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The Hows and Whys of Biological Change: Causal Flexibility in Children’s Reasoning

By

Kristin L. Szymanowski Price

Submitted as partial fulfillment of the requirements for

The Doctor of Philosophy in Psychology

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An Abstract of

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The focus of the current research is the development of causal reasoning in school-age children. In two studies, children and adults were presented with open- and closed-ended questions (question format) about the origins of adaptive features for animals and humans, and functional features for artifacts (e.g., human hands, butterfly wings, chair legs). In a mixed factorial design, participants were assigned to different conditions by question-type (why or how questions). Participants in Study 1 comprised 26 5- and 6-year-olds, and 23 adults; Study 2 included 97 5- to 14-year-olds divided into three age-groups. For the closed-ended questions participants were asked how much they agreed (1-4 scale) with 3 possible causal explanations, representing intentional, functional, and naturalistic modes of reasoning. Responses were analyzed for the number and type of causes endorsed by each age group and whether or not this differed by knowledge domain (animals, humans, artifacts), question type, and question format. Participants in
both studies demonstrated causal flexibility by altering their patterns of responding based on all three factors. All age-groups distinguished between question type by offering naturalistic mechanisms for how questions and functions for why questions in the open-ended format. Developmental changes in explanation preference that varied by domain were also revealed. Finally, when presented with three possible explanations in the closed-ended format, children and adults endorsed multiple appropriate explanations to different degrees, though there were age-related changes in this ability. Previous research portrayed children's reasoning as limited in its explanatory power. By varying question type, question format, and knowledge domain this research highlights the fact that causal flexibility is the hallmark of children's reasoning, whatever the age.
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I would like to dedicate this dissertation to someone I truly admire, respect, love, and miss greatly. To Heather, who had every reason in the world to quit, but somehow never did. Because by no choice of your own, you’ll never get this chance, I will take it for both of us my friend. For reaching for the stars and in my eyes, going beyond them… this is for you.
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Robert Wilson and Frank Keil (1998) believe that causal explanations of events and others’ behaviors are pervasive: “We appeal to causes even when, in a very real sense, we don’t know what these are: we seem almost perceptually built to infer the presence of causes, even if the theoretical understanding necessary to understand the nature of those causes lags far behind” (p. 153). Understanding the nature of causal attributions in general has had an enormous impact on our understanding of people, and has proved to have important implications for research in many areas of psychology including social, cognitive, industrial organizational and clinical psychology. Topics researched in these areas include psychological disorders such as depression and paranoia (Kinderman & Bentall, 1997, 2000), student and employee performance (Garland & Price, 1977; Perry & Magnusson, 1989), marital satisfaction (Fincham & Bradbury, 1987), parenting (Palmer & Hollin, 1997), education (Green, 1977), prejudice (Schmitt & Branscombe, 2002), criminal behavior (Palmer & Hollin, 1997), and coping skills (Roesch & Weiner, 2001).

Much of the research examining causal explanations involves the interpretation and explanation of human behavior (e.g., Malle, Moses & Baldwin, 2001). When considering social causality, in this case explaining others’ behaviors, causal explanations
often involve mental states such as reasons (i.e., desires, beliefs), causal agents, and the background knowledge of causal history (i.e., what would usually cause such an action) (Malle et al., 2001). Social psychologists Harvey and Weary (1984) argue that the main reasons people make attributions is to achieve a greater understanding of and control over their environment. They state “In its simplest form, attribution work is concerned with attempts to understand the factors involved in perceived causation” (Harvey & Weary, 1984, p. 428). Notice that this does not limit attribution work to social cognition. Perhaps the far reaching, almost limitless, nature of causal attributions is best described by the father of attribution theory himself, Fritz Heider. Heider (as cited in Harvey & Weary, 1984) explained attribution by stating that it is part of our cognition of the environment. Whenever you cognize your environment you will find attribution occurring. And any change in the environment gains its meaning from the source to which it is attributed (Heider, 1944). If the attributions we make are directly linked to the motivation to make sense of or control our environment, then when trying to understand the nature of attributions, we must consider the various environmental events one may encounter. The current research examines causal explanations for events involving change in natural and artifact kinds. However, such an examination involves considering and accounting for many of the same components that are used to reason about and explain causes of human behavior, and will therefore share some of the same foci (e.g., causal agents, knowledge about causes, mental states).

The following examination of causal reasoning begins with an introduction to causal understanding and provides an overview of various aspects of causal reasoning and the way in which this reasoning develops from birth to middle childhood. This is
followed by a discussion of the way in which questions can be used to elicit causal attributions and causal understanding, which can be examined in detail through explanations given by children. The focus of the subsequent section is on certain cognitive biases that are thought to influence causal understanding and explanations. The way in which causal explanations can differ when reasoning about natural kinds and artifacts is then discussed. This is followed by a rationale for why biological understanding is a worthwhile area in which to examine causal explanations. Various types of causal attributions including different kinds of causes as well as single and multiple causal chains are then discussed within this context. The aim throughout is to further our understanding of the way in which causal reasoning develops throughout childhood.

**Causal Understanding**

Ernst Mayr (1961) proposed that causal reasoning involves an interpretation of teleological or goal-directed phenomena, the prediction of future events, and an explanation of past events (“a posteriori causality”). In other words, according to Mayr, notions of causality begin with an interpretation of what is seen as purposeful or goal-seeking behavior. This is followed by the prediction of how that behavior affects what happens next. And finally, notions of causality conclude with an explanatory account of the cause-effect relationship. Further, these three elements of causal understanding seem to be influenced by various factors.

Bullock, Gelman, and Baillargeon (1982) identified and distinguished between three factors that influence the interpretation, prediction, and explanation of causal events in adults: *principles* underlying definitions of cause and effect, *stimulus information*
utilized in making causal attributions, and the role of knowledge about objects or events in causal attributions and explanations. Bullock et al. (1982) argued that there are at least three general principles, or cognitive assumptions, that underlie our beliefs about cause and effect. The first principle is called causal determinism, which refers to the assumption that events are, indeed, caused. Even if the precise cause is unknown, the event is not assumed to be causeless. A second principle, priority, refers to the understanding that causal relations are unidirectional: causes either precede or coincide with their effects. In other words, any happening that follows an event would not be considered a candidate for a cause of the event in question. Finally, the third principle outlined by Bullock et al. (1982) is the principle of mechanism. This is the assumption that either directly or indirectly, causes bring about their effects by “transfer of causal impetus”. Therefore, when searching for a cause, adults will look for those which they believe have the potential to cause the effect, and ignore those that they believe to be impossible causes.

The second factor distinguished by Bullock et al. (1982) and thought to influence the interpretation, prediction, and explanation of causal events involves the stimulus information involved in the event that is used when making causal attributions. When we do not have a complete understanding of an event, we rely on cues to help us make a decision about the cause of the event. For example, spatial and temporal contiguity of events are common cues used by adults because causes are often spatially and temporally related to their effects. Regularity with which events co-occur is another cue that can be used to make judgments about possible causes.
Finally, the third factor, the knowledge and understanding that one holds about a particular sequence of events is ultimately what leads to the choice of one cause, or set of causes, over another. Bullock et al. (1982) distinguished between two sources of knowledge: one that is specifically about the types of events involved, and another that is more generally about transformations over time. Specific event knowledge refers to what we know and what we may not know about the event and possible causes. For example, if we have never heard of a specific type of cause, we would not automatically assume it to be involved. Generally, causal events are understood in the way the objects involved relate to one another, how they transform one another, and the direction of this transformation. These components of our knowledge make up our general ability to track objects through time and over transformations.

The practice of causal reasoning and the search for explanatory causes can be found both cross-culturally and historically. Wilson and Keil (1998) offer the example of the rich explanations for disease and illness given by both laypeople and medical experts throughout history (e.g., witchcraft, phrenology). Although the causes proposed in these explanations were often incorrect, they were causal explanations nevertheless (Lindberg, 1992; Magner, 1992; Scarborough, 1969). Further, despite variations in the proposed mechanisms explaining disease and illness across cultures, cross-cultural research has demonstrated that the search for causal explanations, in this case for disease and illness, is also widespread across cultures (Atran, 1996). In other words, while the explanations may vary greatly, people across cultures and historical periods have felt compelled to explain events by proposing causes, and the origin of disease and illness is one area in which this has been demonstrated.
Although the causal reasoning of a young child might appear to be different from that of an adult, there is no doubt that the beginnings of causal understanding appear much earlier than was previously believed. Piaget (1930, 1974) characterized preschoolers as precausal. That is, he assumed they did not yet possess the underlying principles that adults used to interpret casual events. However, it is now generally believed that the methods employed in some of the procedures used by Piaget (e.g., 1930, 1974) in his research on causal understanding incorrectly characterized young children’s abilities (e.g., Bullock et al., 1982). That is, reliance on explanation for events with which children were unfamiliar, the cycle of the moon for example, did not allow children to appropriately demonstrate their use of causal principles. Despite these methodological difficulties, Piaget recognized the importance of examining the beginnings of causal reasoning, which is precisely what inspired more recent researchers to continue examinations in this area, with the use of age appropriate methods. Fortunately, this has led to the discovery that, contrary to the Piagetian notion that causal reasoning did not develop until well after the preschool years, even very young children may possess some of the basic principles involved in causal reasoning.

In fact, recent examinations of the development of causal understanding reveal a wide range of abilities, beginning with a recognition of causal events in infancy (e.g., Oakes, 1994; Rochat, Morgan, & Carpenter, 1997), followed by an initial and early surface understanding of causal events (e.g., Bullock, Gelman, & Baillargeon, 1982; Kushnir & Gopnik, 2005), leading to explanations of causal events (e.g., Hickling & Wellman, 2001), and finally progressing to a deeper level of causal understanding and
reasoning (e.g., Bullock, 1981; Naas, 1956). Each of these abilities is evident at different points throughout infancy and childhood. Specifically, the extant literature has traced the development of causal understanding from 3 months of age to well into childhood and even adolescence. Additionally, various studies that have examined causal reasoning have discovered that certain factors such as probability of outcome, type of causal agent, and contextual cues appear to affect causal reasoning abilities in infants and children (e.g., Kushnir & Gopnik, 2005; Oakes, 1994).

**Infancy.** Recent research on causal understanding has determined that some aspects of the preference for searching for and offering causes appears relatively early in the life of a human (e.g., Cohen, Rundell, Cashon, & Spellman, 1998; Morgan & Rochat, 1998; Oakes, 1994; Rochat & Morgan, 1995; Rochat, Morgan, & Carpenter, 1997). The existence of physical causality, or understanding of the causes involved in physical manipulation of objects, as well as social causality has even been examined as early as infancy. In fact, it has been argued that the ability to perceive social causality is evident in infants as young as 3 months of age (Rochat et al., 1997). Other research with 3- to 5-month-old infants has suggested that by this age infants can also demonstrate an understanding of their own body as a causal agent in the environment, as evidenced in a preferential-looking paradigm utilizing visual manipulations of infants’ own leg movements (Rochat & Morgan, 1995).

Research with 7- and 10-month-olds has shown how infants’ perception of physically causal relationships between objects continues to develop into the second half of the first year of life (Oakes, 1994). Specifically, by 7 months of age infants can use cues such as spatial or temporal contiguity to perceive causality and at 10 months of age
infants recognize causality even when the causal movement of two objects is dissimilar. Then, sometime between 10 and 15-months of age there appears to be a developmental shift (Cohen et al., 1998). When viewing a causal chain of events, or multiple events following one after another, each seemingly caused by the preceding event and resulting in a final outcome, 15- but not 10-month olds dishabituated to the replacement of a toy which adults judged to be the causal agent in a sequence. Perhaps the more complex nature of causal chains (i.e., the occurrence of multiple events) may serve to distract younger infants from recognizing and distinguishing causal agents from non-agents.

Preschool years. Examination of preschoolers’ understanding of physical causality has further demonstrated Piaget’s underestimation of childhood cognitive abilities. For example, Bullock and Gelman (1979) demonstrated that 3-, 4-, and 5-year-olds share the following, previously outlined, adult assumptions when making causal attributions for physical events: 1) priority: that causes are unidirectional; that they only either precede or coincide with their effects but do not follow them, 2) mechanism: their explanations focus on possible causes and ignore impossible causes, and 3) determinism: that events are indeed caused, they do not happen otherwise.

Different types of cues that may help children infer causal strength about an event (i.e., how likely one thing is to cause another) have also been examined in preschoolers. Kushnir and Gopnik (2005) created an interesting paradigm that involved a musically lighted “detector” that was activated, or not activated, when different blocks were placed on its surface. After a series of manipulated trials, children were asked to choose the best block to “make it go”. Results indicated that 4-year-olds were able to use probabilistic cues, particularly the frequency of activation, and opportunity for their own intervention
(i.e., how often they themselves were successful) to make judgments about cause-effect relationships (Kushnir & Gopnik, 2005). Specifically, children were able to use frequency of co-occurrence to make inferences about causal agents, choosing the block that most often activated the detector. Additionally, children weighed the effects of their own intervention more heavily than those of another person, choosing the block with which they themselves were most successful. However, when results of their own intervention were in conflict with the frequencies of co-occurrence, children preferred their own interventions (Kushnir & Gopnik, 2005). This suggests that while preschool children are capable of recognizing and utilizing frequency of co-occurrence as well as the effects of their own intervention, when forced to choose, the salience of self-intervention overrides frequency of co-occurrence when judging probabilistic causality.

**Explanations and Questions**

The way in which children search for and explain causal information about the world around them has been found to show an interesting developmental pattern. Specifically, Hood and Bloom (1979) found that children usually begin to make causal statements and causal responses to questions about the time their parents begin asking *why* questions, when the children were between 24 and 26 months old. When children were about 30 months old they began asking *why* questions themselves. Similarly, in another longitudinal study, Bloom, Merkin, and Wootten (1982) examined the spontaneous speech of seven children from about 22 to 36 months of age. Questions including the verb *how* were observed at about 33 months, followed by those including the verb *why*, at about 35 months. In another study, when speech samples were specifically analyzed and categorized with regard to modes of explanation (e.g.,
psychological, physical, biological) and entities being referred to in explanations (e.g.,
persons, animals, objects), it appears that children have an early interest in seeking out
explanations themselves by asking questions. Hickling and Wellman (2001) examined
speech samples from parent and child conversations when children were 2 to 5 years of
age. Analyses revealed that *why* questions occurred earliest, at age 2, and causal
questions occurred earlier than causal statements. This again suggests that the beginnings
of causal understanding are present early in life, and specifically that toddlers and
preschoolers are active in their search for causes.

However, it is important to note that the quality of children's explanations may be
a function of the type of question posed to them. There are a variety of ways in which
language in general, and questions in particular, can be a tool for gaining information. If
the goal is to ask the best possible question in order to reveal the child’s causal
framework, it is necessary to consider the nature of the question. Due to the fact that
questions differ in the type of causal responses they elicit, it is important to take care
when selecting them. One way in which the type of question posed influences the choice
of responses that make up an explanation concerns the temporal relationship between
cause and effect. Specifically, proximate cause explanations are those that refer to
mechanisms immediately preceding the event in question. Explanations which emphasize
causes or reasons for an outcome which are more removed from the event in question are
often termed distal causes. The way in which this temporal relationship between cause
and effect (proximate or distal) is used to explain an event is often the direct result of the
type of question posed.
Statements explaining *why* an event occurred can range from restating the phenomenon, to identifying salient features of the event, to listing a complex chain of casual mediators (e.g., one thing causing another, which in turn causes another, and so on) (Bullock et al., 1982). Moreover, *why* questions tend to result in “reason explanations” or mental states that help produce an intentional action, which can be thought of as the more distal causes of an event (Malle et al., 2001). On the other hand, we generally reference some implied or demonstrated mechanism, which more immediately precedes the event, a proximate cause, to explain *how* a cause worked to bring about its effect (Bullock et al., 1982).

Naas (1956) noticed that many of the early studies in this area, including those of Piaget, had presented children with *why* questions. He stated “It is quite possible that such questions direct the child’s thinking toward seeking some sort of purpose or motivation.” (p. 192). He addressed this issue by testing the hypothesis that questions worded to suggest the possible operation of animistic or dynamic forces (*why* questions) yield more non-naturalistic responses than those which are not worded as such (*how* questions) (Naas, 1956). In fact, findings indicated (Naas, 1956) that when 8- to 10-year-olds were questioned about *why* we have wind, and *why* clouds move, they were much more likely to give non-naturalistic responses such as “it’s a sign to tell you that rain is over”. On the other hand, when children were questioned with what Naas referred to as “non-suggestive” questions such as “*How* do leaves come to fall off the trees?”, children offered more naturalistic responses such as “they turn different colors, dry up, die, and fall off”. 
To further demonstrate the effect of question type, Bullock (1981) asked children to explain how or why several events occurred, ranging from simple sequences to complex chains of events. They were asked to explain this to either someone who had viewed the event, or someone who had not viewed the event. The results suggest that children’s explanations were more complete, as well as more mechanistic and physically oriented, when asked to explain how something occurred (vs. why) and when offering the explanation to someone who had not witnessed the event (vs. to someone who had). Results such as these suggest that children are sensitive to subtle manipulations, such as language and recipient of explanation, and thus care must be taken when interpreting children’s ability to reasoning causally, based on method of questioning (Bullock et al., 1982).

**Biases Influencing Causal Frameworks**

Related to the effects of question type there appear to be basic cognitive biases, or modes of construal, that constrain our thinking about the occurrence of different events (Keil, 1994; Wellman & Gelman, 1998). These biases in turn influence how we reason about and subsequently explain causal phenomena. Specifically, researchers have suggested that children seem to be operating under the influence of three ontological modes of construal that shape their understanding of biology and other domains: essentialism, teleology, and intentionality (Evans, 2000b, 2001; Gelman, 2004; Keil, 1994, 2003; Wellman & Gelman, 1998). These three modes of construal represent (1) the intuition that there are unobservable, underlying properties that make biological entities what we believe them to be (essentialism), (2) the belief that these entities exist to fulfill
some function or purpose (teleology), and (3) the notion that behaviors and actions are intentional (intentionality).

**Essentialism.** Susan Gelman (2003) argues that people possess an intuitive belief that there is some unobservable, underlying property that causes objects to be the way they are. In other words, humans make implicit assumptions about the underlying reality or true nature of an entity, called its essence. In the biological world, this leads to the belief that an organism’s essence remains stable and unchanged even though the organism grows, reproduces, and undergoes morphological transformations (Gelman, 2003). Some important implications follow from this argument. If children are essentialists, their concepts and assumptions about a wide variety of entities must reach beyond obvious and visible qualities and therefore play a role in their reasoning about the entities.

**Teleology.** An important assumption that guides human reasoning in the psychological domain is that an object’s existence and behavior are purposeful. This is known as a teleological, or what I will call *functional*, mode of construal (Keil, 1994; Kelemen, 1999). That is, adults, and children in particular, are likely to judge a variety of artifacts (human-made objects) and events as existing to serve a particular purpose or to perform a certain function. Functional causes are interesting because they do not immediately precede an event but can be thought of as more distal causes, or causal consequences that fulfill a need.

