, p < .001$, effect size = .383 and the results of planned comparisons revealed a pattern identical to that of the 2nd/3rd group. Specifically, biological questions (98.46%) = psychobiological (90.77%); and biological > perception (M = 89.23%), emotion (M = 60.77%), desire (M = 51.54%) and epistemic (M = 56.92%). Additionally, psychobiological = perceptual but psychobiological > emotion, desire and epistemic. Also, perceptual > emotion, desire, and epistemic states; and emotion = desire = epistemic.

For the adult group, the effect of Question Type was significant, $F(2.72, 173.79) = 17.90, p < .001$, effect size = .219, and the results of planned comparisons for this age group revealed the fully “classic” pattern described and predicted at the outset: biological (M = 98.46%) = psychobiological (M = 98.46%) = perception (M = 94.62%) > emotion (M = 80.77%) = desire (M = 76.15%) = epistemic (M = 72.31%). Note that percentage discontinuity responses for biological and psychobiological questions are both identical and essentially at ceiling (98.46%) for this age group, suggesting that by adulthood (and

possibly earlier) continuity/discontinuity reasoning for psychobiological states has become fully untethered from that associated with the more “purely” psychological states (emotion, desire and epistemic). Importantly, within each age group, and consistent with the original predictions, discontinuity responses for emotions, desires and epistemic states (the “psychological group”) were generally lower than those associated with biological, psychobiological and perceptual questions (the “biological group”). Moreover, with increasing age, responses within each of these two groups became increasingly similar to each other, resulting by adulthood, in the full statistical separation of the two groups.

The Age Group x Question Type interaction was also explored via a one-way (4) ANOVA on Age Group, conducted separately for each Question Type (biological, psychobiological, perception, emotion, desire, and epistemic). Each ANOVA was highly significant (all $F_s > 12.96$, all $p_s < .001$). Planned post hoc analysis revealed that for biological questions, pre-K/K ($M = 69.84$) $<$ for 2nd/3rd ($M = 98.31$) = 5th/6th ($M = 98.48$) = adult ($M = 98.46$). The pattern was identical for both psychobiological questions, pre-K/K ($M = 37.30$) $<$ for 2nd/3rd ($M = 85.83$) = 5th/6th ($M = 90.15$) = adult ($M = 98.46$); and perceptual questions, pre-K/K ($M = 56.45$) $<$ for 2nd/3rd ($M = 82.20$) = 5th/6th ($M = 89.39$) = adult ($M = 94.62$). The pattern for emotion questions was as follows: pre-K/K ($M = 24.60$) $<$ for 2nd/3rd ($M = 50.00$), 5th/6th ($M = 60.77$), and adult ($M = 80.77$); 2nd/3rd = 5th/6th $<$ adult. For desire, pre-K/K ($M = 22.22$) = 2nd/3rd ($M = 38.33$) and 2nd/3rd $<$ 5th/6th ($M = 52.27$) and adult ($M = 76.15$); and 2nd/3rd = 5th/6th $<$ adult. For epistemic questions, pre-K/K ($M = 26.98$) = 2nd/3rd ($M = 44.02$) but pre-K/K $<$ 5th/6th ($M = 45.16$) and adult ($M = 39.56$); 2nd/3rd = 5th/6th but 2nd/3rd $<$ adult; and 5th/6th = adult.

In summary, and as predicted, levels of discontinuity responses increased with age for each question type. Importantly, the developmental pattern for the more purely “biological” question types (biological, psychobiological, and perceptual) was statistically identical: $\text{pre-K/K} < 2^{\text{nd}}/3^{\text{rd}} = 5^{\text{th}}/6^{\text{th}} = \text{adult}$. Moreover, this finding suggests that discontinuity reasoning for these states is essentially mature by $2^{\text{nd}}/3^{\text{rd}}$ grade. In contrast, the development of discontinuity reasoning for emotions, desires and epistemic states occurs more slowly, and as reported above, never reaches the levels displayed for biological, psychobiological and perceptual states.

Specific Animal

Initial predictions included the finding of lower overall levels of discontinuity reasoning for predators than nonpredators for emotions, desires, and epistemic states. As reported above, under “Question Type by Predatory Status Interaction,” although differences in discontinuity responses were in the predicted direction for desire and epistemic question types (and statistically significant for the epistemic questions), they did not differ for emotion questions as predicted - and this pattern did not vary by age as also predicted. The fundamental reason for this pattern may be that insufficient fear was elicited by predators relative to the nonpredators. Recall that four animals (two predators, wolf and lion; and two nonpredators, sheep and zebra) were individually featured in (one of four) video vignettes. To further assess whether there were differences in performance as a function of which animal was featured, and to also thereby also explore potential differences between predators (and differences between predators in relationship to nonpredators), a 6 (Question Type) x 4 (Age Group) x 4 (Animal) ANOVA with repeated measures over the Question Type factor was conducted. The results indicated significant

effects for Question Type, $F(3.83, 895.54) = 123.33, p < .001$, effect size = .345, Age Group, $F(3, 234) = 43.67, p < .001$, effect size = .359, and Animal, $F(3, 234) = 4.83, p = .003$, effect size = .058. The Question Type by Age Group interaction, $F(11.48, 895.54) = 5.16, p < .001$, effect size = .062, and the Question Type by Animal interaction, $F(11.48, 895.54) = 5.06, p < .01$, effect size = .061, were also significant. The three-way interaction and the Age Group x Animal interaction was nonsignificant.

Recall that differences between predatory and nonpredatory animals were only predicted for emotions, desires and epistemic states. Mean discontinuity responses associated with each of the four animals for each question type are presented in Table 4. Follow-up ANOVAs for biological and psychobiological questions were nonsignificant. The ANOVA for perceptual questions was significant, $F(3, 248) = 2.67, p = .049$, effect size = .031, as were all three ANOVA's for the more purely "psychological" question types: emotion, $F(3, 249) = 5.52, p = .001$, effect size = .062; desire, $F(3, 250) = 3.97, p = .009$, effect size = .045; and epistemic question types, $F(3, 250) = 5.99, p = .001$, effect size = .067.