In addition to explaining the purpose of artifacts and the goals of actions, teleological explanations may also extend to living things, and even natural non-living things, such as rivers and rocks. Kelemen (1999) argues that this latter extension of the
natural non-living world may apply specifically to children. According to Kelemen, unlike adults, children do not limit their teleological or functional explanations to biological traits and artifacts. Instead, it is argued that children have limited information about the mechanisms of the natural non-living world, and in the absence of this knowledge children substitute their understanding of intentional and purposeful behavior. Thus, their intuitive reasoning, which inspires purposeful teleological explanations, may be qualitatively different from that of scientifically educated adults, whose reasoning is based on knowledge of the physical world. Recent support for this bias was demonstrated by DiYanni and Kelemen (2004) when they found that 5- to 9-year-olds viewed both natural and artifact kinds that no longer performed certain activities as needing to be fixed or even replaced. For example, children were just as likely to “replace” a cat which could not play around as they would a hammer that could no longer pound nails. In this way, the strong black and white nature of children’s teleological reasoning, stemming from their notions of intentional and purposeful/functional behavior, differs from that of adults, who tend to use teleological/functional reasoning more flexibly.

*Intentionality.* From a very early age children are likely to (a) view behaviors as intentional and (b) treat intentional behaviors as special (Malle et al., 2001). Intentional explanations often consist of mental states, which are more distal causes that initiate a mechanism immediately preceding an event. A child might decide to feed a dog, for example, and this thought and subsequent plan of action precedes the hand movements that are the immediate cause of the actual event—the feeding of the dog (Evans, in press). In “Intentions and Intentionality” Malle, Moses, and Baldwin (2001) argue that a behavior is likely to be judged as intentional if the agent desires the outcome, if the agent
believes that his or her behavior will lead to the outcome, and if the agent has the skill and awareness required to perform the behavior that leads to the outcome. Note that a crucial aspect of intentionality is the understanding of desire. Importantly, Harris (2000), along with Wellman and Gelman (1998) suggest that children understand desires before they understand beliefs and also refer to desires more often than they refer to beliefs, implying that children’s behavioral observations include the understanding of desire, which is an important criterion for understanding intentions.

Also, for both objects and natural kinds, children reference intention when naming entities (Gelman & Bloom, 2000), when naming pictorial representations of entities (Bloom & Markson, 1998), and when conceptualizing and categorizing entities (Bloom, 1996). The result, for a child, is a world filled with intentional behavior.

Essentialism, teleology, and intentionality thus influence children’s causal understanding across a variety of domains. One recent area of interest for developmental psychologists has been how intentional, essentialist, and teleological intuitions influence children’s causal reasoning in general, and how this varies across domains, particularly, across the natural and artificial worlds. Differential exposure to nature across cultures has led researchers to various interpretations of reasoning capabilities in children (Medin & Atran, 2004). However, children around the world are exposed, at least to some degree, to both natural and artifact kinds from birth. One important distinction is between living and non-living things, and even infants readily distinguish between animate and inanimate actions (Wellman & Gelman, 1998). If, from an early age children are sensitive to the distinction between these two broad classes of entities that make up their world,
they may treat living things, specifically animals, differently from artifacts when making judgments about casual events.

Natural Kinds versus Artifacts

Natural kinds are those entities not created by human beings, whereas artifacts are all of the objects in our world that are created by humans. As described above, at an early age children distinguish natural kinds from artifacts. However, Bloom (1996) suggests that the mental representation of artifact kinds is quite similar in structure to that of natural kinds, in that if an artifact is thought to be intentionally created to belong to a certain kind, it is classified as the same as others of that kind. However, natural kinds and artifacts also differ in important ways. Artifacts and natural kinds are not essentialized in the same way.

Keil (1994) argues specifically that natural kinds have clearer and causally more potent essences than artifacts. In addition, Keil makes the distinction that while properties for both groups have purposes, those of living things will be more self-serving and intrinsic than those of artifacts. He offers the interesting example of roses which have thorns to protect themselves, while barbed wire has barbs so as to keep animals from getting at something of value to humans, an extrinsic purpose. Keil (1995) found that 4-year-olds attribute distinct sets of causal relations to living kinds only, but not to artifacts.

A final important difference between artifacts and natural kinds involves the understanding of intent. Children are likely to consider the creator’s intent when judging what to name human-made artifacts and when deciding how to categorize them, a phenomenon specific to artifacts. Gelman and Bloom (2000) asked children to name simple objects that were either described to be created purposefully, or by accident. Even
3-year-olds were more likely to give the object an artifact name (e.g., ‘a knife’) if it had been intentionally created than if they believed it was created by accident (in the accidental situation children were likely to give material-based descriptions (e.g., ‘plastic’). In another study done by Bloom and Markson (1998) 3- and 4-year-olds were asked to draw a balloon and then a lollipop, which resulted in two identically shaped pictures. However, when asked to name the objects they had recently drawn, children appropriately labeled them according to the original intentions held while drawing each picture, and insistently corrected the experimenter when the same shape was labeled to be the opposite object.

_Causality within the Biological Domain_

The biological domain is a worthwhile area in which to examine causal reasoning because it is an area which children understand, as well as one that incorporates physical and psychological notions in addition to biological ones (Wellman and Gelman, 1998). Within the biological domain, several key topics have been examined. Children's explanations of death, inheritance, and illness are some of the areas that have been of interest in the past. More recently, causal responses explaining biological change, both at the macroevolutionary level, about the origin of species (Evans, 2000, 2001), and at the microevolutionary level, about adaptive changes or the origins of novel features within species (Szymanowski, 2005), have been examined. When considering explanations for these two types of change, the origin of whole species versus the origin of a feature or part of an animal, differential responses would be expected. Christian fundamentalist religious leaders, for example, claim that while God is responsible for the origins of species, adaptive changes within species are likely to be a function of natural
mechanisms. From this perspective, God endowed each "species" with an unique immutable essence, meaning that one "kind" cannot change into a completely different "kind," even though some variation within kinds might be expected (Evans, in press).

In children and lay adults, Evans (2000b, 2001, in press) demonstrated an interesting and systematic developmental pattern in their understanding of the origin of species. Age-related shifts in causal explanations were found from the early to late elementary school years. Initially, young children were likely to endorse creationist and/or spontaneous generationist explanations, then they shifted to an exclusively creationist account regardless of community beliefs, and finally they endorsed either evolutionist or creationist explanations in early adolescence, which reflected the beliefs of the adults in their community.

Spontaneous generationist accounts of species origins include explanations that are natural but non-transformational, implying that the organism was always on earth but not visible - it just appeared. For example, “the organism came out of the ground”. Creationist accounts attribute origins to some higher power or supernatural being, assuming an intentional and purposeful intelligent design. Examples of this include “God wanted, created, gave, or made” the organism. In younger children, these ideas seem to reflect children's emerging understanding of the origins of artifacts (i.e., that they were "made for a purpose"), which could well provide a base analogy that is then extended to the origins of animals (Evans, 2001). Finally, the evolutionist accounts of the origin of species found in early adolescence include explanations in which natural transformations from one kind of animal to another occurred. Children and adults were unlikely, however, to endorse Darwinian mechanisms of change in their accounts of biological
transformations and were more likely to reference a pre-Darwinian or “Lamarckian” mechanism of adaptation, growth, or development.

While there does appear to be a developmental pattern in the understanding of the origin of species, it is interesting to note that members of the public, rarely explain the concept of evolutionary change in the way Darwin proposed (Evans, 2000a, in press). Instead, many adults possess an “intuitive theory” of biological change in which it is assumed that variation is a result of a response to an environmental need (Evans, 2001). For example, the idea that giraffes have formed their long necks in response to the need to reach high into trees for food is common (Evans, 2001). However, this is largely a Lamarckian idea and according to Darwin’s theory of natural selection, it is incorrect (Audesirk, Audesirk, & Byers, 2001). Instead, natural selection accounts for changes in populations, not in individual members of a species (Audesirk et al., 2001). Although simplified, the following explanation is the way in which Darwin’s theory of natural selection accounted for species variation and the emergence of new species. A random change occurs first. Then, if that change is favorable for survival because organisms that possess the feature are better adapted to their environment, the result is a greater probability of reproduction. This is precisely the understanding that is lacking in folk or intuitive biological ideas about species variation and changes.

Interestingly, Keil (1994) suggests that this folk understanding of adaptation might arise somewhat earlier than originally suspected. He demonstrated that even kindergarteners are able to grasp and display some understanding of adaptation. However, at this point in development, the understanding can only be what is considered static adaptation, which assumes that every feature of an organism is adapted to a
specific environment, neglecting the role of the environment as a source of change (Evans, 2000a, 2000b, 2001). Because the endorsement of static adaptation assumes that the organism is destined to fit its surroundings, it is an understanding compatible with both creationist and spontaneous generationist accounts. However, dynamic adaptation incorporates the understanding of the inheritance of characteristics that are acquired in order to adapt to a changing environment, and thus is a belief that is typically endorsed only at a later point in development, in “Lamarckian” adaptationist accounts (Evans, 2000a).

In contrast to Evans’ line of research, in the current study children were asked about the origins of adaptive features, which should expose their conceptual frameworks regarding microevolutionary processes. For example, the long neck of a giraffe is an example of change within a species. Audesirk et al. (2001) define microevolution as “change over successive generations in the composition of a population’s gene pool”. Macroevolution, on the other hand is change that occurs at levels above that of the species. This would account for the evolutionary change that initiates the origin of “new” species, and therefore, compared to microevolution, it is an idea that has proven to be more incompatible with creationism (Poling & Evans, 2004).

For the purposes of this study, the topic of interest was children’s explanations of adaptive change within species, thus microevolution was the focus. Another important difference between the current research and the related studies by Evans concerns the type of questions asked. Whereas Evans’ participants answered only one type of question (i.e., how) about macroevolution, participants in the current research were asked either how or why questions about microevolutionary processes. Based upon these changes, that
is the use of *how* and *why* questions about microevolutionary (parts) rather than macroevolutionary (wholes) processes, it is predicted that the findings from the current research are likely to differ significantly from Evans’s research in theoretically interesting ways, as discussed below.

*Types of Causal Attributions*

*Proximate and distal cause.* Little research has been dedicated to identifying the specific way in which causal explanations change with age after the preschool years. For example, might children offer different types of causes throughout development, based on their understanding of causality. One distinction between different types of causes is that of proximate versus distal causes. Recall that proximate causes refer to mechanistic causes immediately preceding the event. For example, if asked “why did Jamie get an A on his exam?”, an explanation including a proximate cause would be “he answered all of the questions correctly” (i.e., what he did immediately before receiving the A). On the other hand, distal causes, which are sometimes also referred to as ultimate, original, or final causes, refer to causes further removed from the event in question. In the example of Jamie’s successful test performance, an explanation involving a distal cause would be “Jamie wanted very badly to pass the test so he studied very hard last week.” (i.e., what originated the process of test success).

Although it is specific to the biological domain, one of the most recognized distal-proximate cause distinctions was made by evolutionary scientist Ernst Mayr, in his 1961 article “Cause and Effect in Biology”. The term *ultimate* or *final* goes back to natural theology, and originally meant “caused by God” or “established at the time of creation” (Mayr, 1993). Mayr admits that this reference to creation may cause confusion so he
often uses the term evolutionary causation instead of ultimate or distal causation. Mayr primarily utilized this distal-proximate distinction in the domain of biology, but he argued that there is always a proximate set of causes and a distal set of causes, and that both have to be interpreted for a complete understanding of a given phenomena. Most generally, for biologists, proximate causes are involved in ontogenetic development (e.g., genes, DNA) and distal causes are factors in phylogenetic development (e.g., natural selection). An example offered by Mayr concerning the migration patterns of birds may help to better explain this distinction. Lack of food in the winter in ancestral environments and the genetic predisposition of the bird to migrate would be considered distal causes. These causes have a history and have been incorporated into the biological system through many thousands of generations of natural selection. On the other hand, the physiological condition of the bird interacting with the drop in temperature would create a set of proximate causes.

The types of causes examined in the current research can be categorized in terms of the distal-proximate distinction as well, based on their temporal proximity to the event in question (see Table 1, for a summary). Recall that intentional mental state explanations are considered to be distal causes because they are farther removed from the event in question. Oftentimes, creationist accounts include intentional mental state explanations (e.g., “God wanted it that way”) and are thus consistent with ultimate or distal cause reasoning. In this way, the response seems to imply that the effect actually precedes the cause, as a causal consequence. However, unlike the mental state intention just discussed, explanations that involve an intentional or goal-directed action (e.g., “God made it”), more immediately precedes the event in question and is therefore most likely used as a
proximate cause. It is worth noticing that creationist responses that contain intentional mental states are compatible with theistic evolutionary responses, implying that God set in motion a series of naturalistic events. On the other hand, proximal responses such as those referencing intentional actions are more consistent with literal accounts of the bible in which God is the immediate cause of the origin of species (Evans, in press).

Naturalistic growth is thought to be a proximate cause because these changes most often immediately precede the event in question (e.g., “Animals grew them from their body”). However, recall that natural causes that reference evolutionary mechanisms are considered to be distal causes because their influence is farther removed from the event (Mayr, 1993).

The final type of cause considered in the current research relates to the teleological or functional bias. Functional causes are somewhat difficult to classify using this metric, because they do not immediately precede the event in question and are thus, in some sense, more distal causes, or causal consequences (i.e., fulfilling a need). Yet, one cannot be sure how a respondent is using the functional cause. Investigating more precisely how children and adults use these causes to explain an event is a focus of the current research.

Table 1 presents a potential framework for categorizing responses in terms of distal and proximate causes. In two studies, these responses are investigated in detail and particular patterns of responding to different target domains are compared. The potential application of this proximal-distal framework to these responses is addressed in the general discussion.
**Why and how questions.** As previously mentioned, evidence indicates that *why* and *how* questions differ in the type of responses they elicit. Recall that explanations involving mental states or need based reasons often follow *why* questions. In the current research, I examine whether *why* questions elicit intentional or functional causes and whether or not this pattern changes with age. Responses to *how* questions, on the other hand, most often reference an implied or demonstrated mechanism or cause (e.g., an intentional or natural action), which more immediately precedes the event (Bullock et al., 1982). Thus the focus for *how* questions was whether they elicit proximate or mechanistic causes and whether this changes with age. Various types of causes may be used in response to either type of question. The responses coded in the current set of studies, as well as examples of each explanation, are outlined in Table 1. Responses involving intentional causes are those containing intentional mental states or intentional or goal-directed action, such as someone’s ideas or the actual creation of an entity. Functional responses are made up of either intrinsic or extrinsic need-based causes. Naturalistic explanations can include natural mechanisms like growth, which can be thought of as taking place immediately before the event, or can be more evolutionary-based, preceding the event by millions of years and encoded genetically. Explanations from children and adults in the current set of studies are coded as including any one or a combination of these types of causes. The pattern of endorsement of these causes for *how* and *why* questions, and how this changes with age, is one focus of this research.

**Causal chains.** Not only are causal explanations made up of different types of causes but they can also be made up of a varying number of causes. For example, while a single proximate cause can be a sufficient explanation for some events, it is also possible
that an event may be interpreted as being caused by a more complex chain of causal mediators, where distal causes set off a sequence of events leading to more proximate causes. How and when are proximate and ultimate causes integrated into a complex causal chain? Cohen et al. (1998) defined a causal chain as multiple events following one after another each seemingly caused by the preceding event and resulting in a final outcome. When and how might reasoning about an event shift from considering a single causal candidate to making allowances for multiple causes linked into a causal chain? It is possible that the elicitation of different types of causes and different numbers of causes changes over development, as children's causal reasoning increases in both capacity and flexibility. It is also important to determine if, in fact, distal causes are part of a causal chain. Specifically, when distal causes are offered by an adult or by a child they may or may not be considered as the original cause of a causal chain. The identification of such patterns is an additional focus of the proposed research.

Summary. The major focus of the current research is the development of causal reasoning in school aged children and adults. Change in explanations were examined by coding children's and adults' use of intentional, functional, and naturalistic causes, in response to how and why questions, (see Table 1, for a summary). The focus is on explanations for biological changes in non-human animals. Humans and artifacts are also included as they offer an informative comparison with the animal targets. Two studies are included in the current research. In Study 1, causal responses from 5- and 6-year olds and their parents are examined. Study 2 extends the childhood age range by including three groups of school-aged children ranging in age from 5- to 14 years.
The purpose of Chapter One was to lay out a general introduction to both studies. Included in Chapter Two is an introduction, method, results, and brief discussion of the first study. Chapter Three includes the same sections for the second study. Finally, in Chapter Four there is a general discussion of the research findings for both studies. Additionally, in the discussion, the extent to which children's and adults' responses can be characterized as proximal or distal causes, and whether the proposed proximal-distal framework (see Table 1) can be applied to these responses, is addressed.
Chapter Two

Study 1

It appears that a variety of developmental, conceptual, linguistic, and contextual factors influence the way in which children reason about causes. The extant body of literature in this area has begun to provide a solid foundation for understanding how and when infants and children recognize and understand causal relationships. In an effort to more precisely target the factors influencing the development of children's causal explanations about biological change within species, Szymanowski (2005) manipulated question type (how and why) and knowledge domain (natural and artifact targets of a causal event) when examining explanations of adaptive change from 8- to 12-year-old children and their parents. Open-ended responses from preadolescent children and their parents were examined. Responses were categorized by the presence or absence of different types of causes: intentional, functional, naturalistic action, and evolutionary (see Table 1). A unique contribution of this study was the inclusion of different question types, in that children and adults were asked either how or why questions. As discussed previously, question type has been hypothesized to influence explanations, with naturalistic causes offered for “how” questions and intentional and teleological causes offered for “why” questions (Alessi, 1992).

Interestingly, Szymanowski (2005) found that children did distinguish between question type. In answering why questions about the origins of body parts, such as a
butterfly's wings, all respondents offered teleological causes (e.g., they needed them). However, surprising results were revealed when examining responses to the how questions. Children were more likely to offer naturalistic causes (e.g., growth) and adults were more likely than children to offer creationist responses (e.g., “God made them”, “God knew they needed them”). For artifacts, however, children, like adults, offered intentional actions to explain how chairs got their legs (e.g., “Someone made them like that”).

In conclusion, when asked to reason about the origins of both animal and artifact parts, 8- to 12-year-olds were capable of distinguishing between question type and, in contrast to adults, preferred the use of naturalistic causes when reasoning about natural kinds in response to how questions. It is worth noting that participants in this original study (Szymanowski, 2005) were initially asked a series of questions focusing on the origin of various species before they were asked about the origin of their parts. It is possible that questions about the origins of species triggered intentional creationist responses (e.g., “God put them here”), which could have primed adults to respond with intentional explanations for both natural and artificial kinds. Additionally, adults were asked if they would change their explanations if they were asked to respond to a 3- to 4-year-old instead of a 10- to 12-year-old. Parents were inconsistent, with half of the sample choosing to change their responses in some way for younger children, and the other half choosing to offer the same explanation to both age groups.