Pairwise comparisons of animal at each of the question types revealed the following significant differences. For the perceptual question type, only one difference, lion > sheep, approached significance ($p = .051$). For the emotion question type, lion > sheep = wolf; and wolf < zebra was marginally significant ($p = .051$). For the desire question type, the only significant differences were lion > wolf, and zebra > wolf. For the epistemic question type, the wolf produced significantly lower discontinuity scores than the other three animals that did not differ from one another. Note that no differences were found between animals for biological and psychobiological questions.

Although no initial predictions were made regarding levels of discontinuity reasoning for individual predators (lion, wolf) and individual nonpredators (sheep, zebra), the finding of lower levels of discontinuity reasoning for individual predators in comparison to individual nonpredators for emotion, desire and epistemic states (averaged across age groups) would nonetheless be consistent with initial predictions (i.e., specifically, of lower levels of discontinuity reasoning for predators, averaged together, as compared to individual nonpredators, averaged together, for these three question types and three oldest age groups). Importantly, the lowest levels of discontinuity reasoning were found for wolf (averaged across age groups) for emotions, desires and epistemic states. However, lion was associated with the highest absolute levels of discontinuity reasoning for emotions and desires, and the second highest for epistemic. Although it is possible that the reason the wolf vignette and/or picture elicited the greatest levels of fear in participants, consistent with the author's general line of reasoning and predictions, the fact that the lion was associated with relatively high levels of discontinuity reasoning in these analyses, especially in comparison to both the sheep and zebra, suggests that the differences found between the animals in this study may be due to factors other than predatory status.

The Question Type x Animal Interaction was also explored via four separate 6-Way ANOVAs (one for each animal) with repeated measures over the question type factor. Each ANOVA was highly significant (all $F_s > 20.98$, all $p_s < .001$). Planned pairwise comparisons revealed the following for the lion: biological = psychobiological, perceptual, and biological > emotion, desire, epistemic; psychobiological = perceptual,

emotion, and psychobiological > desire, epistemic; perception > emotion, desire, epistemic; emotion > desire, epistemic; and desire= epistemic.

For wolf: biological = psychobiological, and biological > perception, emotion, desire, epistemic; psychobiological = perception, and psychobiological > emotion, desire, epistemic; perception > emotion, desire, epistemic; emotion = desire, epistemic; desire = epistemic. For zebra: biological > psychobiological, perception, emotion, desire, epistemic; psychobiological = perception, and psychobiological > emotion, desire, epistemic; perception > emotion, desire, epistemic; emotion = desire, epistemic; and desire = epistemic. For sheep: biological > psychobiological, perception, emotion, desire, epistemic; psychobiological = perception and epistemic, and psychobiological > emotion, desire; perception = epistemic, and perception > emotion, desire; emotion = desire, and emotion < epistemic; desire = epistemic.

DISCUSSION

Initial predictions included the following: 1) that relatively high levels of discontinuity reasoning would be consistently observed for biological states across age and relative to the other question types; 2) increased age would be associated with increased levels of discontinuity reasoning across all mental state types; 3) by at least the 5th/6th age group and possibly as early as 2nd/3rd age group, levels of discontinuity reasoning for emotions, desires and epistemic states would become and remain lower than that observed for perceptual and psychobiological states; and 4) discontinuity reasoning for emotions, desires and epistemic states would be lower for predators, as compared to nonpredators, for all age groups above preschool/kindergarten. The findings of the study were clearly and fully consistent with Predictions 1-3, but only minimally consistent with Prediction 4.

The most significant implication of the current findings is the generalization of previous findings (of gradualism in the development of discontinuity reasoning, and the relative resistance of emotions, desires and epistemic states to discontinuity reasoning that persists into adulthood) from the contexts of death and sleep for human and/or highly anthropomorphized animal characters to that of death for realistic animal characters engaged in ecologically relevant pursuits, i.e., “real animals.” Additionally, the general developmental patterns of discontinuity reasoning for the various mental states observed in previous studies (Bering & Bjorklund, 2004; Bering, et al., 2005; Cormier, 2005) were also observed in the current study.

Explaining Post-Death Continuity Reasoning for Mental States

Bering and Bjorklund (2004) attributed observations of imperfect discontinuity reasoning for the psychological states of deceased characters that persists with age to “default simulation” (Harris, 1991, 1992; see “Simulation Theory” above). According to Bering and Bjorklund, although children may be able to adjust their default settings to simulate alternative mental states, there is no mechanism in place for representing unconsciousness (i.e., the lack of active mental state activity). Any attempts to do so are blocked by inherent “simulation constraints” on the system, resulting in the “default simulation” of (nonexistent) mental state activity. It is only with age, according to these authors, that biological knowledge becomes enriched to a degree that allows for the explicit overriding of the inferences that are implicitly and automatically generated by the process of “default simulation.”

Moreover, this “enrichment” process is gradual, and as such is responsible for developmental increases in discontinuity responses (for various mental state types). Importantly, however, the difficulties associated with the successful application of biological knowledge to the task of overriding default simulation in considerations of the minds of deceased agents varies by mental state type, thereby accounting for higher levels of discontinuity responses for psychobiological and perceptual states in comparison to those associated with emotion, desire and epistemic states. The fundamental cause of these differences, according to the authors, is varying levels of experience with the nonexistence of various states during consciousness, i.e., specifically, that children and adults have more conscious experience devoid of psychobiological states and perceptions than they do with emotions, desires and

epistemic states. In other words, the absence of these latter states is seldom, if ever, experienced in consciousness.

This explanation, as argued by Cormier (2005), is likely to be incomplete. For although the opposing forces of default simulation and steadily increasing biological knowledge may interact to produce a general pattern of increasing discontinuity reasoning with age, there is no compelling reason to believe that default simulation should distinguish so clearly and persistently between the various mental states studied. Although it may possibly be true that adults and children have more experience with consciousness devoid of psychobiological and perceptual activity (than consciousness devoid of emotions, desires and epistemic activity), the biological knowledge required to successfully override default simulation for all of these states is most likely in place by late childhood. If not, then surely by adulthood, and even more certainly for college-educated adults.