Of particular interest in this previous study (Szymanowski, 2005) is that, although children and adults differed on the types of causes they attributed to the events in question, they did not differ on the number of causes reported. Instead, children and
adults alike chose a single mechanism or cause for explaining the event. While it is possible that adults reasoned through a series of mediating causes and arrived at the most distal or original cause, deciding that would be the most appropriate response, the evidence is not conclusive. Adults may never have considered the more proximate causes such as growth to be equally valid.

An obstacle to solving this issue in this previous study (Szymanowski, 2005) concerned the nature of the interview/questionnaire format. Children and adults were presented with open-ended questions to which they responded verbally and in writing. Examination of responses to such questions revealed that one of three main reasoning patterns were endorsed when explaining changes in the biological domain: teleological/functional reasoning (e.g., exist for a purpose), intentional reasoning (e.g., were intelligently designed), and naturalistic reasoning (e.g., growth). It is possible that adults did not take the necessary amount of time it would require to record all of the causes or even all of the candidate causes involved in their reasoning. However, if given the opportunity to endorse a variety of causes in a forced-choice format, adults might then endorse multiple causes including both proximate and distal causes. In the current study a forced-choice format was adopted. This also had the advantage that it would allow much younger children to be included, whereas before they were excluded due to their limitations in answering open-ended questions. While lack of elaboration due to limited productive vocabulary is an issue for young children presented with open-ended questions, a forced-choice format where different options are available for the child could eliminate this barrier.
The overall goal of the current set of studies was to understand the development of causal reasoning from childhood to adulthood. This was done by examining patterns of causal responding within different contexts. In the first study, I examined the influence of age and question type (how, why), on causal explanations for different knowledge domains, animal, human, and artificial kinds. As described earlier, these different domains should elicit different patterns of responding (Evans 2001; Gelman & Bloom, 2000; Keil, 1995; Szymanowski, 2005). If children and adults shift their patterns of response, depending on the knowledge domain and question type, then they will be exhibiting causal flexibility (Poling & Evans, 2002). Alternately, young children, in particular, in contrast to the 9- to 12-year-olds in Szymanowski (2005), may default to established and less flexible modes of responding, such as the promiscuous teleology found among younger children in Kelemen's studies (1999).

In Study 1, 5- and 6-year-old children and their parents responded to questions about animals, humans and artifacts in open-ended and closed-ended formats. In the latter case, they were provided with a variety of responses that could potentially assess naturalistic, (mechanistic or proximate) causes and teleological and intentional causes. Specifically, children and adults were asked to rate their endorsement of different responses to how and why questions about the origins of functional parts in animals, humans and artifacts. Interest lies in how question type and age affected the type of causes attributed to the knowledge domain in question.

Research predictions. The predictions are outlined below. In the primary analyses, the focus is on the pattern of responding, by age group, in different knowledge
domains, the distinction between why and how questions, and the use of causal chains demonstrated in different formats.

(1) **Reasoning Patterns in Knowledge Domain.** The type of reasoning children and adults engaged in was expected to be influenced by knowledge domain (animal, human, artifact), age, and the type of question asked (why, how). Specifically, age differences were expected when responding about natural kinds. Within the animal domain, it was expected that naturalistic causes would be preferred by children and intentional causes by adults, particularly for *how* questions (Szymanowski, 2005). In contrast to animals, it was predicted that children and adults would perform similarly when responding to questions about artifacts, by offering functional explanations for *why* questions (Kelemen, 1999; Szymanowski, 2005) and intentional explanations for *how* questions (Szymanowski, 2005). A secondary prediction posed was that evolutionary reasoning would be limited in its use, but increase with age (Evans, 2000a, 2001, in press). This pattern was also expected to be used only for natural kinds.

(2) **Question type.** In the current set of studies children and adults were expected to differentiate between question type by offering functional responses to *why* questions and different mechanisms (e.g., growth for children and intentional action for adults) to *how* questions (Bullock et al., 1982; Malle et al., 2001; Naas, 1956).

(3) **Causal chains in Open- versus Closed-ended Questions.** Open-ended responses from children and adults were expected to be causally limited, most likely including only a single primary cause (Szymanowski, 2005). It was expected that the presentation of a closed-ended multiple-cause format would elicit an increased number of explanations from both children and adults.
Method

Participants. Participants included 26 5- and 6-year-old children\(^1\) (with a mean age of 5.7 years) and their parents \((n = 23)\), from different faith traditions. Families from Toledo, Ohio and surrounding communities were recruited via mail and telephone to visit the lab where data were collected through child interviews and parent questionnaires, see Appendices A and B, respectively. While parents completed the questionnaire they were able to see and hear their children via a baby monitor and one-way mirror leading to the room where their child was being interviewed by the experimenter. The child sample was approximately 79% European American, 17% Multi-racial and 4% Hispanic. Parents were predominantly female (85%) and children were split almost equally by gender (12 males and 14 females). Approximately 30% of the children attended a Catholic school, 30% attended public school, 22% attended a Christian Preschool, 9% attended private preschool, 4% attended charter school, and 4% were home schooled. Place of worship was also reported by parents. Religious demographics were as follows: 51% Catholic, 12% Lutheran, 8% Non-Denominational Christian, 4% Greek Orthodox, and 20% reported not attending any place of worship (5% did not respond to this item).

Design. Before beginning the interview, the participant was placed into one of two conditions, those receiving *how* questions or those receiving *why* questions. In addition to obtaining consent from the University of Toledo Human Subjects Committee, parental consent was obtained for each child participant (see Appendix C) and verbal assent was also obtained from each child and recorded prior to beginning the interview.

\(^1\) Study 1 included two pairs of siblings. One child from each pair was randomly selected and removed. Analyses were repeated and significant outcomes remained unchanged. Therefore, all children remained in dataset.
(see Appendix D). With parent and child permission, all child interviews were audio-taped. (See Appendix E for interview form.)

Participants were further divided into two age groups (Child, Adult). The Child group ranged in age from 5.0- to 6.6-years, with a mean age of 5.7 years (How = 13, Why = 13). In the Adult (parent) group, 12 participants answered How questions and 11 answered Why questions. The age of the adult group was not determined.

Materials. Materials used in the child interview included a set of 15 animal and artifact laminated photographs, identical to the 15 images depicted in Appendices A and B. A set of four (dis)agreement cards was used to assess the level of agreement with each statement. Each card was labeled with a number 1-4, depicted a smiling/frowning face, and the words “(dis)agree a lot” or “(dis)agree a little” (i.e., 1: disagree a lot, strong frowning face; 2: disagree a little, weak frowning face; 3: agree a little, weak smile; 4: agree a lot, strong smile). Materials for the parent questionnaire consisted only of the questionnaire itself (see Appendix B).

Procedure

Warm-up task. Prior to questioning, all children successfully completed a task that served both as a warm-up and as an indication that they were familiar with the items they would later be asked to use (photographs and (dis)agreement cards). During the warm-up children were asked to identify at least one exemplar from each of five target groups using the photographs they would be using in the interview. They were then asked to use the (dis)agreement cards in response to some true or false statements made by the experimenter about some of the photos. For example, the experimenter would present the
photograph of a frog and state “If I said ‘This is a dog’ using these cards, would you agree or disagree?” All children demonstrated correct usage of the cards.

Open-ended questions. Participants were given a series of five open-ended questions (how or why) about the adaptive change of animals, humans, and artifacts. Before beginning this section, children heard the following:

“Now, I want you to tell me your own ideas about how some things got their parts. There are no right or wrong answers to the questions, just different kinds of ideas. Think about what you would say if another kid asked you these questions. So if another kid asked you “[child’s name], how/why did the ______”. Now, think about the X. "How/Why do you think Xs get Xs?”

Instructions on the parent questionnaire asked the adults to respond as if the question had been posed by the 10- to 12-year-old child. Children (verbally) and adults (written) were able to respond with as much or as little information as they preferred. If the child hesitated the experimenter probed the child with the following statement: “I would like to hear any ideas you might have, whatever you think. Remember there are no right or wrong ideas.” Then the question was repeated. The order of entities and their parts questioned about were as follows: Butterfly/wings, deer/antlers, frog/webbed feet, human/hands, chair/legs.

Responses were coded by two trained undergraduates, using a coding scheme adapted from previous research in which children answered similar questions (Szymanowski, 2005), see Appendix F. Each response was assigned to one or more reasoning patterns according to the explanations utilized in the response. It is worth noting that while a variety of causes were coded for the open-ended questions, different types of causes were collapsed together under one of the six main reasoning patterns. For
example, responses that included intentional agents, actions, and mental states were collapsed together under the term “intentional causes”.

Each response received a score ranging from 0-1 for each of the six reasoning patterns/explanations. Since the five coded responses contained three pertaining to animals, one to humans, and one to artifacts, the animal scores were averaged across the three exemplars when analyzed. This resulted in each domain (animal, human, artifact) receiving a score ranging from 0-1 for each of the six reasoning patterns/explanation-types. Coding was done individually, with an original reliability ranging from 95.8 – 100% and an average reliability of 98.5%. All disagreements were resolved to 100% agreement before final coding was entered.

_Closed-ended questions._ After completion of the warm-up and open-ended portions of the interview, participants were given a series of 15 forced-choice questions about parts of different entities. The _how/why_ condition remained the same throughout the interview. The questions focused on eliciting the reasons/causes for the existence of adaptive parts in humans (e.g., hands) and animals (e.g., butterfly wings), and parts of artifacts (e.g., chair legs): _How or why_ these randomly ordered entities got their parts. Participants were asked to then rate their level of agreement with three statements that followed each question.

Both children and adults were told that these responses were given by children and that they should rate their own level of agreement with each response. These statements were created from prototypical responses given by older children in previous studies when asked the same questions in an open-ended format (Szymanowski, 2005). Specifically, the most common responses given by 8- to 12-year-olds, from each of three
reasoning patterns (intentional, teleological, naturalistic), were selected and utilized in the current study. Recall the example of intentional agents, mental states, and actions being collapsed together under “intentional causes”. Since intentional agents and actions were the causes given most frequently under this reasoning pattern, intentional action was chosen as the focus for this reasoning pattern. Thus the following explanations were presented after each question: “Someone or something made it” (intentional), “It needed them” (teleological), “It grew them” (naturalistic). The order of these statements (reasoning patterns) following each question was randomly pre-determined. For the child interview, the order in which each target entity was used was randomly determined by the child by choosing from the pile of cards faced-down on the table in front of them.

Thus for each of 15 exemplars (3 humans with hands, 3 butterflies with wings, 3 frogs with webbed feet, 3 non-human mammals- a deer with antlers, a rabbit with ears, and a squirrel with paws, and 3 artifacts- a cup with a handle, a chair with legs, and a door with a handle), participants were shown a picture and given the three causes/reasons for an exemplar’s adaptive parts. They rated their level of agreement to each question using the 1-4 (dis)agreement scale. If participants agreed, by choosing scale level 3: agree a little, or 4: agree a lot for the intentional or teleological choice, they were then asked to state who or what made the parts, and what they needed them for, respectively. Upon completion, children were given a small thank-you gift along with a certificate of participation.

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2 Intentional mental states were referenced six times only, across both studies. All remaining references coded in this reasoning pattern included intentional agents and actions.
Results

For the open-ended questions, the primary analysis consisted of a 2 (age group) X 2 (question type) X 6 (causal explanations) mixed factorial Analyses of Variance (ANOVAs), with causal explanation as a repeated measure. This analysis was repeated for each of the three knowledge domains. These were performed to identify reasoning pattern use by age and by how/why questions within each domain. Of particular interest was the animal domain, with the human and artifact domains included as comparisons. These analyses were then followed by three 2 X 2 X 3 analyses with the closed-ended questions, one focused on the animal domain and the other two including the human and artifact domains, for comparison. Finally, an analysis of multiple-cause endorsement for both open- and closed-ended questions was included in order to identify differences between open- and closed-ended questions in terms of the number and kind of causes endorsed.

Before each set of results, patterns of responding that were of interest for each domain are highlighted; they can be seen in the set of figures accompanying each analysis. All figures display the means and standard errors. Note that for both open and closed-ended questions, figures include only the three main reasoning patterns of interest: Intentional, Functional, and Naturalistic. Other reasoning patterns (Essentialist, Evolutionist, and Other) were included in open-ended analyses but excluded from the figures for sake of visual clarity. These were not examined in detail because they were rarely referenced in the open-ended format, and not presented at all in the closed-ended format. However, any hypothesized age differences within the use of a specific explanation were examined using correlation analyses and follow the primary analyses.
Open-Ended Questions

Primary analyses for the open-ended questions focused on determining the ways in which age, question type and causal reasoning varied according to a particular domain of knowledge. It was expected that, for natural kinds (animals and humans) both children and adults would respond with functional explanations to why questions, and with different mechanistic explanations to how questions. That is, age differences were predicted in the use of these different mechanisms to answer how questions (i.e., naturalistic causes would be preferred by children and intentional actions would be preferred by adults). For artifacts, a distinction in question type as well as a similar pattern of responding from children and adults was predicted, where functional explanations were used for why questions and intentional explanations were used for how questions.

Thus, for each knowledge domain (animal, human, artifact), a 2 (age group) X 2 (question type) X 6 (explanation) mixed factor repeated measures ANOVA was conducted on the mean number of endorsements for each explanation. Where there were significant interactions, further analyses consisted of two- and one-way ANOVAs and post-hoc Bonferroni/Dunn tests (to adjust for multiple comparisons). Endorsement scores were averaged across the exemplars for each knowledge domain and thus represent the mean level of endorsement with a particular explanation (1 = presence, 0 = absence). Animal scores were averaged across the three animal targets for ease of comparison with the single human and artifact target. Finally, secondary analyses comparing the use of a particular explanation across targets, or change in the use of a particular explanation with
age, were performed and included only if they were of specific interest if the primary results were not clear-cut.

*Animals.* As can be seen in Figure 1, *how* questions elicited naturalistic responses and *why* questions elicited functional responses. Age differences are evident in the use of the functional response for *why* questions, with adults endorsing this explanation more than children. The analysis of responses to open-ended questions about animals (e.g., “How/Why did the butterfly get wings?”) revealed a main effect of age $F(1, 45) = 10.48, p < .01, \eta^2 = .19$ and a main effect of explanation $F(5, 225) = 27.00, p < .01, \eta^2 = .38$. Interactions were found between explanations and age $F(5, 225) = 2.88, p = .02, \eta^2 = .06$, between explanations and question type $F(5, 225) = 29.70, p < .01, \eta^2 = .40$ as well as between explanation, age, and question type $F(5, 225) = 2.79, p = .02, \eta^2 = .06$.

One-way ANOVAs split by age and question type reveal an effect for *how* questions in both the child $F(5, 60) = 36.32, p < .01, \eta^2 = .75$ and adult $F(5, 55) = 17.08, p < .01, \eta^2 = .61$ age groups. Bonferroni/Dunn post-hoc tests revealed that both children and adults significantly used naturalistic explanations (e.g., “they grew them”) more than each of the other explanations ($ps < .01$). Analyses for *why* questions also reveal effects for the child $F(5, 60) = 3.13, p = .01, \eta^2 = .21$ and adult $F(5, 50) = 18.21, p < .01, \eta^2 = .65$ age groups. Post-hoc comparisons indicate that while both children and adults most preferred the use of functional explanations (e.g., “they needed them to fly”), adults preferred this more than all other types of explanations, and children did so only significantly more than evolutionist (e.g., “they evolved”) and “other” (e.g., “leaves fell on them”) explanations ($ps < .01$). Comparisons between the child and adult age groups
for functional responses to why questions revealed that adults used functional reasoning significantly more than children $F(1, 22) = 9.61, p < .01, \eta^2 = .30$.

**Humans.** As can be seen in Figure 2, for why questions, there is a clear preference for functional explanations over all other responses, whereas the pattern for how questions was not clear-cut. Examination of responses to open-ended questions about humans (i.e., “How/Why did the human get hands?”) revealed main effects of age $F(1, 45) = 10.15, p < .01, \eta^2 = .18$ and of explanation $F(5, 225) = 5.31, p < .01, \eta^2 = .11$, as well as an interaction between question type and explanation $F(5, 225) = 6.66, p < .01, \eta^2 = .13$. The mean endorsement of all explanations (with standard deviation in parentheses) for the main effect of age were .15 (.05) for children and .22 (.09) for adults. A two-way repeated measures ANOVA investigating the interaction of question type and explanation reveals a main effect of explanation $F(5, 235) = 5.30, p < .01, \eta^2 = .10$, and an interaction of explanation by question type $F(5, 235) = 6.69, p < .01, \eta^2 = .13$.

One-way ANOVAs for each question type revealed effects of explanations for both how $F(5, 120) = 4.37, p < .01, \eta^2 = .15$ and why $F(5, 115) = 7.78, p < .01, \eta^2 = .25$ questions. Post-hoc tests indicate that for how questions participants prefer naturalistic explanations more than both evolutionary and “other” explanations ($ps < .01$), and for why questions participants prefer functional causes over all other types ($ps < .01$).

**Artifacts.** Figure 3 displays the pattern of responding for how questions in which participants preferred intentional explanations, and for why questions in which participants preferred functional explanations. Obviously, but of important note is that naturalistic explanations were not used at all. For both children and adults, intentional and functional responses were most preferred.
The 2 (age) X 2 (question type) X 6 (explanation) mixed factor ANOVA for questions about artifacts (i.e., “How/Why did the chair get legs?”) revealed a main effect of age $F(1, 45) = 4.90, p = .03, \eta^2 = .10$, a main effect of explanation $F(5, 225) = 32.14, p < .01, \eta^2 = .42$, an interaction between explanation and age $F(5, 225) = 3.84, p < .01, \eta^2 = .08$, and an interaction between explanation and question type $F(5, 225) = 16.26, p < .01, \eta^2 = .27$. A two-way ANOVA for explanation and age revealed main effects of age $F(1, 47) = 5.05, p = .03, \eta^2 = .10$ and explanation $F(5, 235) = 24.67, p < .01, \eta^2 = .34$ as well as an interaction between age and explanation $F(5, 235) = 3.09, p = .01, \eta^2 = .06$.

A two-way ANOVA for explanation and question type revealed an effect of explanation $F(5, 235) = 29.73, p < .01, \eta^2 = .63$ and explanation by question type $F(5, 235) = 15.58, p < .01, \eta^2 = .25$. When split by question type, analyses for the how questions indicate a main effect of explanation $F(5, 120) = 26.14, p < .01, \eta^2 = .52$, where participants used intentional explanations more than all others ($ps < .01$). For why questions $F(5, 115) = 19.62, p < .01, \eta^2 = .46$ participants used functional explanations more than all others ($ps < .01$).