To underscore the salience of this point, it may be useful to describe a somewhat analogous set of findings of differences in cognitive performance that have been observed in research on the phenomenon of “cheater detection” (Cosmides & Tooby, 1992). In numerous studies on this topic, participants were administered two versions of a logic problem based on the Wason selection task (Wason & Johnson-Laird, 1972). Although both versions of the tasks in these studies present problems that are logically and conceptually identical, problems are presented in two forms: one involving a purely abstract context, and the other a context that requires “cheater detection,” i.e., detection of rule violation. Despite having identical conceptual and logical structures, the abstract

context is consistently associated with relatively low levels of performance by college age students (e.g., < 25%) in comparison to the “cheater detection” context (e.g., >75%).

Here is an example of a Wason selection problem presented with an abstract context: You have been hired as a clerk. Your job is to make sure that a set of documents is marked correctly, according to the following rule: *If the document has a “D” rating, then it must also be marked code “3.”* There are errors in some of the documents and you must find these errors. Each document has a letter rating on one side and a numerical code on the other. Here are four documents. Which document(s) do you need to turn over to check for errors? The four “documents” are then presented with the following showing: “D,” “F,” “3,” and “7.”

Now consider the following presentation of the problem: You have been hired as a bouncer at a bar, and you must enforce the following rule: *“If a person is drinking beer, then he must be over 20 years old.”* The cards below have information about four people in the bar. One side of each card lists a person’s age and the other side shows what he is drinking. Which card(s) do you need to turn over to be sure no one is breaking the law? The “cards” are then presented with following showing: “beer,” “cola,” “25 years,” and “16 years.” In both versions of the task, the correct solution is to identify the first and last items as needing to be turned over and inspected. As you have likely determined, performance is much higher on the second version of the task, which requires detection of rule violation. These findings have been replicated numerous times and with contents that are completely unfamiliar (unlike the current “bar bouncer” version of the task). To explain these findings, Cosmides and Tooby (1992) have proposed the existence of a specialized “cheater detection” module in the mind (see “Modularity Theory and

Information-Processing Accounts” above), and, in fact, and consistent with this proposal, the capacity for cheater detection has been isolated in brain-damaged patients (Stone, Cosmides, Tooby, Krool & Knight, 2002).

The current author is proposing that the differences in discontinuity reasoning observed in the current and multiple previous studies for psychobiological and perceptual states in comparison to that observed for emotions, desires, and epistemic states, are analogous to the differences in performance observed in cheater detection research. The logical problem presented in considering questions of continuity for all mental state types in deceased agents is identical, with the correct solution requiring the same basic syllogistic reasoning: Life is required to support life functions; with the occurrence of death, all life functions cease. Mental state “x” (i.e., psychobiological, perceptual, emotion, desire, or epistemic) is a life function. Therefore, mental state “x” necessarily ceases with the onset of death.

Given the objective logical simplicity and isomorphic nature of discontinuity reasoning for all mental state types, one should expect to see equivalent levels of discontinuity responses within age groups for all mental states – unless, of course, there exists some intrinsic difference(s) in the implicit representation of various mental state types. Intrinsic differences of the type suggested here are most likely to arise from one of two general sources: intuitive theoretical factors associated with theory-theory accounts of ToM (see “Theory Theory” above), or the action of domain-specific evolved cognitive modules subserving ToM that uniquely guide reasoning about some or all mental states. The current author proposes that the modular perspective provides the best framework for

understanding the apparently unique status of emotions, desires and epistemic states within ToM. Support for this proposal is developed below.

The Living/Dead Discrimination Mechanism and Intentional Persistence

As described by Leslie (1988, 1994), conceptual development within domains for which there is no core architecture (i.e., domains for which a dedicated architecture driving conceptual development along a reliable developmental schedule is lacking), i.e., no domain-specific cognitive modules, is characterized by extended and highly variable individual trajectories. Within such domains, conceptual development is highly dependent upon the acquisition of relevant knowledge and principles, and the process by which this occurs is often described in terms of “theory change,” i.e., in terms of “theory-theory.” Carey and colleagues (Carey, 1985; Gopnik & Meltzoff, 1997) propose a theory-theory account of children’s developing understanding of death in which children initially possess no core architecture to provide them with the relevant causal principles for understanding death but subsequently develop a “folk” or “intuitive” biology (i.e., a theory-theory based understanding of life and death) in which life is understood to require the presence of the causal mechanisms by which it is sustained.

Numerous studies support the theory change view of the development of understanding of death. Johnson and Carey (1998), for example, reported that developmentally impaired individuals (Williams syndrome, specifically) who lacked a mature folk biology, performed poorly, compared to controls, on measures of death understanding that rely on folk biology. Similarly, multiple additional studies support the proposal that comprehension of the principle that relevant biological processes are required for sustaining life is important for later-developing aspects of understanding of

death. In addition to acknowledging that many aspects of the understanding of death do appear to require the acquisition of theory-like knowledge, Barrett and Behne (2005) propose that at least one aspect of the understanding of death is subserved by an early developing core architecture: the concept that death is equated with the cessation of agency. One aspect of this proposed architecture is a cognitive “switch” that is responsible for remapping an object from the ontological category of “Animate Object” (living animal) to “Biological Substance.” Consistent with what would be expected for the evolutionary design of this mechanism (given the relatively greater costs associated with false negatives as compared to false positives) is the observation that it is relatively “skeptical” of such transformations, i.e., that it is “sticky” and therefore require positive evidence of death (causal cues) before “flipping” (Barrett & Behne).

Cormier (2005) proposed a means by which the “stickiness” of the living/dead discrimination “switch” is maintained: intentional persistence, i.e., the implicit attribution of continued intentionality for deceased agents as indexed by the relatively low levels of discontinuity reasoning observed for emotions, desires and epistemic states within both that study (for the context of sleep) and multiple previous and related studies (for the context of death). The observation of highly similar results in the current study for deceased, realistic animal characters bolsters the proposal that intentional persistence serves to maintain the “stickiness” of this mechanism. Additionally, the close association of Cormier’s proposed concept of intentional persistence with the living/dead discrimination switch proposed by Barrett and Behne (2005) suggests the presence of shared underlying mechanisms and structure. As cogently argued by Barrett and Behne, the living/dead discrimination switch is likely modular in nature. Therefore, intentional

persistence is most likely produced and maintained by modular structures contained within the agency system.

Theory of Mind (ToM) and Cooptation

Although presumably all animals have evolved mechanisms for dealing with potentially dangerous encounters with conspecifics, predators and other animal types, humans presumably have the broadest range of such mechanisms. Moreover, evolved mechanisms of the specific type being discussed here are likely to include not only highly domain-specific capacities, such as the living/dead discrimination mechanism (Barrett & Behne, 2005) described above, but to also draw on whatever additional mechanisms and capacities possessed by the organism (including those that have originally or primarily evolved for entirely unrelated purposes) that may be brought to bear on such problems. In the case of humans, the range of potential candidate mechanisms for this suggested “shared” or “partially coopted” use of evolved mechanisms is expected to be large, especially considered in light of the uniquely human capacities associated with ToM.

This latter concept, for which the current author has coined the phrase “*cooptation*,” is being suggested as an additional explanation for observations of the relative persistence of emotions, desires, and epistemic states to discontinuity reasoning (i.e., intentional persistence) in both the current and multiple previous studies (Bering & Bjorklund, 2004; Bering et al., 2005; Cormier, 2005). Unlike *exaptations* (Buss, Haselton, Shackelford, Bleske & Wakefield, 1998; Gould, 1991, 1997; Gould & Lewontin, 1979; Gould & Vrba, 1982), which are evolved features whose current functions differ from that for which the features originally evolved (e.g., possibly, bird feathers, which may have originally evolved to promote thermoregulation, but currently

support flight), cooptations are proposed to be evolved features or mechanisms that continue to serve a primary fitness-related function (for which they originally evolved or were exapted), but whose existence or functioning have been additionally coopted for a concomitant or secondary purpose by another adaptive process or feature. Importantly, and unlike that which occurs in cases of exaptation, the process of cooptation does not significantly distort the primary phenotypic or functional characteristics of the coopted feature or process.

In terms of the current discussion of human problems associated with managing potentially dangerous encounters with animals who are of ambiguous agency status (or, who, at the very least, lack sufficient causal cues to death), what is currently being proposed is that the agency system generates intentional persistence for the purpose of maintaining a heightened sense of vigilance and behavioral readiness while in the presence of such creatures. Cooptation is suggested in this case, in that the agency system, while not exapting ToM, nonetheless clearly (according to the current line of reasoning) draws on representations and inferences that have or would otherwise be naturally generated within the ToM system operating within in its natural domain (the “minds” of living agents). Cooptation is also suggested by the fact that ToM clearly initially evolved for and continues to serve the primary purpose of generating inferences about the mental states of living agents. As such, any use by other systems, e.g., the living/dead discrimination mechanism, is purely secondary. Moreover, the use of outputs generated by ToM (e.g., emotions, desires, and epistemic states) by other systems, and in the manner described here (as cooptation), does not appear, and would not seem to theoretically require, any dramatic alterations to the basic ToM system, itself.

The concept of intentional persistence is suggestive, however, of the possibility of one alteration to the basic ToM system that may have been imposed by the agency system via the proposed evolutionary process of cooptation. Although highly speculative, it is not unreasonable to assume that ToM may have originally existed in a form that would have resulted in equivalent levels of discontinuity reasoning, within age-groups, for all mental state types within a study using the current paradigm. In other words, ToM might have originally evolved such that, emotions, desires and epistemic states had no “special status” within the ToM system as compared to psychobiological and perceptual states. This possibility seems especially likely in the event that the mechanisms subserving ToM evolved prior to the evolutionary cooptation of inferences about the existence and nature of emotions, desires and epistemic states by the agency system, and thereby resulting in the appearance of intentional persistence. However, given the likelihood that the agency system is evolutionarily much older system than the ToM system, it seems more likely that emotions, desires and epistemic states were coopted by the agency system from the time of their initial emergence within ToM.

Predatory Status

Consistent with the concept of intentional persistence as an evolved feature designed ultimately to promote heightened awareness, vigilance, and behavioral readiness in the presence of potentially dangerous humans and animals characterized by ambiguous agency status, it was predicted that levels of discontinuity reasoning for emotions, desires and epistemic states would be lower for predators than nonpredators for all age groups above preschool/kindergarten. The results were inconsistent with this prediction, in that no age-related differences due to predatory status were observed.

Although no predictions were initially made regarding levels of discontinuity responses for the individual animals (two predators, lion and wolf, and two nonpredators, sheep and zebra) at each question type (biological, psychobiological, perceptual, emotion, desire and epistemic), the finding of significantly or even lower absolute levels of discontinuity responses for the individual predators as compared to the individual nonpredators, for emotions, desires, and epistemic states, would have been consistent with initial predictions. As reported within the results section, examination of discontinuity levels for each animal at each question type revealed that discontinuity responses for lion were significantly higher than those for wolf for emotions, desires and epistemic states, and levels of discontinuity responses for the two nonpredators were “sandwiched” in between the two predators for emotion and desire. Although sheep had the highest level of discontinuity responses for epistemic (as would be expected), zebra was still nonetheless in-between lion and wolf.

Failure to obtain the expected differences for predators and nonpredators (for emotions, desires, and epistemic states, for the three oldest age groups) does not damage the intentional persistence concept as conceived by Cormier (2005). It is quite possible that intentional persistence functions relatively uniformly for both predators and nonpredators (or even all) animal (including human) types, as evolutionary pressures may not have sufficiently distinguished between these two general (or other) classes of agents in producing intentional persistence. It is also quite possible that intentional persistence does manifest differently for predators and nonpredators, and in the manner initially predicted, but that the current paradigm simply failed to capture this effect.