Once split by age group, main effects of explanation for the child $F( 5, 125) = 5.93, p < .01, \eta^2 = .19$ and for the adult $F(5, 110) = 24.30, p < .01, \eta^2 = .53$ age groups were revealed. Bonferroni/Dunn post-hoc tests indicate that when asked about artifacts children prefer intentional explanations over naturalistic and evolutionary explanations ($ps < .01$) and use functional explanations significantly more than naturalistic, evolutionary, and “other” explanations ($ps < .01$). Adults, on the other hand, prefer to use intentional and functional explanations, which were the only two types used, more than all others ($ps < .01$).
Evolutionary reasoning. Recall the specific reasoning pattern prediction that although evolutionary explanations would be limited, their use would increase with age. This prediction was examined in a secondary analysis examining the correlation for use of this reasoning pattern and age group. The use of evolutionary reasoning (e.g., “They evolved over millions of years”) was positively related to an increase in age, $r = .18, p < .01$.

Summary. As expected, it seems clear that when looking at the types of explanations that were used the most when open-ended questions were asked, the type of question (how or why) was especially important. That is, whether reasoning about animals, humans or artifacts, both adults and children used different types of reasoning depending on whether they were asked how something happened or why something happened. When questioned about changes in both natural kinds and artifacts, the posed hypotheses were confirmed when participants offered functional causes to explain why something occurred. But when explaining how something happened, in the case of natural kinds, particularly animals, participants offered naturalistic causes while in the case of artifacts they offered intentional causes. This finding confirms two specific predictions which were posed about how questions: that intentional causes are preferred for artifact change and that children prefer naturalistic explanations for change in natural kinds. Further, while it is clear that participants distinguished between question type, as predicted, the expected preference for the intentional explanation by adults was not found for responding about how natural kinds received their parts.

Finally, as predicted, an increase in evolutionary explanations with age was found. In fact, this reasoning pattern was used only by adults, used only in response to
questions about natural kinds, and even in this case used very limitedly. See Table G9 for means and standard deviations.

**Closed-Ended Questions**

As with the open-ended questions, it was expected that, for natural kinds children and adults would respond with functional explanations to *why* questions, and with different explanations to *how* questions (i.e., naturalistic causes would be preferred by children and intentional causes would be preferred by adults). For artifacts, a distinction in question type as well as a similar pattern of responding from children and adults was predicted; functional explanations would be used for *why* questions with intentional explanations used for *how* questions. However, in contrast to the open-ended questions, it was expected that, within each domain, the presentation of causes would elicit endorsement of an increased number of explanations.

A 2 (age group) X 2 (question type) X 3 (explanation) mixed factor repeated measures ANOVA was calculated on agreement level with each explanation and this was done for each knowledge domain (3: Animal, Human, Artifact), resulting in three primary analyses. Where there were significant interactions, further analyses consisted of two- and one-way ANOVAs and post-hoc Bonferroni/Dunn tests (to adjust for multiple comparisons). Agreement scores were averaged across the exemplars for each knowledge domain and thus represent the mean level of agreement with the statement endorsing a particular explanation (1 = strong disagreement, 4 = strong agreement). Finally, secondary analyses comparing the use of a particular explanation across domains, or change in the use of a particular explanation with age, were performed and included only if they were of specific interest if the primary results were not clear-cut.
**Animals.** As can be seen in Figure 4, for how questions participants preferred naturalistic explanations just as they did with open-ended questions. However, in this case they also endorsed functional explanations. For why questions functional responses were most significantly preferred, as was the case with all of the open-ended why questions. However, it can be seen that although to a lesser degree, children also endorsed intention and adults endorsed intentional and naturalistic causes.

The results indicated that when answering questions about the adaptive features of animals (e.g., “How/Why did the butterfly get wings?”) there was a main effect of explanation \( F(2, 68) = 14.80, p < .01, \eta^2 = .30 \) and an interaction between explanation and question type \( F(2, 68) = 6.89, p < .01, \eta^2 = .17 \). A two-way ANOVA for explanation by question type revealed a main effect of explanation \( F(2, 72) = 14.43, p < .01, \eta^2 = .29 \) and an interaction of explanation by question type \( F(2, 72) = 7.37, p < .01, \eta^2 = .17 \). For how questions \( F(2, 36) = 13.18, p < .01, \eta^2 = .42 \) participants endorsed functional (i.e., “they needed them”) and naturalistic (i.e., “they grew them”) explanations significantly more than the intentional explanation (i.e., “someone or something made them”) \((ps < .01)\). For why questions \( F(2, 36) = 8.43, p < .01, \eta^2 = .32 \) participants endorsed functional explanations more than both intentional and naturalistic explanations \((ps < .01)\).

**Humans.** Figure 5 displays the pattern of responding in which participants preferred functional responses when answering how questions. For why questions functional responding was yet again preferred over both other types of responses. And although to a lesser degree, just as with open-ended animal questions, children also endorsed intentional causes and adults also endorsed intentional and naturalistic causes. Age differences appear when considering the use of naturalistic responses. Children and
adults both most highly preferred functional causes but adults also preferred naturalistic responses.

When answering questions about the adaptive features of humans (e.g., “How/Why did the human get hands?”) there was a main effect of age, $F(1,40) = 7.90, p = .01, \eta^2 = .17$ as well as a main effect of explanation, $F(2, 80) = 11.64, p < .01, \eta^2 = .23$. Results also indicated an interaction of explanation by age, $F(2, 80) = 7.52, p < .01, \eta^2 = .16$ and an interaction of explanation by question type, $F(2, 80) = 5.75, p = .01, \eta^2 = .13$.

A two-way ANOVA for the explanation by question type interaction above revealed an effect of explanation $F(2, 84) = 11.08, p < .01, \eta^2 = .21$ and an interaction of explanation by question type $F(2, 84) = 5.71, p = .01, \eta^2 = .12$. Effects for how questions $F(2, 40) = 5.05, p = .01, \eta^2 = .20$ indicate that participants endorsed functional (i.e., “they needed them”) more than intentional (i.e., “someone or something made them”) responses ($p < .01$). For why questions $F(2, 44) = 12.14, p < .01, \eta^2 = .36$ participants endorsed functional explanations more than both intentional and naturalistic responses ($ps < .01$).

A two-way ANOVA of the explanation by age factors revealed an effect of age, $F(1, 42) = 8.12, p = .01, \eta^2 = .16$, an effect of explanation $F(2, 84) = 10.59, p < .01, \eta^2 = .20$, and an interaction of explanation by age $F(2, 84) = 7.24, p < .01, \eta^2 = .15$. Children $F(2, 46) = 10.62, p < .01, \eta^2 = .32$ preferred to endorse functional responses over both intentional and naturalistic responses ($ps < .01$), while adults $F(2, 38) = 7.76, p < .01, \eta^2 = .29$ preferred functional and naturalistic explanations more than intentional explanations ($ps < .01$).
Artifacts. As can be seen in Figure 6, participants appear to be responding to how and why questions similarly, by using functional and intentional but not naturalistic explanations. This pattern of responding mimics that from the open-ended artifact questions except for the additional endorsement of functional responses for how questions and intentional for why questions. Patterns of responding across age groups differ in that children seem to have preferred both intentional and functional responses, whereas adults preferred the primary cause of intention followed by the secondary cause of function.

When answering questions about the adaptive features of artifacts (e.g., “How/Why did the chair get legs?”) a main effect of age was close to significant, $F(1, 42) = 3.87, p = .06, \eta^2 = .08$. A main effect of explanation $F(2, 84) = 157.40, p < .01, \eta^2 = .79$, an interaction between explanation and age group $F(2, 84) = 7.59, p < .01, \eta^2 = .15$, and an interaction between explanation and question type $F(2, 84) = 3.10, p = .05, \eta^2 = .07$ were all significant.

A two-way ANOVA for explanation by question type revealed an effect of explanation $F(2, 88) = 139.48, p < .01, \eta^2 = .76$ and an interaction of explanation by question type $F(2, 88) = 3.14, p = .05, \eta^2 = .07$. For both how questions $F(2, 44) = 62.82, p < .01, \eta^2 = .74$ and why questions $F(2, 44) = 80.27, p < .01, \eta^2 = .79$ participants endorsed functional and intentional explanations more than naturalistic explanations ($ps < .01$).

A two-way ANOVA for explanation by age group revealed an effect of explanation $F(2, 88) = 153.58, p < .01, \eta^2 = .78$ and an interaction between explanation and age group $F(2, 88) = 7.74, p < .01, \eta^2 = .15$. Children $F(2, 48) = 59.81, p < .01, \eta^2 = \ldots$
.71 preferred both functional and intentional over naturalistic explanations \((ps < .01)\) and adults \(F(2, 40) = 129.58, p < .01, \eta^2 = .87\) preferred intentional, followed by functional, followed by naturalistic explanations \((ps < .01)\).

**Summary.** Just as with the open-ended questions, these analyses revealed that when looking at the types of reasoning used most when closed-ended questions were asked, the type of question (how or why) was important, but less so than with open-ended questions. For example, when reasoning about natural kinds adults and children used different types of reasoning depending on whether they were asked *how* something happened or *why* something happened. Specifically, participants offered functional causes when explaining *why* natural change occurred but added a second explanation as well. However, when explaining *how* something happened, participants preferred functional causes for adaptive change in humans but both functional and naturalistic causes for adaptive change in animals. It was hypothesized that naturalistic explanations would be most preferred for explaining change in natural kinds. In fact, naturalistic explanations were one of several explanations endorsed, but the closed-ended format elicited additional explanations as well. Importantly, this endorsement pattern of more than a single cause was predicted and confirmed.

As expected, children and adults responded similarly to questions about artifacts, however question type did not affect responses for artifact change as was predicted. Instead, participants endorsed functional and intentional, but not naturalistic causes, regardless of question type. It is not surprising that these are the two types of explanations endorsed for artifacts and it is possible that the endorsement of both causes,
which is likely a product of the closed-ended format, disguised the question type
distinction that was present when single causes were offered for open-ended questions.

Children and adults clearly differed when reasoning within some domains. For
example, when reasoning about humans, children preferred one functional cause while
adults endorsed functional and naturalistic causes. This pattern of responding speaks to
the prediction regarding multiple cause endorsement. It appears that not only does
question-format (open vs. closed) affect the number of causes endorsed, but age does so
as well. Specifically, for the human domain there was an age-related increase in multiple
cause endorsement. On the other hand, for the artifact domain an increase in age was
accompanied by a slight decrease in multiple cause endorsement. Although this was not
predicted, it appears to be a result of a decrease in use of the functional explanation with
age as a function of children’s tendency to apply functionality across a variety of
knowledge domains, which is a prediction posed and examined in the next set of
analyses.

*Functional reasoning.* It was expected that functional reasoning would decrease
with age, due to children’s promiscuous functional application across domains. This
hypothesis was examined within the following set of correlations.

Age was not found to be significantly correlated with use of functional
explanations for the animal, \( r = -.09, p = .56 \), and human, \( r = -.07, p = .64 \) domains.
However, within the artifact domain, endorsement of functional explanations
significantly decreased with age, \( r = -.40, p < .01 \). Examination of the means in Table
G16 further support the finding that age differences were apparent in adults’ distinction
between domains when using functional explanations. The functional explanation was a
primary cause preferred by adults when asked about natural kinds, but not when asked about artifacts. Children, on the other hand, highly endorsed functional reasoning for both natural and artifact kinds, which appears to support the hypothesis that functional reasoning is applied more promiscuously (i.e., across more domains) by children than by adults. However, recall that for open-ended questions about animals, adults actually used functional responses significantly more than children. Thus it seems that while children may demonstrate a functional bias for artifacts, the bias is not as evident when reasoning about natural kinds. The pattern of multiple cause endorsement will now be examined in more detail.

**Multiple Cause Endorsement**

The final set of analyses for Study 1 examined the number of explanations endorsed by each age group, for both question types, in each domain. A three-way 2 (age group) X 2 (question type) X 3 (domain) mixed factor repeated measures ANOVA was calculated on agreement level with each explanation. Significant interactions were followed by two-way ANOVAs and Bonferroni/Dunn post-hoc comparisons. Means and standard deviations can be found in Table 2. These analyses are included for open- and then closed-ended questions. The range of causes endorsed for open-ended questions is 0-6. For the closed-ended questions, a cause was considered endorsed if the agreement rating fell in the range of 3.0 – 4.0. A few children used a rating of 2.5 (falling between “disagree a little” and “agree a little”) for various items. These were not counted as endorsements. The number of causes endorsed was averaged across the exemplars for each knowledge domain and thus it ranged from 0-3. It was hypothesized that while
open-ended questions elicit one main type of causal explanation, closed-ended questions will elicit multiple causal endorsements.

Open-ended questions. The examination of multiple causes used in open-ended questions revealed only a main effect of age $F(1, 45) = 11.87, p < .01, \eta^2 = .21$. Bonferroni/Dunn post-hoc tests indicated that the mean number of causes used by parents was greater than that used by children ($p < .01$). Age and number of causes used, collapsed across domain, were positively correlated, $r = .39, p < .01$. See Table 2 for means and standard deviations.

Closed-ended questions. A main effect of age $F(1, 42) = 4.64, p = .04, \eta^2 = .10$, a main effect of domain $F(2, 84) = 32.56, p < .01, \eta^2 = .44$, and an interaction between age and domain $F(2, 84) = 12.64, p < .01, \eta^2 = .23$ was found. A two-way ANOVA for age and domain revealed an effect of age $F(1, 44) = 4.89, p = .03, \eta^2 = .10$, an effect of domain $F(2, 88) = 34.34, p < .01, \eta^2 = .44$, and an interaction of domain by age $F(2, 88) = 13.32, p < .01, \eta^2 = .23$. Effects of domain were revealed for both the child $F(2, 50) = 4.50, p < .02, \eta^2 = .15$ and the adult $F(2, 38) = 38.68, p < .01, \eta^2 = .67$ age groups. While children used significantly more causes when reasoning about animals than when reasoning about artifacts ($p < .01$), adults used significantly more causes when reasoning about both animals and humans than when reasoning about artifacts ($ps < .01$). Age and number of causes used, collapsed across domain, were positively correlated, $r = .25, p < .01$. See Table 2 for means and standard deviations.

Summary. As expected, participants endorsed one main causal explanation in response to open-ended questions. However, causal endorsement increased with age for these open-ended questions, which was not predicted. This pattern of responding to open-
ended questions suggests an active but subtle influence of age on quantity of causal endorsement.

For closed-ended questions, participants endorsed multiple causes. As predicted, more causes were endorsed than when presented with open-ended questions, which is obvious when comparing the means in Table 2. Specific domain effects were also revealed in that for both children and adults, natural kinds elicited more explanations than artifacts, which was an unexpected finding.

Discussion

*Question type differences with Domain.* Both adults and children exhibited causal flexibility, as their responses varied based on question type and domain in question. For example, it is very clear from the results of this study that the type of causal explanation used most when open-ended or closed-ended questions were asked varied depending on the type of question, *why* or *how*, for both children and adults. Within the open-ended format, *why* questions elicited functional responses for natural and artifact change and *how* questions elicited naturalistic causes for natural change and intentional causes for artifact change.

When comparing responses from previous research (Szymanowski, 2005) to those in the open-ended section of Study 1, children in both studies demonstrated similar patterns of responding for *how* questions about change in natural kinds. However, one unexpected finding concerns the lack of intentional explanations by adults in response to *how* questions about natural change. While the intentional explanation was one of the multiple causes endorsed by adults on closed-ended questions about natural change, it was not most highly preferred and was not used in response to open-ended questions.
about natural change. Various possibilities, such as sample differences or priming effects, which may explain such differences are addressed in the general discussion.

Within the closed-ended format, for *why* questions participants endorsed functional and intentional explanations for natural change, but significantly preferred the functional explanation. When asked about artifacts, participants equally preferred functional and intentional explanations. *How* questions, on the other hand, elicited functional and naturalistic explanations for natural kinds (although for humans, participants most significantly preferred function), and functional and intentional explanations for artifacts.

One specific finding highlighted here is that when asked about artifacts in a closed-ended format, question type did not have an effect on the type of explanation used as was predicted. That is, functional and intentional explanations, but not naturalistic ones, were used regardless of question type. It is possible that the endorsement of both causes, which is likely a product of the closed-ended format, disguised the question type distinction that was present when single causes were offered for open-ended questions. In other words, whereas a clear question type distinction may be seen when one cause is endorsed for each question type, the distinction may be moderated when multiple causal explanations are used for each type of question.

*Causal chains within open- and closed-ended questions.* Interestingly, previous research (Szymanowski, 2005) that presented older children and adults with *open-ended* *why* questions about the origins of animal, human, and artifact features or parts revealed the same pattern of responding as was found for the open-ended questions in the current study, confirming previous expectations about the results of this study. That is,
participants endorsed one main (functional) cause. However, the current study also reveals that, when presented with closed-ended questions about why animals, humans, and artifacts got their parts, both young children and adults now endorsed multiple causes (function and intention), as predicted.

When examining responses to how questions about living kinds, another interesting difference between open- and closed-ended questions was revealed. When compared to participants’ responses in the open-ended section of Study 1 as well as older children’s and adults’ open-ended responses in a previous study (Szymanowski, 2005), participants in Study 1 maintained their endorsement of naturalistic explanations but now endorsed multiple causes (i.e., the additional endorsement of functional causes) when presented with various options to choose from.

It appears that even the youngest participants can demonstrate a “sophisticated” causal reasoning ability that includes the distinction of question type (how vs. why) as well as question-format (open vs. closed). However, whereas both the naturalistic and functional causes were now supported, participants still avoided using the intentional cause. It seems clear that these participants endorsed the same overall types of causes in open- and closed-ended how questions, but the forced-choice format exposed both their naturalistic and functional reasoning, as evidenced by their endorsement of both explanations.

Age differences. An increase in evolutionary reasoning with age was predicted and confirmed. However, paired with the rarity in which these explanations were endorsed, this finding supports the argument that even many adults misunderstand evolution (Evans, 2000a).
An even more interesting age difference regarding use of the functional explanation was revealed within the closed-ended questions. Specifically, children did not mirror the adult pattern of multiple cause endorsement in all domains. For questions about human change adults endorsed all 3 types of explanations, yet 5- and 6-year-olds continued to reason using a single functional cause, as they did with open-ended questions. In fact, as can be seen in Figures 4-6, 5- and 6-year-olds seem to default to a functional explanation to account for adaptive change in domains of both natural kinds and artifacts. However, it must be noted that within the animal domain, adults generated functional responses to open-ended questions more than children.

Interestingly, results suggest that while the number of causes endorsed increases with age when reasoning about natural kinds, the same may not be true when reasoning about artifacts. Recall that for the artifact domain an increase in age was accompanied by a slight decrease in multiple cause endorsement. Although this was not predicted, this is likely due to a decrease in the use of functional explanations with age when explaining artifact change. Specifically, because children seem to apply functional reasoning to the artifact domain more than adults do, they appear to be endorsing more causes when examining responses within this domain (i.e., endorsing intention but also particularly endorsing function more highly).