If so, multiple factors may be implicated, but inadequate differences in fear generated within the study by predators and nonpredators would appear to be the most likely cause of this potential problem. Inadequate differences in fear are likely to be the result of multiple factors within the current study: the presented scenarios were fictional, involved no real contact with live animals, presented no real danger to either the subjects or other people or animals, and involved the fictional predation of second-person characters (i.e., that participants were not asked to imagine or experience a story in which they are presented as prey targets for predators). It is recommended that future studies address one or more of these limitations (with the exception, of course, of the lack of real danger).

A related set of findings, not explicitly stated within the initial predictions, but nonetheless consistent with them, was observed, namely, of a (nonsignificant) difference in the predicted direction for desire states (i.e., lower levels of discontinuity reasoning for predators), and a significant difference in the predicted direction for epistemic states (averaged across age groups for both desire and epistemic states). Note also that no differences were found within this analysis for biological, psychobiological, or perceptual states. Both of these latter sets of findings bode well for the predator/nonpredator distinction and suggest that it remains a viable hypothesis that may be confirmed within future studies.

One interesting possibility follows from cross-cultural considerations. The groups tested within the current study come from a fully modern and industrialized first-world society in which very little contact with living animals and no contact or exposure to wild animals (with the exception of zoo animals) is the cultural norm. Moreover, the vast

majority of study participants presumably also have absolutely no real-life experience with hunting or killing, as either predator or prey, and therefore, any knowledge or exposure to the basic facts and dynamics of predator/prey interaction are not only secondhand (e.g., those experienced via classroom teaching, nature programs on television, animated or other stories and movies, books, etc.) but remain essentially “abstract.”

It is possible that the current paradigm would have successfully demonstrated the predator/prey distinction, and in the manner predicted, if administered within a traditional culture, i.e., subsistence hunter-gatherer society, in which the hunting, killing and deaths of animals, as well as the experience of predatory threat to one’s own and the lives of others is the stuff of normal, daily existence. One implication of these considerations is that although the intentional persistence heuristic may still be regarded as most likely being the product of modular cognitive mechanisms that require very little to no real-world contact or experience with predator/prey dynamics (see Barrett & Behne, 2005), the predator/prey distinction may nonetheless require some minimal level of developmentally “appropriate” or “expected” experience for its developmental expression. These considerations seem especially reasonable when considered in light of the fact that modern, industrialized society represents a radical and only very relatively recent departure from the environments encountered by all humans throughout the vast majority of human evolutionary history-in which dealing in death, hunting, killing, predation and predator-avoidance were ubiquitous and inescapable daily realities.

Despite the reasonableness of the considerations described immediately above, it is nonetheless the case that the most likely experimental context for confirming the

predator/prey distinction is one in which participants, regardless of culture, are presented with scenarios in which they are the intended targets of predatory intentions. It may, in fact, be the case that the first-person experience of such predatory targeting (i.e., being potential prey) may be the primary, if not absolutely the only context in which the predator/prey distinction will manifest. Other contexts in which this distinction may possibly manifest are those involving the potential predation of loved ones, other members of one's "group," or other situations in which the potential predation of others (including nonhuman pets, livestock, etc.) is personally meaningful. Moreover, given the very limited exposure to animals and personally meaningful and realistic predator/prey interactions that characterize human development and life in the modern world, it is likely that scenarios involving "interactions" with predatory human characters are more likely to elicit the proposed predator/prey distinction than those involving animals.

Conclusion

The observation within the current study of developmental increases in overall levels of discontinuity reasoning, accompanied by intentional persistence for the older age groups (i.e., relatively lower levels of discontinuity reasoning for emotions, desires and epistemic states, as compared to biological, psychobiological, and perceptual states) is highly similar to results obtained for the condition of death of human and human-like characters (Bering and colleagues, 2004, 2005) and sleep for human-like characters (Cormier, 2005). The primary significance of these findings is the extension of these observations to the context of death of realistic animal characters ("real animals"). Considered collectively, these convergent findings strongly support the notion that intentional persistence is a universal feature of human psychology.

The predicted developmental emergence of differences in discontinuity reasoning for predators and nonpredators (i.e., lower levels for the former, for emotions, desires and epistemic states) was not found. However, the finding of an absolute difference in discontinuity reasoning in the predicted direction for emotions, and a significant difference in the predicted direction for epistemic states (averaged across age groups for both state types) suggests that the predator/nonpredator distinction remains a theoretically viable possibility that may be confirmed in future studies.

Cormier (2005) proposed that intentional persistence is an evolutionary adaptation designed to maintain one's vigilance while in the presence of humans and animals whose status as effective intentional agents is ambiguous. Cormier additionally proposed that intentional persistence functions to maintain the "stickiness" (i.e., the proper error management balance) of the living/dead discrimination mechanism described by Barrett and Behne (2005), and as such, is likely to be the product of modular structures as opposed to "default" simulation (e.g., Harris, 1991, 1992), intuitive theory change (e.g., Gopnik & Wellman, 1994; Woolley & Wellman, 1992, 1993), or the development of domain-general mechanisms (see Carlson, Moses & Breton, 2002; Chiappe & McDonald, 2005; Flavell & Miller, 1998; Geary, 2005; Keenan, 2000). The current author has additionally proposed that intentional persistence has been made possible by the evolutionary cooptation of ToM for emotions, desires and epistemic states as traditionally conceived (i.e., as applied to the minds of living agents).

Table 1

Percentage of Discontinuity Responses by Question Type, Age Group and Predatory Status

<u>Question</u>	<u>Age Groups</u>							
	<u>Pre-K/K</u>		<u>2nd/3rd</u>		<u>5th/6th</u>		<u>Adult</u>	
	Non-predator	Predator	Non-predator	Predator	Non-predator	Predator	Non-predator	Predator
Biological	70.00	71.88	98.28	98.28	100.00	96.88	100.00	96.88
Psychobiological	40.00	35.94	82.76	91.38	89.39	92.19	98.48	98.44
Perceptual	51.67	60.94	74.14	89.66	86.36	92.19	96.97	92.19
Emotion	20.00	29.69	39.66	62.07	65.15	56.25	87.88	73.44
Desire	21.67	23.44	37.93	39.66	57.58	45.31	83.33	68.75
Epistemic	38.33	17.19	53.45	43.10	62.12	51.56	78.79	65.63

Table 2

Percentage of Discontinuity Responses by Predatory Status and Question Type

<u>Question Type</u>	<u>Predatory Status</u>	
	Nonpredator	Predator
Biological	91.73	90.87
Psychobiological	76.95	79.37
Perceptual	78.35	83.60
Emotion	53.94	54.76
Desire	51.17	44.05
Epistemic	57.42	44.05

Table 3

Percentage of Discontinuity Responses by Age Group and Question Type

<u>Question</u>	<u>Age Groups</u>			
	Pre-K/K	2 nd /3 rd	5 th /6 th	Adult
Biological	70.97	98.28	98.46	98.46
Psychobiological	37.90	87.07	90.77	98.46
Perceptual	56.45	81.90	89.23	94.62
Emotion	25.00	50.86	60.77	80.77
Epistemic	27.42	48.28	56.92	72.31

Table 4

Percentage Discontinuity Responses by Animal Type and Question Type

<u>Animal</u>	<u>Question Type</u>					
	Biological	Psychobiological	Perceptual	Emotion	Desire	Epistemic
Lion	89.68	78.57	89.68	68.25	55.56	57.14
Wolf	92.06	80.16	77.42	41.27	32.54	30.95
Zebra	92.42	76.87	82.84	61.36	55.22	54.48
Sheep	90.98	77.05	77.33	45.90	46.72	60.66



A. Lion



C. Zebra



B. Wolf



D. Sheep

Figure 1. Animal Photographs (reduced size)

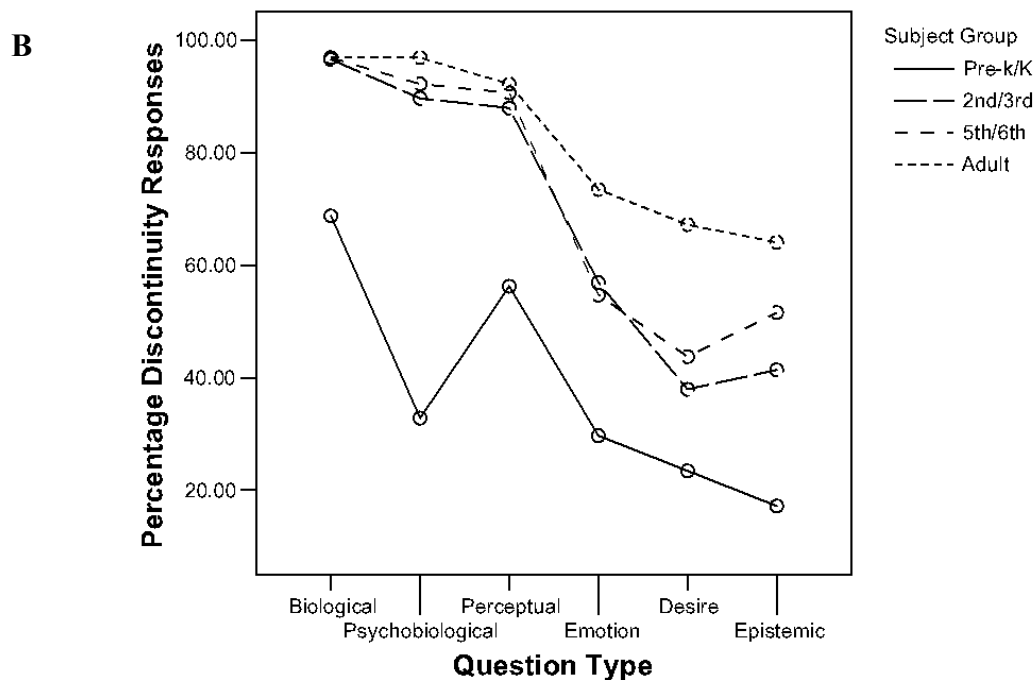
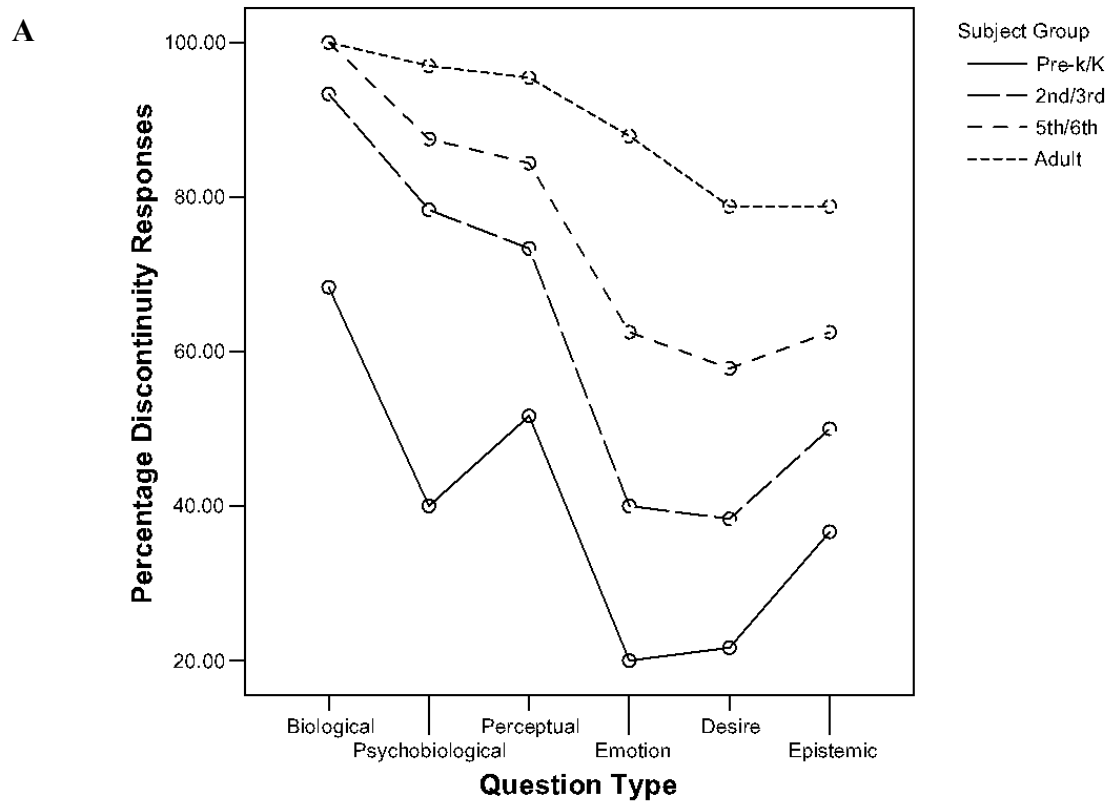