Perhaps children’s functional bias remains present in certain domains (i.e., the human domain) longer than others (i.e., animal and artifact) considering 5- and 6-year-olds willingness to accept additional causes for animal and artifact change, but not human change. This is one case in which these results, I shall argue, indicate that adults are more likely to use causal chains, including naturalistic and intentional causes. This has
important implications for studies examining causal reasoning in young children, which are discussed in Chapter Four.

Study 2 was conducted in an effort to identify the developmental trajectory of causal understanding in more detail by providing the same closed-ended questions, which were successful in eliciting multiple causes in adults, and children in some cases, to more 5- and 6-year-olds as well as older children, similar to those used in previous studies (8-to 12-year-olds). Additionally, still including open-ended as well as closed-ended questions may make it easier to pinpoint when age-related differences appear. Doing so may help to map the developmental trajectory of causal understanding more completely.
Chapter Three

Study 2

In Study 2 the same questioning methods were presented to an expanded age range of children in an effort to expose the development of causal explanations and attributions more completely. Thus children ranging in age from 5- to 14-years were the focus of this study. However, the current study introduced questions using the new closed-ended format, allowing for comparisons across question type. Additionally, the extension of the age range allows for a possible replication and extension of findings from the young children in Study 1 (5- and 6-year-olds) as well as a more complete portrayal of developmental change within a single study. As was the case in Study 1, the way in which closed- or open-ended format, question type (how, why) and knowledge domain (natural vs. artifact) influenced the endorsement of different types of causes in several age groups was investigated.

Research predictions. One purpose of this study was to replicate and extend findings from Study 1 as well as previous research (Szymanowski, 2005). In the primary analyses, the focus is on the pattern of responding, by age group, in different knowledge domains, the distinction between how and why questions, and the use of causal chains demonstrated in different formats.

(1) Reasoning Patterns in Knowledge Domain. The type of reasoning children engaged in was expected to be influenced by knowledge domain (animal, human,
artifact), age, and the type of question asked (why, how). Age differences were expected with natural kinds. Within the animal domain it was expected that naturalistic causes would be preferred by younger children, but with increasing age, more children would prefer intentional explanations (Szymanowski, 2005). In contrast to responses within the animal domain, it was predicted that children of different age groups would perform similarly when responding to questions about artifacts, by offering functional explanations for why questions (Kelemen, 1999; Szymanowski, 2005) and intentional (e.g., “Someone made them like that”) for how questions (Szymanowski, 2005). Results of the closed-ended questions of Study 1 led to the current prediction that functional reasoning would be applied more broadly (i.e., across both knowledge domains) by younger children when compared to older children, resulting in a decrease of functional reasoning with age in closed-ended questions. Finally, a secondary prediction is that open-ended evolutionary explanations would be limited, used only for natural kinds, and increase with age (Evans, 2000a, 2001, in press).

(2) Question Type. In the current set of studies children were expected to differentiate between question type by offering functional responses to why questions and different mechanisms (i.e., growth for the youngest age groups and intentional action for the oldest age groups) to how questions (Bullock et al., 1982; Malle et al., 2001; Naas, 1956).

(3) Causal chains in Open- versus Closed-ended Questions. Open-ended responses from children and adults are expected to be causally limited, most likely only including a single primary cause (Szymanowski, 2005). It was expected that the
presentation of a closed-ended multiple-cause format would elicit an increased number of explanations from all three age groups of children.

Method

Participants. Participants included 97 children, ranging in age from 5- to 14-years. Children were recruited from three schools in Swanton, Ohio including Saint Richard Catholic School, as well as Park and Crestwood Elementary Schools. After obtaining consent from the Superintendent of Swanton Local Schools and each of the school principals, teachers and parents, each child also granted verbal assent to participate. Participation involved one 15 minute interview during the school day, see Appendix E. Interviews were conducted in a nurse’s office, library, or quiet hallway. The sample was approximately 97% European American, 1% Multi-racial and 1% Middle Eastern and was split by gender (51 males and 46 females). Approximately 44% of the children were interviewed at the Catholic school, while 56% attended one of the two public schools. Place of worship was reported by children. Religious demographics were as follows: 48% Catholic, 7% Non-Denominational Christian, 3% Lutheran, 2% Methodist, and 1% Presbyterian. Sixteen percent of children gave responses categorized as “Other” (e.g., “the place uptown”), and 23% reported not attending any place of worship.

Design. Participants were divided into three age groups (Young, Middle, Old) and each age group had two conditions (How, Why). The Young group consisted of children in grades Kindergarten through 2nd \((n = 32)\) and ranged in age from 5- to 8-years, with a mean age of 6.5 years \((\text{How} = 16 \text{ children}, \text{Why} = 16 \text{ children})\). The Middle group
consisted of children in grades 3 and 4 \((n = 29)\) who were 8 and 9 years of age, with a mean age of 9.2 years (How = 15 children, Why = 14 children). The Old group consisted of children in grades 4 through 8 \((n = 36)\) and ranged in age from 10- to 14-years, with a mean age of 12.1 years (How = 17 children, Why = 19 children).

**Materials.** Materials used in the interview included a set of nine animal and artifact laminated photographs, identical to the nine images depicted in Appendix C. The same set of four (dis)agreement cards that was used in Study 1 was used again in Study 2.

**Procedure**

**Warm-up task.** The warm-up task for this study was identical to that utilized in Study 1.

**Open-ended questions.** The open-ended portion of Study 2 was identical to that utilized with children in Study 1.

All responses were coded by the experimenter using the same coding scheme as in Study 1, which was adapted from previous research in which children answered similar questions (Szymanowski, 2005) (see Appendix F). For reliability purposes, 20% of the responses were also coded by a trained undergraduate researcher. Initial coding reliability ranged from 96.6 – 100%, with an overall average reliability of 99.66%. All disagreements were resolved to 100% agreement before final coding was entered. As in Study 1, each response was assigned to one or more reasoning patterns according to the explanations utilized in the response. Thus each response received a score ranging from 0-1 for each of the six reasoning patterns/explanations. Since the five coded responses contained three pertaining to animals, one to humans, and one to artifacts, the animal

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\(^3\) Study 2 included nine pairs of siblings. One child from each pair was randomly selected and removed. Analyses were repeated and significant outcomes remained unchanged. Therefore, all children remained in
scores were averaged across the three exemplars when analyzed. This again resulted in each domain (animal, human, artifact) receiving a score ranging from 0-1 for each of the six reasoning patterns/explanation-types.

Closed-ended questions. After completion of the warm-up and open-ended portions of the interview, participants in Study 2 were given a series of 9 forced-choice questions about parts of different entities, in contrast to the 15 forced-choice questions presented in Study 1. Again, the how/why condition remained the same throughout the interview. Three statements, identical to those used in Study 1, followed each question. For each of randomly ordered nine exemplars (3 humans with hands – an African, a European, and an Asian human, 3 animals -1 butterfly with wings, 1 frog with webbed feet, 1 squirrel with paws, 3 artifacts- a cup with a handle, a chair with legs, and a door with a handle), participants were shown a picture and given the three randomly ordered causes/reasons for their adaptive parts. Just as in Study 1, participants rated their level of agreement to each statement using the (dis)agreement cards (1-4 scale). If participants agreed, by choosing scale level 3: agree a little, or 4: agree a lot, with the intentional or teleological choice they were then asked to state who or what made the parts, and what they needed them for, respectively. In order to reduce testing time, and in contrast with Study 1, only three animal exemplars were included as stimuli. (In Study 1, nine animal exemplars were included.) Upon completion, children were given a small thank-you gift along with a certificate of participation.

Results

For open-ended questions, the primary analysis consisted of a 3 (age group) X 2 (question type) X 6 (causal explanations) mixed factorial Analyses of Variance dataset.
(ANOVAs), with causal explanation as a repeated measure. This analysis was repeated for each of the three knowledge domains. These were performed to identify reasoning pattern use by age and by how/why questions within each domain. Of particular interest was the animal domain, with the human and artifact domains included as comparisons. These analyses were then followed by three 3 X 2 X 3 analyses with the closed-ended questions, one focused on the animal domain and the other two including the human and artifact domains, for comparison. Finally, an analysis of multiple-cause endorsement for both open- and closed-ended questions was included in order to identify differences between open- and closed-ended questions in terms of the number and kind of causes endorsed.

Before each set of results, patterns of responding that were of interest for each domain are highlighted; they can be seen in the set of figures accompanying each analysis. All figures display the means and standard errors. As in Study 1, figures for both open and closed-ended questions include only the three main reasoning patterns of interest: Intentional, Functional, and Naturalistic. Other reasoning patterns (Essentialist, Evolutionary, and Other) were included in open-ended analyses but excluded from the figures for sake of visual clarity. These were not examined in any detail because they were rarely referenced in the open-ended format, and not presented at all in the closed-ended format. However, any hypothesized age differences within the use of a specific explanation were examined using correlation analyses and follow the primary analyses.

Open-Ended Questions

It was expected that, for natural kinds (animals and humans) all age groups would respond with functional explanations to why questions, and with different mechanistic
explanations to *how* questions. Age differences were predicted in the use of the different mechanisms employed to answer *how* questions (i.e., naturalistic causes would be preferred by the youngest children as older children begin to consider intentional action causes). For artifacts, the same distinction in question type was predicted (i.e., functional responses to *why* questions and mechanistic responses to *how* questions). Specifically, it was predicted that the mechanisms used in response to *how* questions would consist primarily of intentional explanations (e.g., “Someone made it like that”). Although differences may appear more subtle than when comparing children and adults in Study 1, age differences were predicted again when examining functional reasoning. In particular, the younger children could apply functional reasoning more promiscuously (i.e., to more domains) than older children.

As in Study 1, the primary set of analyses for the open-ended questions focused on determining the ways in which age, question type and causal reasoning varied according to a particular domain of knowledge. In other words, determining which explanations (6: intentional, functional, essentialist, naturalistic, evolutionist, other) were endorsed by each age group (young, middle, old) in response to both question types (how and why), was of interest. Therefore, for each knowledge domain (animal, human, artifact), a 3 (age group) X 2 (question type) X 6 (explanation) mixed factor repeated measures ANOVA was conducted on the mean number of endorsements for each explanation. Where there were significant interactions, further analyses consisted of two- and one-way ANOVAs and post-hoc Bonferroni/Dunn tests (to adjust for multiple comparisons). Endorsement scores were averaged across the exemplars for each knowledge domain and thus represent the mean level of endorsement with a particular
reasoning pattern/explanation (1 = presence, 0 = absence). Animal scores were averaged across the three animal targets for ease of comparison with the single human and artifact target. Finally, secondary analyses comparing the use of a particular explanation across domains, or change in the use of a particular explanation with age, were performed and included only if they were of specific interest if the primary results were not clear-cut.

Animals. As can be seen in Figure 7, how questions were answered with naturalistic responses and why questions were answered with functional responses. This pattern was also seen within the open-ended questions of Study 1. Patterns of responding also differed with age. The young age group most highly preferred naturalistic reasoning, followed by functional reasoning. The middle age group seems to have endorsed naturalistic and functional causes in the same way, whereas the oldest age group responded with functional, followed by naturalistic causes. Interestingly, it appears that from the youngest to the two older age groups, functional reasoning increased, a repeated pattern from the open-ended questions from Study 1.

Analyses of responses to open-ended questions about the existence of adaptive animal parts (e.g., “How/Why did the frog get webbed feet?”) revealed a main effect of explanation $F(5, 455) = 63.49, p < .01, \eta^2 = .14$, an interaction between age and question type $F(2, 91) = 4.11, p = .02, \eta^2 = .08$, an interaction between explanation and question type $F(5, 455) = 55.50, p < .01, \eta^2 = .38$, and an interaction between explanation and age group $F(10, 455) = 4.96, p < .01, \eta^2 = .10$. For the age by question type interaction, effects of question type were found only for the old age group $F(1, 34) = 9.65, p < .01, \eta^2 = .22$ where their mean endorsement of all combined explanations was higher for how versus why questions ($p = .03$).
A two-way ANOVA for explanation and question type revealed an effect of explanation $F(5, 475) = 58.09, p < .01, \eta^2 = .38$ and an interaction between explanation and question type $F(5, 475) = 50.86, p < .01, \eta^2 = .35$. For *how* questions an effect of explanation $F(5, 235) = 44.39, p < .01, \eta^2 = .49$ indicates that participants significantly prefer naturalistic explanations (e.g., “they grew them”) over all other type of causes ($ps < .01$). For responses to *why* questions $F(5, 240) = 65.91, p < .01, \eta^2 = .58$ participants preferred functional explanations (e.g., “they needed them to swim”) over all other types of explanations ($ps < .01$) and also preferred naturalistic explanations (e.g., “They grew them”) significantly more than essentialist (“they were born with them”) and evolutionary (“they evolved over millions of years”) ($ps < .01$).

A two-way ANOVA for explanation and age group revealed effects for explanation $F(5, 470) = 40.21, p < .01, \eta^2 = .30$ and an interaction between explanation and age group $F(10, 470) = 3.34, p < .01, \eta^2 = .07$. Significant effects of explanation were found for the young $F(5, 155) = 20.08, p < .01, \eta^2 = .39$, middle $F(5, 140) = 12.86, p < .01, \eta^2 = .32$, and old $F(5, 175) = 14.85, p < .01, \eta^2 = .30$ age groups. The young age group preferred naturalistic explanations over all others ($ps < .01$) and functional explanations over intentional, essentialist, and evolutionary explanations ($ps < .01$). The middle age group preferred the naturalistic and functional explanations over all others ($ps < .01$). And the old age group preferred functional explanations over all others ($ps < .01$) and naturalistic explanations over essentialist, evolutionary, and “other” explanations ($ps < .01$).

*Humans.* Figure 8 depicts the preference for intentional explanations in response to *how* questions, and the repeated pattern of functional explanations in response to *why*
questions. For responses to open-ended questions about the existence of human adaptive parts (i.e., “How/Why did the human get hands?”), a main effect of question type $F(1, 91) = 4.22, p = .04, \eta^2 = .04$, a main effect of explanation $F(5, 455) = 31.97, p < .01, \eta^2 = .26$, and an interaction between explanation and question type $F(5, 455) = 39.36, p < .01, \eta^2 = .30$ were found. A two-way ANOVA for explanation by question type revealed an effect of question type $F(1, 95) = 4.36, p = .04, \eta^2 = .04$, an effect of explanation $F(5, 475) = 31.99, p < .01, \eta^2 = .25$, and an interaction between explanation and question type $F(5, 475) = 38.49, p < .01, \eta^2 = .29$. For how questions $F(5, 235) = 7.19, p < .01, \eta^2 = .13$ participants preferred intentional explanations (e.g., “God made them”) more than all but essentialist explanations (e.g., “They were born with them”) ($ps < .01$), which were preferred over evolutionary explanations (e.g., “Genes for hands were passed down over millions of years”) ($p < .01$). For why questions $F(5, 240) = 130.51, p < .01, \eta^2 = .73$ participants preferred functional explanations (e.g., “They needed them”) more than all other types ($ps < .01$).

**Artifacts.** Patterns of responding for both how and why questions can be seen in Figure 9. For how questions the primary preferred response was an intentional explanation, followed by secondarily preferred functional explanations. The pattern of preference for functional causes in response to why questions was again repeated. Analyses of responses to open-ended questions about artifact adaptive parts (i.e., “How/Why did the chair get legs?”) revealed a main effect of explanation $F(5, 455) = 109.28, p < .01, \eta^2 = .55$, an interaction between explanation and age $F(10, 455) = 1.87, p = .05, \eta^2 = .04$, and an interaction between explanation and question type $F(5, 455) = 79.58, p < .01, \eta^2 = .47$. A two-way ANOVA for explanation and age indicated a main
effect of explanation only $F(5, 470) = 59.32, p < .01, \eta^2 = .39$ where participants used
intentional ($M = .47, SD = .50$) and functional ($M = .55, SD = .50$) explanations more that
all others ($ps < .01$). Mean endorsement (with standard deviations in parentheses) of other
explanations were as follows: essentialist .01 (.10), naturalistic .00 (.00), evolutionist .00
(.00), other .04 (.20).

A two-way ANOVA for explanation and question type revealed an effect for
question type $F(1, 95) = 4.05, p = .05, \eta^2 = .04$, explanation $F(5, 475) = 106.43, p < .01,$
$\eta^2 = .53$, and explanation by question type $F(5, 475) = 76.15, p < .01, \eta^2 = .45$. An effect
of explanation for how questions $F(5, 235) = 68.49, p < .01, \eta^2 = .59$ reveals that
participants preferred intentional explanations more than all other types ($ps < .01$) and
functional explanations more than essentialist, naturalistic, and evolutionary explanations
($ps < .01$). When answering why questions $F(5, 240) = 126.85, p < .01, \eta^2 = .73$
participants preferred functional responses over all others ($ps < .01$).

**Evolutionary reasoning.** It was predicted that evolutionary reasoning be limited,
increase with age, and be used for only for natural kinds. The hypothesis that these
explanations would increase with age was examined in a secondary analysis examining
the correlation for use of this reasoning pattern and age group. In fact, the use of
evolutionary reasoning (e.g., “They evolved over millions of years”) was positively
related to an increase in age, $r = .18, p < .01$.

**Summary.** As expected, when looking at the types of explanations that were used
the most when open-ended questions were asked, age, and especially question type (how
or why) were important. That is, whether reasoning about animals, humans or artifacts,
children used different types of reasoning depending on whether they were asked *how*
something happened or *why* something happened. For changes in both natural kinds and artifacts, participants offered functional causes when explaining *why* something occurred. When explaining *how* something happened, for adaptive change in animals children offered naturalistic causes, while for adaptive change in humans children preferred to use intentional causes. They also offered intentional causes for artifact change, but used functional causes as well. These findings confirm the prediction that children offer different responses for different types of questions. Functional responses were used for *why* questions and mechanistic responses were used for *how* questions. However, the specific mechanisms used in response to *how* questions, particularly for the human domain, were not expected. In contrast to animals, for which children preferred naturalistic responses, children preferred the use of intentional explanations for humans. Children also used these intentional responses when explaining artifact change, which was predicted, but also used functional responses as well.

These age groups differed when considering explanations for adaptive change in animals. As hypothesized, the youngest age group preferred to use naturalistic explanations. The middle age group preferred naturalistic causes as well as functional causes. However, instead of moving to the use of intentional explanations, as was predicted, the oldest age group preferred functional explanations.

Finally, use of evolutionary explanations was found to be positively correlated with age. Additionally, these explanations were not used by the young or middle age groups, and used rarely by the oldest age group in response to questions about animals, see Table G31.
Closed-Ended Questions

As with the open-ended questions, it was expected that, for natural kinds children would respond with functional explanations to why questions, and with different explanations to how questions (i.e., with age children would move from offering naturalistic causes to intentional causes). For artifacts, a distinction in question type and age differences were predicted; functional explanations would be used for why questions with intentional explanations used for how questions, and the youngest children would use functional explanations more than the oldest children. Importantly, in contrast to the open-ended questions, it was expected that, within each domain, the presentation of various causes would elicit endorsement of an increased number of explanations.