Figure 2. A. Percentage Discontinuity Responses by Age Group and Question Type for Nonpredators. B. Percentage Discontinuity Responses by Age Group and Question Type for Predators

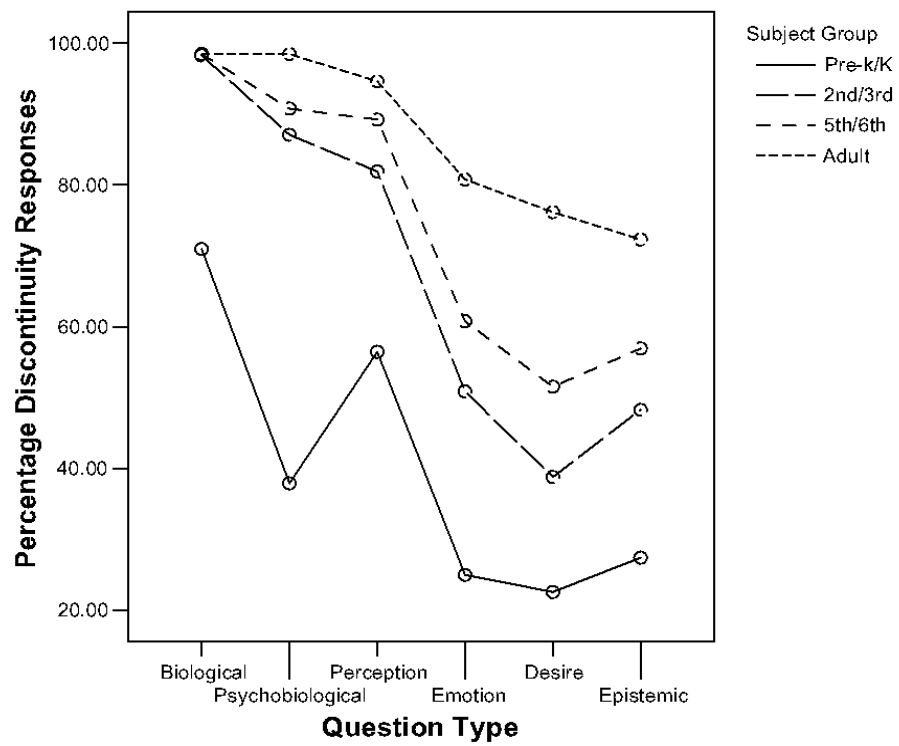


Figure 3. Percentage Discontinuity Responses by Age Group and Question Type.

APPENDICES

Appendix A

Vignette Narratives and Interview Questions

A. Lion Narrative

Hi. I'm going to show you a story today. It's about a real kind of animal. Do you know what a lion is? A lion is a scary hunter that likes to hunt and eat other animals.

Lions have very sharp teeth and claws for catching and eating animals like zebras.

They're very scary and dangerous for people too. Here's a picture of a lion. Do you see his sharp teeth? Do you see how scary he looks? Now we both know that the animals in the story are just toys, but for today, let's just pretend that they're real. Here's our story:

Lion went hunting deep in the woods for an animal to catch and bring back for his family to eat. He could hear birds singing everywhere. They sounded so pretty. After a long while, his paws started to get sore because he had been walking for such a long time. He really wanted to get back home quickly because he was thinking about how hungry his baby cubs were. One nice thing that he noticed about the woods around him is that there were lots of flowers, and they smelled really nice. After a long, long time Lion started to feel sick to his stomach from walking too much. Suddenly, Lion noticed a zebra ahead! Lion was excited because this zebra was big enough for his whole family to eat. And if there was one thing Lion knew, it was that he was a good hunter. So Lion ran and jumped on the zebra with his sharp claws and bit it really hard. The zebra was no longer alive. By that time it was dark out. Lion was mad that it was too late to bring the zebra home to his family. He wished that they could be here right now so they could eat, too. Lion turned around and started to run home, but just then he suddenly tripped, and fell down onto some big rocks. He was no longer alive.

Lion Interview Questions

Now that Lion is no longer alive...

Biological

1...do you think that Lion will ever need to drink water again?

2...do you think that Lion will ever need to eat food again?

Psychobiological

1...do you think Lion's paws feel sore?

2...do you think Lion feels sick to his stomach?

Perceptual

1...do you think Lion can hear the birds singing?

2...do you think Lion can smell the flowers?

Emotion

1...do you think Lion feels excited about how big the zebra is?

2...do you think Lion feels mad about it being too late to bring the deer home to his family?

Desire

1...do you think Lion wants to get back home quickly?

2...do you think Lion wishes his family could be with him?

Epistemic

1...do you think Lion is thinking about how hungry his cubs are?

2...do you think Lion knows he's a good hunter?

B. Wolf Narrative

Hi! I'm going to show you a story today. It's about a real kind of animal. Do you know what a wolf is? A wolf is a scary hunter that likes to hunt and eat other animals. Wolves have very sharp teeth and claws for catching and eating animals like sheep. They're very scary and dangerous for people too. Here's a picture of a wolf. Do you see her sharp teeth? Do you see how scary she looks? Now we both know that the animals in the story are just toys, but for today, let's just pretend that they're real. Here's our story:

Wolf was hunting for sheep one afternoon in the big valley. It was winter time and the wind was blowing, so she could feel the cold air all the way under her thick fur. She was happy that the sheep were beginning to come back to the valley for the winter and she knew that she was a great hunter. She hoped that her wolf pack would get to have all the sheep in the valley for themselves. But she believed that coyotes would try to get all the sheep too. Wolf had been walking so long at this point that it was getting late, and she was feeling sleepy. It was so late that she could even see the moon coming out. Suddenly, Wolf saw a sheep ahead in the dark. She ran towards it as fast as she could and grabbed it really hard with her sharp teeth. The sheep was no longer alive. Wolf was sad that it would take her so long to bring the sheep back in the dark for her family. She was also hungry because she hadn't eaten anything in a long time, and so she started to carry the sheep back home as quickly as she could. She really wanted to get the food back to her family so everybody could eat soon. While she was walking back in the dark she took a wrong step near the river and fell in. She couldn't swim very well and went under the water and didn't come up again. She was no longer alive.

Wolf Interview Questions

Now that wolf is no longer alive...

Biological

1...do you think Wolf will ever need to drink water again?

2...do you think Wolf will ever need to eat food again?

Psychobiological

1...do you think Wolf feels sleepy?

2...do you think Wolf feels hungry?

Perception

1...do you think Wolf feels the cold air?

2...do you think Wolf can see the moon?

Emotion

1...do you think Wolf is happy that the sheep were coming back to the valley?

2...do you think Wolf is sad that it would take so long to bring the sheep back to her family?

Desire

1...do you think Wolf hopes that the wolves would get to have all the sheep for themselves?

2...do you think Wolf wants to get the sheep back to her family?

Epistemic

1...do you think Wolf knows that she's a good hunter?

2...do you think Wolf believes that the coyotes will try to get all the sheep too?

C. Zebra Narrative

Hi! I'm going to show you a story today. It's about a real kind of animal. Do you know what a zebra is? A zebra is a nice animal that likes to be quiet and just eat grass. Zebras have special ears for hearing very quiet sounds and special hooves, kind of like feet, for running fast. They're very gentle and nice around people too. Here's a picture of a zebra. Do you see her special ears? Do you see how nice she looks? Now we both know that the animals in the story are just toys, but for today, let's just pretend that they're real. Here's our story:

Zebra went walking alone in the woods, looking for a new home that would keep her family warm in the winter. She could hear birds singing everywhere. They sounded so pretty. After a long while her hooves started to get sore because she had been walking for such a long time. She really wanted to find a nice cave and get back home quickly because she was thinking about how lonely her baby was. Once nice thing that she noticed about the woods around her was that there were lots of flowers and they smelled really nice. After a long, long time, Zebra started to feel sick to her stomach from walking too much. Suddenly, Zebra noticed a cave ahead! She was very excited because she had found a great winter home for her family, and if there was one thing Zebra knew, it was that she was good at taking good care of her family. Zebra started to run towards the cave so she could see it up close, but just before she got there, she saw a human hunter shooting at a bird. Zebra was so mad at the hunter for doing that. She wished that he would go away and never come back. Zebra started to run home to tell her family about their new cave, but just then she suddenly tripped and fell down onto some big rocks. She was no longer alive.

Zebra Interview Questions

Now that Zebra is no longer alive...

Biological

1...do you think that Zebra will ever need to drink water again?

2...do you think that Zebra will ever need to eat food again?

Psychobiological

1...do you think Zebra's hooves feel sore?

2...do you think Zebra feels sick to her stomach?

Perception

1...do you think Zebra can hear the birds singing?

2...do you think Zebra can smell the flowers?

Emotion

1...do you think Zebra feels excited about finding a home for her family?

2...do you think Zebra feels mad at the hunter for shooting at the bird?

Desire

1...do you think Zebra wants to get back home quickly?

2...do you think Zebra wishes the hunter would go away?

Epistemic

1...do you think Zebra is thinking about how lonely her baby is?

2...do you think Zebra knows she's good at taking care of her family?

D. Sheep Narrative

Hi. I'm going to show you a story today. It's about a real kind of animal. Do you know what a sheep is? A sheep is a nice animal that likes to be quiet and just eat grass. Sheep have special ears for hearing very quiet sounds and special fur called "wool" for keeping warm. They're very gentle and nice around people too. Here's a picture of a sheep. Do you see his special fur? Do you see how nice he looks? Now we both know that the animals in the story are just toys, but for today, let's just pretend that they're real. Here's our story:

Sheep was walking far from home one day in search of a new home that would keep his family warm and safe. It was winter, and the wind was blowing so he could feel the cold all the way under his fluffy white fur. But he was happy that it wasn't too cold for his baby sheep. He also knew that if he tried hard enough he would eventually be able to find a nice warm place for his family to live. He hoped that the new place would also have lots of delicious grass. He believed that the best fields were across the big river that no sheep had ever crossed before. Sheep was at the river now and began to paddle across. He had to paddle really hard because the water was kind of fast. By the time he got across the river, his legs were really tired and he felt really sleepy too. By this time it was late and he could even see the moon coming out. Sheep started to feel sad that he was all alone. He was also hungry because he hadn't eaten anything in a long time. Suddenly, sheep saw a hunter looking for an animal to shoot. He didn't like that and just wanted the hunter to go away and never come back. Sheep kept walking in the dark but he was near the river and he slipped and fell in. The river was too deep and strong in this part and sheep went under the water and didn't come up again. He was no longer alive.

Sheep Interview Questions

Now that Sheep is no longer alive...

Biological

1...do you think that Sheep will ever need to drink water again?

2...do you think that Sheep will ever need to eat food again?

Psychobiological

1...do you think Sheep feels sleepy?

2...do you think Sheep feels hungry?

Perception

1...do you think Sheep feels the cold air?

2...do you think Sheep can see the moon?

Emotion

1...do you think Sheep is happy that it wasn't too cold for his baby?

2...do you think Sheep is sad to be all alone?

Desire

1...do you think Sheep hopes that the new home would have lots of grass?

2...do you think Sheep wants the hunter to go away?

Epistemic

1...do you think Sheep knows that he could find a home for his family?

2...right now do you think Sheep believes that the best fields are across the river?

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