Primary analyses for the closed-ended questions focus on determining which reasoning patterns/explanations (3: intentional, teleological, naturalistic) were endorsed by each age group (young, middle, old) in response to both question types (how and why). Thus a series of three-way 3 (age group) X 2 (question type) X 3 (explanation) mixed factor repeated measures ANOVAs were calculated on agreement level with each explanation and this was done for each knowledge domain (3: Animal, Human, Artifact). Where there were significant interactions, further analyses consisted of two- and one-way ANOVAs and post-hoc Bonferroni/Dunn tests (to adjust for multiple comparisons). Agreement scores were averaged across the exemplars for each knowledge domain and thus represent the mean level of agreement with the statement endorsing a particular reasoning pattern/explanation (1 = strong disagreement, 4 = strong agreement). Finally, secondary analyses comparing the use of a particular explanation across domains, or
change in the use of a particular explanation with age, were performed and included only if they were of specific interest if the primary results were not clear-cut.

**Animals.** As can be seen in Figure 10, responses did not seem to differ across question type. However, it appears that all three age groups prefer functional responses, and to a lesser degree, the naturalistic and intentional responses. Results indicate that when answering questions about the adaptive features of animals (e.g., “How/Why did the butterfly get wings?”) there was a main effect of explanation $F(2, 182) = 34.38, p < .01, \eta^2 = .27$ and an interaction between explanation and age group $F(4, 182) = 2.81, p = .03, \eta^2 = .06$. A two-way ANOVA for explanation by age group revealed significant effects of explanation $F(2, 188) = 33.93, p < .01, \eta^2 = .27$ and explanation by age $F(4, 188) = 2.70, p = .03, \eta^2 = .05$. Both the young $F(2, 62) = 25.34, p < .01, \eta^2 = .45$ and old $F(2, 70) = 8.00, p < .01, \eta^2 = .19$ age groups endorsed the functional explanation (i.e., “they needed them”) significantly more than both the naturalistic (i.e., “they grew them”) and intentional explanations (i.e., “someone or something made them”) ($p$s < .01). The middle age group $F(2, 56) = 5.19, p = .01, \eta^2 = .16$ endorsed the functional explanation over the intentional explanation ($p < .01$).

**Humans.** Figure 11 again suggests that participants’ responses did not depend on question type. Instead, for both types of questions all three age groups again preferred functional responses. It appears that the middle and older age groups also preferred the intentional response. When answering questions about the adaptive features of humans (e.g., “How/Why did the human get hands?”) there was a main effect of age, $F(2, 91) = 3.57, p = .03, \eta^2 = .07$ as well as a main effect of explanation, $F(2, 182) = 60.86, p < .01,$
\(\eta^2 = .40\). Results also indicated an interaction of explanation by age, \(F(4, 182) = 3.13, p = .02, \eta^2 = .06\).

A two-way ANOVA for explanation by age group revealed effects of age \(F(2, 94) = 3.47, p = .04, \eta^2 = .07\), explanation \(F(2, 188) = 62.18, p < .01, \eta^2 = .40\), and explanation by age group \(F(4, 188) = 3.12, p = .02, \eta^2 = .06\). Significant effects of explanation were found for the young \(F(2, 62) = 39.96, p < .01, \eta^2 = .56\), middle \(F(2, 56) = 11.66, p < .01, \eta^2 = .29\), and old \(F(2, 70) = 15.84, p < .01, \eta^2 = .31\) age groups. Bonferroni/Dunn post-hoc comparisons revealed that the young children preferred functional (i.e., “they needed them”), followed by intentional (i.e., “someone or something made them”), and finally naturalistic (i.e., “they grew them”) explanations (\(ps < .01\)). Middle and older children responded similarly but preferred both functional and intentional explanations over naturalistic explanations (\(ps < .01\)).

**Artifacts.** As was the case with closed-ended questions in the animal and human domains, Figure 12 suggests that question type did not greatly impact the types of explanation used. Also, as with all other artifact questions, none of the age groups endorsed naturalistic reasoning. Patterns of responding for the young age group included intentional and functional reasoning, and patterns for the middle and older age groups appear to include intentional, followed by functional reasoning.

When answering questions about the adaptive features of artifacts (e.g., “How/Why did the chair get legs?”) there was a main effect of age \(F(2, 91) = 6.51, p < .01, \eta^2 = .13\), a main effect of explanation \(F(2, 182) = 925.71, p < .01, \eta^2 = .91\), and an interaction between explanation and age group \(F(4, 182) = 6.16, p < .01, \eta^2 = .12\). A two-way ANOVA for explanation and age group revealed significant effects for age group
\[ F(2, 94) = 6.38, p < .01, \eta^2 = .12, \] explanation \[ F(2, 188) = 907.33, p < .01, \eta^2 = .91, \] and explanation by age group \[ F(4, 188) = 5.82, p < .01, \eta^2 = .11. \] Significant effects of explanation for the young \[ F(2, 62) = 353.36, p < .01, \eta^2 = .92, \] middle \[ F(2, 56) = 331.79, p < .01, \eta^2 = .92, \] and old \[ F(2, 70) = 264.72, p < .01, \eta^2 = .88 \] age groups were revealed. While the young children endorsed functional and intentional explanations over naturalistic explanations \((ps < .01)\), the middle and old age groups endorsed intentional, followed by functional, followed by naturalistic explanations \((ps < .01)\).

**Functional reasoning.** Finally, the prediction that functional reasoning would decrease with age due to younger children’s promiscuous application of functionality across knowledge domains was examined in the series of correlations below.

Age was not found to be significantly correlated with use of functional explanations for the animal, \(r = -.13, p = .20\), and human, \(r = -.10, p = .31\) domains. However, within the artifact domain, endorsement of functional explanations significantly decreased with age, \(r = -.39, p < .01\).

**Summary.** Examining the types of explanations endorsed when asked about adaptive change in different domains revealed that age played an important role in reasoning within each of the three domains. However, predictions as to which explanations would be used within each domain were based on question type differences, which were previously found within the open-ended format. Interestingly, results revealed that within the closed-ended questions, predicted differences in question type were not evident as they were in the open-ended questions. It appears that because children now endorsed multiple causes, the question type differences previously found were no longer significant.
Specifically, it was predicted that naturalistic responses would be used to explain natural change, especially for how questions. However, no differences in question type were found and thus exact predictions were not confirmed. For adaptive change in animals all three age groups significantly preferred the functional explanation. When asked about adaptive change in humans, young children endorsed functional responses, and middle and older children accepted and endorsed both the functional and intentional responses.

When explaining artifact change, young children were able to accept both the functional and intentional causes. Children in the middle and old age groups endorsed both of these causes as well but preferred the intentional cause more. In other words, children did differ in their use of different explanations, especially in specific domains. Importantly, these findings suggest, and confirm the prediction, that even young children are able to accept multiple causes for an event when presented with various causal options. Additionally, at least in some domains (i.e., humans) the number of causes endorsed increased with age. This suggests once again that while question type, open or closed, plays a role in multiple cause endorsement, age may also play a subtle role as well.

Finally, the endorsement of functional explanations decreased with age significantly within the artifact domain. While this supports the hypothesis that younger children apply functional explanations more broadly (i.e., across more domains) than older children and adults, it also highlights changes in the functional bias with age. Particularly, while younger participants use functional explanations more than older
participants when reasoning about artifacts, older children selectively use their functional
responses by predominantly applying it to natural change.

Multiple Cause Endorsement

The final set of analyses examined the number of explanations endorsed by each
of the three age groups, for both question types, in each domain. Therefore, a three-way 3
(age group) X 2 (question type) X 3 (domain) mixed factor repeated measures ANOVA
was calculated on agreement level with each cause. Significant interactions were
followed by two-way ANOVAs and Bonferroni/Dunn post-hoc comparisons. These
analyses are included for open- and then closed-ended questions. The range of causes
endorsed for open-ended questions is 0-6. As in Study 1, for the closed-ended questions,
a cause was considered endorsed if the agreement rating fell in the range of 3.0 – 4.0. A
few children used a rating of 2.5 (falling between “disagree a little” and “agree a little”) for various items. These were not counted as endorsements. The number of causes
endorsed was averaged across the exemplars for each knowledge domain and thus ranges
from 0-3.

It was hypothesized that while open-ended questions elicit one main type of
causal explanation, closed-ended questions would elicit multiple causal endorsements.
The comparison of children and adults in Study 1 revealed a subtle influence of age in
multiple cause endorsement within open-ended questions. Importantly, it is not predicted
that the same finding would be revealed in Study 2 due to the close range in age between
children.

Open-ended questions. No significant age, domain, or question type effects were
found when examining multiple cause use in open-ended questions. Age and number of
causes used, collapsed across domain, were positively correlated, \( r = .13, p = .03 \). See Table 3 for means and standard deviations.

*Closed-ended questions.* A main effect of age \( F(2, 91) = 3.47, p = .04, \eta^2 = .07 \), a main effect of domain \( F(2, 182) = 17.54, p < .01, \eta^2 = .16 \), and an interaction between age and domain \( F(4, 182) = 7.60, p < .01, \eta^2 = .14 \) were found. A two-way ANOVA for age and domain revealed significant effect for age \( F(2, 94) = 3.51, p = .03, \eta^2 = .07 \), domain \( F(2, 188) = 17.09, p < .01, \eta^2 = .15 \), and domain by age \( F(4, 188) = 7.30, p < .01, \eta^2 = .13 \). An effect of domain was found for the middle \( F(2, 56) = 7.14, p < .01, \eta^2 = .20 \) and old \( F(2, 70) = 22.83, p < .01, \eta^2 = .40 \) age groups. Bonferroni/Dunn post-hoc tests indicate that the middle age group used significantly more causes when reasoning about animals than when reasoning about artifacts \((p < .01)\) while the old age group used significantly more causes when reasoning about both animals and humans than when reasoning about artifacts \((ps < .01)\). Age and number of causes used, collapsed across domain, were positively correlated, \( r = .21, p < .01 \). See Table 3 for means and standard deviations.

*Summary.* As predicted, participants endorsed only one main causal explanation in response to open-ended questions. No increase in causal endorsement with age was revealed. Importantly, for closed-ended questions, it was predicted and revealed that participants endorsed more causes than when presented with open-ended questions, which is clear when comparing the means in Table 3. The specific domain effect of natural kinds eliciting more explanations than artifacts, was not predicted.
Discussion

Age-related change in causal reasoning was addressed by including a sample that matched and extended the ranges used in Study 1 and previous research (Szymanowski, 2005). The goal of the current study was to more precisely determine the development of causal reasoning and the movement from single to multiple cause endorsement. One main hypothesis was that, in contrast to single cause endorsement for open-ended questions, when presented with closed-ended questions multiple cause endorsement would be evident.

_Causal chains within open- and closed-ended questions._ It was predicted and confirmed that the overall number of causes endorsed increased from open- to closed-ended questions when responding about natural kinds. Additionally, an increase in multiple cause endorsement with age was seen within these particular closed-ended responses. Interestingly though, it is clear that when presented with various causes to choose from, even the very youngest children in this study begin to endorse multiple causes.

One “side-effect” of this multiple cause endorsement concerns the hypothesis that responses would differ for _how_ and _why_ questions. It is likely that while such differences are evident when one causal response is given, these question type differences are disguised or absent altogether when multiple responses are offered.

Further, although it was not predicted, the number of causes decreased with age when responding within the artifact domain. It is possible that the promiscuous teleology (Kelemen, 1999), or functional bias, of younger children (i.e., applying functional causes
to multiple domains, particularly the artifact domain) leads them to endorse more causes
to explain artifact change than older children.

*Age differences across knowledge domain.* This explanation regarding the
endorsement of functional causes, which appears to be part of the default reasoning
pattern for the younger children, is particularly relevant when considering how each age
group reasons differently for each of the knowledge domains. Functional explanations are
endorsed by both young and older age groups for natural kinds. However, age differences
appear within the artifact domain, where young children still highly endorse functional
explanations. In this way, young children do not appear to functionally distinguish
between natural kinds and artifacts as older children did. Instead, they appear to treat
artifacts like natural kinds.

Perhaps these young children, who are predominantly reasoning functionally,
have not yet distinguished between the functional differences of artifacts and natural
kinds (e.g., Bloom, 1996; Keil, 1994). Specifically, in the closed-ended questions of both
studies, young children are agreeing with the statement “They needed them” and doing so
for both domains, indicating their belief that the functional parts of both natural kinds and
artifacts exist to serve the target item. Older children’s endorsement of the functional
explanation is similar to younger children’s when asked about natural kinds, but
decreases for artifacts. Perhaps in recognition that it is not the cups, doors, or chairs that
“need” their parts, but instead that their parts benefit humans. This is both an interesting
and important distinction that has apparently not yet made by the younger children.

In addition to age differences in regard to multiple cause endorsement and general
domain knowledge, age differences in type of causal explanation endorsed were also
predicted. Specifically, it was expected that the oldest children examined, 10- to 14-year-olds, would include the cause of intention in their endorsements. One important finding regarding this hypothesis appeared when examining closed-ended causal responses about adaptive change in humans. Whereas young children only endorsed functional explanations, children from both of the older age groups endorsed both functional and intentional explanations, as predicted. Similarly, when asked about artifact change, although all three age groups, including the youngest children, endorsed both functional and intentional causes. However, the two older age groups distinguished between these two causes and primarily preferred the intentional cause.

Study 2 revealed that distinctions in domain knowledge as well as preference for certain causes increased with age. Moreover, just as with Study 1, examining the differences in number of causes endorsed across open- and closed-ended questions in this study (see Table 3) reveals that when asked to generate an explanation on one’s own, all three groups of children tended to offer fewer causes than when presented with various options in a forced-choice format. This predicted and confirmed difference again highlights the need for considering the method of questioning, no matter what the age of the child. As predicted, the most flexible causal reasoning was elicited by closed-ended questions in all age groups.
Chapter Four

General Discussion

In the current research the development of causal reasoning was investigated. Specifically, children’s causal explanations for adaptive or functional change was examined while investigating the influence of age, domain knowledge, question type, and question format on the development of causal explanations and multiple cause endorsement. Together, results of these studies suggest that each of these factors plays a distinct role in both the type and number of explanations that children utilized when reasoning about change in different knowledge domains. These results indicated that even young children demonstrate causal flexibility by shifting their patterns of response based on the investigator’s manipulation of these factors.

Children of all ages displayed the ability to be causally flexible by altering responses based on the types of questions (how or why) that were asked of them, what knowledge domain they were asked about (animal, human, artifact), and what question format they were presented with (open, closed). Children as young as 5-years were able to distinguish between the two question types by offering appropriate mechanisms when asked how questions while offering appropriate functional reasons when asked why questions. Children of all ages also appropriately offered and rejected certain types of explanations based on the knowledge domain in question. For example, intentional causes, but not naturalistic causes were accepted for questions about artifacts. Finally, an
even more advanced level of causal flexibility in young children was evidenced by their willingness to endorse appropriate multiple causes when presented with various choices. Newly introduced explanations were accepted in addition to those children produced initially on their own. The flexible patterns of responding exhibited by children as young as 5 years of age suggests that advanced causal reasoning abilities are present early in development. However, if factors such as those examined in the current research are overlooked, such abilities are likely to be obscured. An overview of the findings for each of these factors will be presented next.4

*Question Type (How vs. Why) within Knowledge Domains*

In the past, causal reasoning ability in children has often been examined without considering the influence of question type on respondents (e.g., Kelemen, 1999; Piaget, 1930, 1974). Findings from the current research suggests that although question type, (specifically, how vs. why), may not greatly influence the number of causes offered in an explanation, it does influence the specific type of explanations used by both children and adults, at least when they are asked open-ended questions. Reason explanations (e.g., functions) are used in response to why questions (Malle et al., 2001), while some implied or demonstrated mechanism (e.g., growth) is usually used to explain how a cause worked to bring about its effect (Bullock et al., 1982). Interestingly, the influence of how questions appears to be more domain-specific than why questions in that functional explanations were offered across all domains for why questions, but responses to how questions depends on knowledge domain. Similar findings from the two studies included participants’ preference for functional explanations when answering why questions,

4 See Table 4 for a summary of the main findings from responses within the animal domain given in Szymanowski, 2005, Study 1 and Study 2. See Tables 5 and 6 for summaries from findings within the
which occurred for both natural and artifact domains. When answering *how* questions naturalistic responses were preferred when explaining natural change in animals and intentional and functional explanations were preferred when discussing change in artifacts.

These differences in explanations in response to different question types have implications for results of previous research suggesting that children are promiscuous teleologists (Kelemen, 1999). Kelemen (1999) suggested that children have a limited understanding of natural processes and therefore inappropriately apply functional or teleological explanations to all types of entities (e.g., artifacts and natural kinds). However, results from the current set of studies highlight the importance of question type in the kind of explanations elicited for changes in natural kinds and artifacts. Even 5- and 6-year-olds, the youngest children in the current studies, demonstrated rather sophisticated causal reasoning when distinguishing between *how* and *why* questions by offering different explanations for each question type. As we have seen, functional explanations were most highly preferred for *why* questions, and this was the case for all age groups.

It is quite possible that Kelemen’s (1999) strict use of *why* questions is directly responsible for the abundance of functional explanations in her studies, rather than a “promiscuous teleology,” which, she claims, is a bias that underlies younger children’s tendency to reason functionally across all domains. Additionally, it should be noted that although teleological/functional explanations decreased with age within the artifact domain, adults actually endorsed these explanations more than children when asked about animals. This is an important difference between the current research and Kelemen’s human and artifact domains in these studies.
previous research in this area and is one example of the importance of considering question type and domain when examining the development of causal explanations, and when accounting for differences in findings.

**Question Format (Open vs. Closed) and Causal Chains**

Whereas question type (how vs. why) influenced the type of explanations used, this research also indicates that the format of questioning, specifically whether participants were presented with forced-choice multiple causes or free-recall opportunities, most likely influences the quantity of explanations used.

*Open-ended questions.* The open-ended responses in Studies 1 and 2 revealed interesting similarities in patterns of children’s responding. For example, when answering why questions, all age groups in the current set of studies utilized functional explanations and did so for all three types of targets: animals, humans, and artifacts. This was expected based on children and adults’ responses in previous studies (Szymanowski, 2005). When answering open-ended how questions all children and adults preferentially endorsed intentional (action) explanations to explain artifact change. Children and adults also performed similarly by using naturalistic explanations to explain adaptive change in animals (growth). Although this pattern of responding by children replicated earlier research (Szymanowski, 2005), the prediction, also based on Szymanowski (2005), that adults would preferentially endorse intentional explanations for open-ended questions, was not supported. Previously, adults were more likely to endorse an intentional action such as “God created the butterfly with wings” (Szymanowski, 2005).

One possible explanation for this difference concerns the phrasing of the question as it was posed to adults (e.g., “What would you say if a 10- to 12-year-old child asked
you the following: How did the butterfly get wings?”). Adults in the original study (Szymanowski, 2005) brought children, whose ages ranged from 8 to 12 years of age, to the laboratory. Perhaps they thought it suitable to use an intentionally based creationist response when explaining adaptive change to children of this age range (i.e., a supernatural intentional agent performs an intentional action which results in wings). In contrast, adults in the first study brought their 5- and 6-year-olds into the lab for participation and were asked the same questions. It is possible that adults overlooked the written directions and opted for what they may have considered a more proximate, naturalistic explanation (e.g., “it grew wings”), suitable for their younger children. Some support for this possibility comes from the inconsistent responses given by parents in the previous study (Szymanowski, 2005) when asked how they would respond to children of different ages. Recall that half of the adult sample changed their answers in some way for younger children, and half did not change their responses for younger children.

Another possible explanation for this difference concerns the questions preceding the adaptation questions in the original study (Szymanowski, 2005). Unlike the current studies, participants were asked a series of questions concerning the origins of entire species, before they were asked about changes in adaptive features of species. Research by Evans (2000b) suggests that when asked about the origin of a whole species, participants are likely to offer creationist (i.e., intentional) responses. Perhaps the original adult participants (Szymanowski, 2005) were primed by the first set of questions in a way that influenced their responses about adaptive parts, and so they responded with intentional explanations. On the other hand, participants in Study 1, who were not asked to answer the same origin questions beforehand, may not have experienced the same
priming. Support for this explanation is provided by adults' and older children's agreement with the closed-ended intentional prompts in the current studies. These prompts elicited agreement with the intentional explanations from participants, even though these same explanations were not provided in an open-ended format.

A third possibility involves sample differences. Parent interest information and demographic data were gathered on both samples of adults. It is possible that examination of this information would reveal important differences that would help account for the pattern of responding in each group of adults. It is probable that all of these explanations contributed to the differences between adult responses in Szymanowski (2005) and adults in the first study. Further research is required to more closely examine these differences.

Closed-ended questions. The most interesting results of using closed-ended questions in the current studies concerned the increase in the number of causes endorsed in explanations of adaptive change. When presented with multiple causes for *how* adaptive change occurs in natural kinds, participants endorsed functional causes in addition to the naturalistic causes they endorsed in the open-ended format. However, they continued to demonstrate a resistance to intentional causes (i.e., “Someone or something made them like that”). The youngest children did not agree with the explanation (mean agreement below 2.6), and older children were less likely to agree with intentional than with functional or naturalistic explanations. In contrast, when answering *why* questions about natural adaptive change, participants again endorsed multiple causes, but this time their responses included both functional and intentional explanations. Younger children, however, resisted using naturalistic "growth" causes, which was the mechanistic cause used most highly for *how* questions.
Note the central role of functional causes across these question types. Interestingly, the introduction of multiple causal candidates in the closed-ended format was directly related to the use of functional causes. Specifically, *how* questions resulted in functional causes being accepted in addition to the single naturalistic proximate cause originally endorsed in the open-ended format. *Why* questions resulted in intentional causes being accepted in addition to the previously predominating single functional cause. In other words, it seems functional causes are being used by the youngest children in two ways. In one way, functionality appears as need-based in terms of survival. That is, the functional cause was added only after a naturalistic proximate cause, like growth, was given in response to a question asking *how* adaptive features came to be. In this way, it seems function is being used as a causal consequence, where the effect or need actually preceded the cause (i.e., growth). Here, in the causal chain including function and growth, function seems to be used as the more distal cause, and no mental state or action was necessary.

The second use of function appears as need-based in terms of intentional actions or mental states. These intentional causes were added only after the functional cause was given when asked *why* adaptive features exist. In this way, function serves as an intermediate candidate in the causal chain, paired with an intentional mental state or action.

*Distal-proximate framework.* To return to the proposed distal-proximate framework (see Table 1) introduced in the first chapter, the data on multiple cause endorsement may offer some insights into participants’ use of causal chains. When only one cause is produced, it is not easy to argue that this cause represents either a proximate
or more distal level. Without further evidence it would be difficult to argue for a particular interpretation. But with multiple cause endorsement, it seems more likely that each cause represents a step in a causal chain. It is notable that with the shift from open-to closed-ended responses, functional explanations were added to how questions and intentional and naturalistic explanations to why questions. The most proximate cause likely immediately preceded the event and the functional cause provides a link between the proximate and more distal levels. Through the presentation of different questioning methods, causal flexibility was a result of the current research. One product of this causal flexibility, multiple cause endorsement, allows for an examination of a distal-proximate framework. Categorizing types of causes within this framework allows yet another opportunity to consider the use of causal explanations developmentally. Future research should investigate whether participants would actually place these explanations in a causal sequence.

Multiple cause endorsement. As predicted, for all age groups of children, as well as adults, the closed-ended format elicited multiple causes for explaining change in natural kinds. That is, when asked to generate an explanation on one’s own, as in the open-ended format, for the most part participants endorsed a single primary cause, but when presented with multiple causal options, children and adults increased the number of explanations endorsed. However, the number of explanations endorsed for natural change also increased with the age of participant. That is, when taken together, question-format and age influenced the number of causes endorsed. Specifically, from open- to closed-ended questions and from 5 years of age to adulthood, participants increased the number of explanations used to explain natural adaptive change. It is worth noting that when
comparing 5- and 6-year-olds with adults, but not when comparing the three age groups of children, even on the open-ended questions adults’ mean endorsement was higher than that of the children, indicating the subtle influence of age alone on the flexibility of causal reasoning. As participants’ age increased and they were presented with a closed-ended questioning format, the most flexible causal reasoning ability was exposed.

This increase in multiple cause endorsement with age has various implications. For example, it could be argued that this increase indicates a more flexible causal reasoning ability, as evidenced by the participant’s acceptance of diverse explanations. On the other hand, such an increase could be argued as indicating a different developmental change. For example, when one cause or explanation is clearly considered the “correct” candidate, such a flexible method of reasoning could be less than ideal, depending on the circumstances. In the case of reasoning about adaptive change, beyond the assessment of participants’ use of inappropriate responses (e.g., use of naturalistic explanations to account for artifact change), the topic of adaptive and functional change can often accommodate multiple appropriate causal candidates and due to diverse belief systems, such an outcome is well expected.

*Natural kinds versus artifacts.* One caveat regarding the increase in multiple cause endorsement with age for closed- versus open-ended questions involves responses used within the artifact domain. While the number of causes on closed-ended questions increased with age when explaining natural change, a decrease with age in number of explanations used was demonstrated when explaining artifact change. This was not expected. Recall that Casler and Kelemen (2005) argued that artifact learning is unique in that children as young as 2 years of age will overlook appropriate properties of artifacts.
that are equally good means to an end after only one exposure to an artifact’s functional
use. After one demonstration they construe the artifact as “for” that particular purpose – a
functional fixedness- and avoid using it for other purposes, whereas uses for natural kinds
are more flexible. However, consider also the argument that children are likely to
consider the creator’s intent when judging what to name human-made artifacts and when
deciding how to categorize them, a phenomenon specific to artifacts (Gelman & Bloom,
2000). When asked to name an artifact, creator’s intent influenced participants as young
as 3 years of age (Gelman & Bloom, 2000).

Taken together, the strong functional and intentional bias, suggested by Casler
and Kelemen (2005) and Gelman and Bloom (2000) respectively, could influence young
children’s causal reasoning about artifacts. This might well explain younger children's
use of both functional and intentional explanations for artifact change in the current
studies. That is, while children are influenced by both an intentional and functional bias
in their causal reasoning about artifacts, the current studies suggest that as their causal
reasoning develops into adulthood their functional bias within this domain tapers off and
they more closely focus on intentional causes (i.e., a creator’s intent) for explaining
artifact change. These findings suggest that younger children differ from adults in their
understanding of functional and intentional causes. However, I will now argue that these
findings are likely specific to the artifact domain.

Kelemen (1999) also argues that children, unlike adults, are promiscuous
teleologists in that they apply functional reasoning to more domains than do adults. In
fact, the functional explanation was a primary cause preferred by adults when asked
about natural kinds, but not when asked about artifacts. Children, on the other hand,
highly endorsed functional reasoning for both natural and artifact kinds, which appears to support the hypothesis that functional reasoning is applied across more domains by children than by adults. In fact, it does appear that the unexpected decrease in causal endorsement with age for the artifact domain is directly linked to endorsement of the functional cause. Specifically, findings from the closed-ended portions of Studies 1 and 2 confirmed that functional reasoning within the artifact domain did, in fact, decrease with age. However, examination of open-ended responses for natural change reveals that it is the adult age group that is more likely to demonstrate a functional bias.

The current research revealed that children do demonstrate a functional bias and can accept multiple causes, but performance in both of these areas is dependent on the knowledge domain in question.

**Developmental Change**

Children, like adults, can access multiple explanations and use them flexibly. They shift between the explanations that they use depending on the nature of the question (*how* or *why*) and the nature of the target (animal, human, or artifact). They display a remarkable causal flexibility (see also Poling and Evans, 2002). There were, however, some age-related changes. The developmental changes included an increase in both the number of explanations endorsed, as well as a change in the type of explanations endorsed.

When presented with multiple explanations in a closed-ended format, the number of explanations endorsed for adaptive change in natural kinds consistently increased with age, from 5- and 6-year-olds through early adulthood. In contrast, the number of explanations endorsed for change in artifacts decreased consistently with age, a finding
that was unexpected. Current findings highlight the possibility that younger children apply functional explanations (i.e., their default reasoning pattern) somewhat incorrectly to artifacts. It is possible that these young children, who are predominantly reasoning functionally, have not yet distinguished between the functional differences of artifacts and natural kinds (e.g., Bloom, 1996; Keil, 1994). Recall the discussion about natural kinds that have features which function to serve themselves, while artifacts have features that function to serve humans. Specifically, in the closed-ended questions of both studies, young children are agreeing with the statement “They needed them” and doing so for both domains, indicating their belief that the functional parts of both natural kinds and artifacts exist to serve the target item. Older respondents’ endorsement of the functional explanation is similar to younger children’s when asked about natural kinds, but decreases for artifacts. Perhaps this is in recognition that it is not the cups, doors, or chairs that “need” their parts, but instead that their parts benefit humans. This is both an interesting and important distinction that has apparently not yet been made by the younger children. Adults, on the other hand, seem to reason more flexibly and accept multiple causal options for natural change but when reasoning about artifacts, they recognize artifacts to be a product of human intention and are less likely to endorse the functional explanation.

As expected, in addition to a developmental change in type of explanations endorsed, the number of explanations utilized also appears to change across development. For example, when asked about the existence of human hands, 5- and 6-year-olds endorsed only a single functional cause. Older children moved to an endorsement of
intentional as well as functional causes, and adults endorsed all three explanations: intentional, functional, and naturalistic.

Another interesting developmental change was evident within the endorsements of the intelligent design explanation (“Someone made it”). When asked about artifact changes, although 5- to 8-year-olds, the youngest age groups in both studies, endorsed both the functional explanation as well as the intelligent design explanation, the two older age groups of children (8- to 14-year-olds) and adults were significantly more likely to prefer the intentional than the functional cause. This supports and extends the findings of previous research (Szymanowski, 2005) which suggests an increase in intentional cause endorsement as well as multiple cause endorsement with age.

A further interesting similarity between the two studies is participants’ lack of or very limited use of evolutionary reasoning. In fact, only adults and the oldest children (i.e., 10- to 14-year-olds in Study 2) ever endorsed this explanation and did so only for natural kinds. Taken together, these results may indicate an increase in evolutionary understanding with age, although it must be noted that in both studies evolutionary responses were limited. This limited use of evolutionary explanations is not surprising when considering the rampant misconceptions that adults hold about the concept of evolution (Evans, 2000a).

Limitations

While the use of different samples, with different recruitment procedures, in the current set of studies may be a strength in some regards (e.g., cross-sectional comparisons), possible limitations must also be considered. For example, Study 1 was conducted in the laboratory where parents completed questionnaires behind a one-way
mirror while their children were being interviewed on the other side of this mirror. Study 2 was conducted in a school-setting, in which parents were not present. It is possible that parent presence could influence responding for both children and adults. Second, adult questionnaires asked parents to answer questions based on how they would respond to children. It is possible that adults’ responses would differ if the instructions did not indicate this; if adults were asked what they themselves believed. Thus collecting an additional sample of adults for comparison would be beneficial for future research. Further, it would also be of interest to include high school students in a future sample specifically because it would serve to complete the school-aged sample as well as more completely fill in any developmental gap that exists between the early adolescent and adult samples already collected.

Additionally, the issue of differences in prior questioning about the origin of entire species becomes relevant when comparing the current studies with prior research (Szymanowski, 2005). These issues should be addressed in future studies, ideally by uniform recruitment procedures and methodology.

The lack of a strong question type difference within the closed-ended questions of Study 2 is possibly due to a lack of power. Participants were presented with nine animal items in Study 1, but only three animal items in Study 2.

Finally, while examining the use of each of the six reasoning patterns/explanations, a within-subjects variable was utilized. It should be acknowledged that the use of dichotomous data in the Analyses of Variance for the open-ended human and artifact comparison questions (i.e., each participant either endorsed or did not endorse each type of explanation) could possibly violate assumptions of the ANOVA.
However, of main concern was the animal domain, in which dichotomous data were not used. Dichotomous data were also avoided in all closed-ended questions.

Broader Implications

The developmental changes in causal reasoning abilities seen in these studies are open to several interpretations. Multiple cause endorsement, at least in this context, appears to reveal an increased flexible reasoning ability. We have seen that from the age of 5 years to adulthood this ability increases when explaining adaptive change in natural kinds, specifically when presented with different explanations. Perhaps with age comes an increasing awareness that a causal chain of events is often responsible for an outcome like natural change. On the other hand, for other types of domains like artifacts, such an ability may appear to decrease as children become less bound by a functional bias and more apt to recognize the importance of a single causal reason for the qualities of human made artifacts: the creator’s intention. Just as this research on causal reasoning should qualify previous findings based on methods used (e.g., how vs. why questions), the importance of the knowledge domain in question should also be recognized. As we have seen, specifying the target of such questions is imperative when discussing findings regarding causal reasoning abilities. In other words, when presented with multiple causal candidates in a case where one explanation is clearly correct, causal flexibility may hinder instead of enhance performance. On the other hand, when an outcome can be considered the product of a causal chain of events, in which multiple causes are possible, causal flexibility is necessary in order to understand the chain of events.

Knowing that different types of causes are offered for different events, and that this changes developmentally, is an important basis for understanding the development of
causal reasoning abilities. As children move from the recognition of proximate causes to
acknowledging the impact of more distal causes, both the quantity and quality of their
causal attributions change. Additionally, the moderating impact of a functional bias
decreases with age, affording the opportunity to both recognize and utilize additional and
alternative causal explanations, including but not limited to ultimate causes.

Conclusion

In the current research, children as young as 5 years of age demonstrated a rather
sophisticated causal reasoning ability. Together, a distinction between question type,
differentiation of knowledge domains, and an increase in cause endorsement across
question formats indicates the presence of causal flexibility in these young participants.
The developmental patterns of responding that were revealed suggest both quantitative as
well as qualitative change from early to middle school years and beyond in terms of
causal attributions. By manipulating a specific set of factors in this series of studies, the
impact of several influences on the flexibility and content of causal explanations was
revealed. In order to more completely uncover the developmental trajectory of causal
reasoning, in addition to considering developmental change, it is both important and
necessary to understand the influence of factors such as knowledge domain, linguistic
demands (why, how), and interrogative manipulations (open- vs. closed ended) on how
causal events are perceived and explained. In addition to demonstrating various ways to
elicit causal explanations and endorsements, perhaps this research has exposed some of
the obstacles to causal reasoning flexibility that may be present at different points
throughout development. Further research should continue to examine and compare
options for studying causal reasoning in childhood, in an effort to reach the most complete understanding of this interesting and critical ability.

In sum, it appears that even young children can demonstrate rather sophisticated causal reasoning abilities when given the opportunity to do so. However, it is important for those examining the development of causal explanations to consider the importance of factors influencing participants’ responding. The goal of the current research was to make strides in outlining the influence of specific factors while mapping the development of causal understanding from early school-age years into adulthood. The current findings have highlighted the importance of considering these influences when interpreting previous as well as the current findings regarding the development of causal explanations.
References


Gelman, S.A., & Bloom, P. (2000). Young children are sensitive to how an object was created when deciding what to name it. Cognition, 76, 91-103.


Merrill, (Originally published, 1748).


tradition in Philosophical religious and institutional context, 600 B.C. – A.D.

1450. Chicago: University of Chicago.


Perry, R., & Magnusson, J. (1989). Causal attributions and perceived performance:
Consequences for college students’ achievement and perceived control in different instructional conditions. *Journal of Educational Psychology, 81*(2), 164-172.


Appendix A

Child Interview: Study 1

<table>
<thead>
<tr>
<th>Child ID:</th>
<th>DATE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent ID:</td>
<td>B(a) or B(b)?</td>
</tr>
<tr>
<td>Siblings in Study: IDs</td>
<td>Interviewer Name/ID:</td>
</tr>
<tr>
<td>Age:</td>
<td>Birth Date:</td>
</tr>
<tr>
<td>Ethnicity:</td>
<td>Male/Female:</td>
</tr>
<tr>
<td>Testing Place:</td>
<td>Age (years/months)</td>
</tr>
<tr>
<td>School Name:</td>
<td>Age (years/tenths)</td>
</tr>
<tr>
<td>Time Started &amp; Time Finished:</td>
<td>Tape No.</td>
</tr>
<tr>
<td></td>
<td>Total Time Taken:</td>
</tr>
</tbody>
</table>

**DEMOGRAPHICS (from Parent Form)**

<table>
<thead>
<tr>
<th>Adult</th>
<th>Relationship to Child</th>
<th>Educational Level</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult 1:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult 2:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult 3:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**RELIGION:**

**ETHNICITY:**

**NOTES**

(1) Child Behavior

(2) Any special problems with task:
**ANIMAL NAMING TASK (WARM-UP)**

Here are some pictures of some animals and of some other things. I want you to tell me which are animals and which aren't animals (begin with a cup). Is this an animal? Can you tell me what it is called?

<table>
<thead>
<tr>
<th>ORDER</th>
<th>ITEM</th>
<th>IS THIS AN ANIMAL?</th>
<th>WHAT'S IT CALLED?</th>
<th>ANY OTHER INFORMATION?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squirrel</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rabbit</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frog</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butterfly</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIRST</td>
<td>Cup</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Chair</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**A1 Animal Category Score**  
Out of 5 YES

**A2 Animal Naming Score**  
Out of 5

**A3 Human as Animal**  
YES or NO

**A4 Artifact Category Score**  
Out of 3 NO

**A5 Artifact Naming Score**  
Out of 3

**AGREEMENT CARD PRACTICE**

These cards are for you to show me how much you agree with what I’m going to tell you. Tell me whether you agree a lot, agree a little, disagree a lot, or disagree a little about what I’m telling you. (Continue until you’re sure they understand the cards)

(1) DOG (for FROG)

(2) RABBIT (for RABBIT)

(3) CUP (for CHAIR)
B. OPEN-ENDED ADAPTATION QUESTIONS
(alternate A and B between participants).

Now, I want you to tell me your own ideas about how some things got their parts. There are no right or wrong answers to the questions, just different kinds of ideas. Think about what you would say if another kid asked you these questions. So if another kid asked you “[child’s name], how/why did the ______”.

Now, think about the X. “How/Why do you think Xs get Xs?” (USE PHOTOS)

PROBE 1: I’d like to hear any ideas you might have, whatever you think. Remember there are no right or wrong ideas. - REPEAT QUESTION

<table>
<thead>
<tr>
<th>NOTE IF YOU HAD TO USE PROBES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(B1a) WHY did BUTTERFLIES get wings?</td>
</tr>
<tr>
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<td></td>
</tr>
</tbody>
</table>
C. CLOSED-ENDED: ADAPTATIONS OF ANIMALS AND ARTIFACTS

<table>
<thead>
<tr>
<th>ORDER</th>
<th>QUESTION and ANSWERS</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HUMANS (PERSONS)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HOW/WHY DID **AFRICAN HUMANS (1)** GET HANDS?

- C1. They needed them.
  
  *What do you think they needed them for?*
  
  1 2 3 4

- C2. Somebody or something made them like that.
  
  **WHO? OR WHAT?**
  
  1 2 3 4

- C3. They grew them
  
  1 2 3 4

HOW/WHY DID **EUROPEAN HUMANS (2)** GET HANDS?

- C1. They needed them.
  
  *What do you think they needed them for?*
  
  1 2 3 4

- C2. Somebody or something made them like that.
  
  **WHO? OR WHAT?**
  
  1 2 3 4

- C3. They grew them
  
  1 2 3 4

HOW/WHY DID **ASIAN HUMANS (3)** GET HANDS?

- C1. They needed them.
  
  *What do you think they needed them for?*
  
  1 2 3 4

- C2. Somebody or something made them like that.
  
  **WHO? OR WHAT?**
  
  1 2 3 4

- C3. They grew them
  
  1 2 3 4
<table>
<thead>
<tr>
<th>ORDER</th>
<th>QUESTION and ANSWERS</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUTTERFLIES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOW/WHY DID <strong>MIMIC BUTTERFLIES (1)</strong> GET WINGS?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1. They needed them.</td>
<td>“What do you think they needed them for?”</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>C2. Somebody or something made them like that.</td>
<td><strong>WHO? OR WHAT?</strong></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>C3. They grew them.</td>
<td></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>HOW/WHY DID <strong>NYMPH BUTTERFLIES (2)</strong> GET WINGS?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1. They needed them.</td>
<td>“What do you think they needed them for?”</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>C2. Somebody or something made them like that.</td>
<td><strong>WHO? OR WHAT?</strong></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>C3. They grew them.</td>
<td></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>HOW/WHY DID <strong>QUEEN BUTTERFLIES (3)</strong> GET WINGS?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1. They needed them.</td>
<td>“What do you think they needed them for?”</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>C2. Somebody or something made them like that.</td>
<td><strong>WHO? OR WHAT?</strong></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>C3. They grew them.</td>
<td></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>ORDER</td>
<td>QUESTION and ANSWERS</td>
<td>SCALE</td>
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<td>-------</td>
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</tr>
<tr>
<td></td>
<td><strong>FROGS</strong></td>
<td></td>
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<tr>
<td></td>
<td>HOW/WHY DID <strong>GRASS FROGS (1)</strong> GET WEBBED FEET?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>WHO? OR WHAT?</td>
<td>1 2 3 4</td>
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<tr>
<td></td>
<td>C3. They grew them.</td>
<td>1 2 3 4</td>
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<tr>
<td></td>
<td>HOW/WHY DID <strong>HARLY FROGS (2)</strong> GET WEBBED FEET?</td>
<td></td>
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<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
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<tr>
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<td>“What do you think they needed them for?”</td>
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<tr>
<td></td>
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<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>WHO? OR WHAT?</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>C3. They grew them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>HOW/WHY DID <strong>SKUNK FROGS (3)</strong> GET WEBBED FEET?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
</tr>
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<td>C2. Somebody or something made them like that.</td>
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<td>ORDER</td>
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<td>SCALE</td>
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</tr>
<tr>
<td>MAMMALS</td>
<td>HOW/WHY DID <strong>DEER</strong> GET <strong>ANTLERS</strong>?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>&quot;What do you think they needed them for?&quot;</td>
<td></td>
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<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
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<td></td>
<td>WHO? OR WHAT?</td>
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<td>C3. They grew them.</td>
<td>1 2 3 4</td>
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<tr>
<td></td>
<td>HOW/WHY DID <strong>RABBITS</strong> GET <strong>EARS</strong>?</td>
<td></td>
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<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>&quot;What do you think they needed them for?&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
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<td></td>
<td>WHO? OR WHAT?</td>
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<tr>
<td></td>
<td>C3. They grew them.</td>
<td>1 2 3 4</td>
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<td></td>
<td>HOW/WHY DID <strong>SQUIRRELS</strong> GET <strong>PAWS</strong>?</td>
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<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
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<td></td>
<td>&quot;What do you think they needed them for?&quot;</td>
<td></td>
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<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
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<td></td>
<td>WHO? OR WHAT?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3. They grew them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>ORDER</td>
<td>QUESTION and ANSWERS</td>
<td>SCALE</td>
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<td></td>
<td>ARTIFACTS</td>
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<td></td>
<td>HOW/WHY DID <strong>DOORS</strong> GET HANDLES?</td>
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<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
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<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
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<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
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<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3. They grew them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>HOW/WHY DID <strong>CHAIRS</strong> GET LEGS?</td>
<td></td>
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<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3. It grew them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>HOW/WHY DID <strong>CUPS</strong> GET HANDLES?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3. They grew them.</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>
## Appendix B

### Parent Questionnaire: Study 1

**VERSION A:**

**ADULT EXPLANATIONS TO A CHILD:** We are interested in the kinds of explanations that adults might give to children about the following questions on the parts of animals and household things.

Imagine YOU were responding to the questions of a 10- to 12-year-old child you know, and he or she had asked you the following. Please briefly write down your answers:

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) WHY did <strong>BUTTERFLIES</strong> get wings?</td>
<td></td>
</tr>
<tr>
<td>(2) WHY did <strong>DEER</strong> get antlers?</td>
<td></td>
</tr>
<tr>
<td>(3) WHY did <strong>FROGS</strong> get webbed feet?</td>
<td></td>
</tr>
<tr>
<td>(4) WHY did <strong>HUMANS</strong> get hands?</td>
<td></td>
</tr>
<tr>
<td>(5) WHY did <strong>CHAIRS</strong> get legs?</td>
<td></td>
</tr>
</tbody>
</table>
CHILDREN’S IDEAS ABOUT WHY ANIMALS AND HOUSEHOLD ITEMS GET THEIR PARTS

Here are some answers (D1, D2 & D3) children have given to the following questions. Please look at the children's ideas and rate how much you agree with them. If you agree with questions D1 and D2, could you also respond to the follow-up questions (Who made them? What do you think they were needed for?)

Look at each of these questions then rate whether YOU agree with each answer. Please circle 1, 2, 3, or 4 using the following 4-point scale:

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2--------</td>
<td>3------</td>
<td>4---------------</td>
</tr>
</tbody>
</table>

QUESTION 1:

Why did CUPS get handles?

D1. They needed them
What do you think they needed them for?

D2. Somebody or something made them like that.
WHO or WHAT MADE THEM?

D3. They grew them.

QUESTION 2:

Why did SQUIRRELS get paws?

D2. Somebody or something made them like that.
WHO or WHAT MADE THEM?

D1. They needed them
What do you think they needed them for?

D3. They grew them.

QUESTION 3:

Why did QUEEN BUTTERFLIES get wings?

D3. They grew them.

D2. Somebody or something made them like that.
WHO or WHAT MADE THEM?

D1. They needed them
What do you think they needed them for?
<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**QUESTION 4:**

Why did GRASS FROGS get webbed feet?

D1. They needed them  
What do you think they needed them for?  
D3. They grew them.  
D2. Somebody or something made them like that.  
WHO or WHAT MADE THEM?

**QUESTION 5:**

Why did AFRICAN HUMANS get hands?

D2. Somebody or something made them like that.  
WHO or WHAT MADE THEM?  
D3. They grew them.  
D1. They needed them  
What do you think they needed them for?

**QUESTION 6:**

Why did NYMPH BUTTERFLIES get wings?

D3. They grew them.  
D1. They needed them  
What do you think they needed them for?  
D2. Somebody or something made them like that.  
WHO or WHAT MADE THEM?
### QUESTION 7:

**Why did HARLY FROGS get webbed feet?**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

D1. They needed them

What do you think they needed them for?

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?

D3. They grew them.

### QUESTION 8:

**Why did DEER get antlers?**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?

D1. They needed them

What do you think they needed them for?

D3. They grew them.

### QUESTION 9:

**Why did EUROPEAN HUMANS get hands?**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

D3. They grew them.

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?

D1. They needed them

What do you think they needed them for?
### QUESTION 10:

Why did CHAIRS get legs?

- **D1.** They needed them
  - What do you think they needed them for? 
  - 1 2 3 4

- **D3.** They grew them.
  - 1 2 3 4

- **D2.** Somebody or something made them like that.
  - WHO or WHAT MADE THEM? 
  - 1 2 3 4

### QUESTION 11:

Why did SKUNK FROGS get webbed feet?

- **D2.** Somebody or something made them like that.
  - WHO or WHAT MADE THEM? 
  - 1 2 3 4

- **D3.** They grew them.
  - 1 2 3 4

- **D1.** They needed them
  - What do you think they needed them for? 
  - 1 2 3 4

### QUESTION 12:

Why did ASIAN HUMANS get hands?

- **D3.** They grew them.
  - 1 2 3 4

- **D1.** They needed them
  - What do you think they needed them for? 
  - 1 2 3 4

- **D2.** Somebody or something made them like that.
  - WHO or WHAT MADE THEM? 
  - 1 2 3 4
<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
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<td>4</td>
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</table>

**QUESTION 13:**

Why did DOORS get handles?

D1. They needed them
What do you think they needed them for?

D2. Somebody or something made them like that.
WHO or WHAT MADE THEM?

D3. They grew them.

**QUESTION 14:**

Why did RABBITS get ears?

D2. Somebody or something made them like that.
WHO or WHAT MADE THEM?

D1. They needed them
What do you think they needed them for?

D3. They grew them.

**QUESTION 15:**

Why did MIMIC BUTTERFLIES get wings?

D3. They grew them.

D2. Somebody or something made them like that.
WHO or WHAT MADE THEM?

D1. They needed them
What do you think they needed them for?
**DEMOGRAPHIC INFORMATION SHEET** No individual parent or child will be identified. We just want to make sure that for each age-level, children have families of similar backgrounds.

(1) What is the highest educational level you and other adult members of your family have COMPLETED and (2) what is the occupation of each adult in your family?

### EDUCATION LEVEL

<table>
<thead>
<tr>
<th>Relation to Child</th>
<th>Highest Educational Level</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>YOU:</td>
<td></td>
<td></td>
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<tr>
<td>OTHER ADULT:</td>
<td></td>
<td></td>
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<tr>
<td>OTHER ADULT:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3) What is the highest level of education that you think your child will COMPLETE (please use the above scale)? *(If more than one of your children took part in the study, please answer for each child)*:

<table>
<thead>
<tr>
<th>Child's Name</th>
<th>Education Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

(4) What kind of Church, Synagogue, Mosque, or other place of worship do you usually attend (PLEASE PUT ITS NAME AND LOCATION)? *(Put NONE if you don't have any one place of worship you attend regularly)*

(5) In order to make sure that we have participants from different ethnic groups in the study, would you please indicate the race/ethnicity of your child with an X. *(If more than one of your children took part in the study, please answer for each child.)*

<table>
<thead>
<tr>
<th>Child Name</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Non-Hispanic White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American (Black)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Native American</td>
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<tr>
<td>Asian/Pacific Islander</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Multiracial</td>
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<td>OTHER?</td>
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THANK YOU VERY MUCH FOR YOUR HELP. Is there anything else you would like to add?
**PARENT QUESTIONNAIRE B:**
**ADULT EXPLANATIONS TO A CHILD:** We are interested in the kinds of explanations that adults might give to children about the following questions on the parts of animals and household things.

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<td></td>
</tr>
<tr>
<td>(3) <strong>HOW</strong> did <strong>FROGS</strong> get webbed feet?</td>
<td></td>
</tr>
<tr>
<td>(4) <strong>HOW</strong> did <strong>HUMANS</strong> get hands?</td>
<td></td>
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<tr>
<td>(5) <strong>HOW</strong> did <strong>CHAIRS</strong> get legs?</td>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>--------</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**QUESTION 1:**

**How did CUPS get handles?**

D1. They needed them

What do you think they needed them for?

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<tr>
<th>1</th>
<th>2</th>
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</thead>
</table>

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>

D3. They grew them.

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<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
</table>

**QUESTION 2:**

**How did SQUIRRELS get paws?**

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?

<table>
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<tr>
<th>1</th>
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<th>4</th>
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</table>

D1. They needed them

What do you think they needed them for?

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<tr>
<th>1</th>
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<th>3</th>
<th>4</th>
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</thead>
</table>

D3. They grew them.

<table>
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<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
</table>

**QUESTION 3:**

**How did QUEEN BUTTERFLIES get wings?**

D3. They grew them.

<table>
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<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>

D1. They needed them

What do you think they needed them for?

| 1 | 2 | 3 | 4 |
### Causal Flexibility 119

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2-3-4</td>
<td></td>
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</tr>
</tbody>
</table>

**QUESTION 4:**

How did GRASS FROGS get webbed feet?

- **D1.** They needed them
  - What do you think they needed them for?

- **D3.** They grew them.

- **D2.** Somebody or something made them like that.
  - WHO or WHAT MADE THEM?

**QUESTION 5:**

How did AFRICAN HUMANS get hands?

- **D2.** Somebody or something made them like that.
  - WHO or WHAT MADE THEM?

- **D3.** They grew them.

- **D1.** They needed them
  - What do you think they needed them for?

**QUESTION 6:**

How did NYMPH BUTTERFLIES get wings?

- **D3.** They grew them.

- **D1.** They needed them
  - What do you think they needed them for?

- **D2.** Somebody or something made them like that.
  - WHO or WHAT MADE THEM?
<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2-3-4</td>
<td>1-2-3-4</td>
<td>1-2-3-4</td>
<td>1-2-3-4</td>
</tr>
</tbody>
</table>

**QUESTION 7:**

How did HARLY FROGS get webbed feet?

D1. They needed them  
What do you think they needed them for?  

D2. Somebody or something made them like that.  
WHO or WHAT MADE THEM?  

D3. They grew them.

**QUESTION 8:**

How did DEER get antlers?

D2. Somebody or something made them like that.  
WHO or WHAT MADE THEM?  

D1. They needed them  
What do you think they needed them for?  

D3. They grew them.

**QUESTION 9:**

How did EUROPEAN HUMANS get hands?

D3. They grew them.  

D2. Somebody or something made them like that.  
WHO or WHAT MADE THEM?  

D1. They needed them  
What do you think they needed them for?
### QUESTION 10:

**How did CHAIRS get legs?**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

D1. They needed them

What do you think they needed them for?

D3. They grew them.

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?

### QUESTION 11:

**How did SKUNK FROGS get webbed feet?**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?

D3. They grew them.

D1. They needed them

What do you think they needed them for?

### QUESTION 12:

**How did ASIAN HUMANS get hands?**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

D3. They grew them.

D1. They needed them

What do you think they needed them for?

D2. Somebody or something made them like that.

WHO or WHAT MADE THEM?
<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>1</td>
<td>2--------</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**QUESTION 13:**

How did DOORS get handles?

- D1. They needed them
  What do you think they needed them for?  
  1 2 3 4

- D2. Somebody or something made them like that.
  WHO or WHAT MADE THEM?  
  1 2 3 4

- D3. They grew them.  
  1 2 3 4

**QUESTION 14:**

How did RABBITS get ears?

- D2. Somebody or something made them like that.
  WHO or WHAT MADE THEM?  
  1 2 3 4

- D1. They needed them
  What do you think they needed them for?  
  1 2 3 4

- D3. They grew them.  
  1 2 3 4

**QUESTION 15:**

How did MIMIC BUTTERFLIES get wings?

- D3. They grew them.  
  1 2 3 4

- D2. Somebody or something made them like that.
  WHO or WHAT MADE THEM?  
  1 2 3 4

- D1. They needed them
  What do you think they needed them for?  
  1 2 3 4
DEMOGRAPHIC INFORMATION SHEET

No individual parent or child will be identified. We just want to make sure that for each age-level, children have families of similar backgrounds.

(1) What is the highest educational level you and other adult members of your family have COMPLETED and (2) what is the occupation of each adult in your family?

<table>
<thead>
<tr>
<th>EDUCATION LEVEL</th>
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</thead>
<tbody>
<tr>
<td>Some High school</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2-year College or Vocational School</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>Graduate School</td>
</tr>
</tbody>
</table>

RELATION TO CHILD

<table>
<thead>
<tr>
<th>(1) HIGHEST EDUCATIONAL LEVEL</th>
<th>(2) OCCUPATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>YOU:</td>
<td></td>
</tr>
<tr>
<td>OTHER ADULT:</td>
<td></td>
</tr>
<tr>
<td>OTHER ADULT:</td>
<td></td>
</tr>
</tbody>
</table>

(3) What is the highest level of education that you think your child will COMPLETE (please use the above scale)? (If more than one of your children took part in the study, please answer for each child):

Child's Name:     Education Level: 1   2   3   4   5
Child's Name:     Education Level: 1   2   3   4   5
Child's Name:     Education Level: 1   2   3   4   5

(4) What kind of Church, Synagogue, Mosque, or other place of worship do you usually attend (PLEASE PUT ITS NAME AND LOCATION)? (Put NONE if you don't have any one place of worship you attend regularly)

(5) In order to make sure that we have participants from different ethnic groups in the study, would you please indicate the race/ethnicity of your child with an X. (If more than one of your children took part in the study, please answer for each child.)

<table>
<thead>
<tr>
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<th>Child Name:</th>
<th>Child Name:</th>
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<tbody>
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<tr>
<td>Hispanic</td>
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<td></td>
</tr>
<tr>
<td>African-American (Black)</td>
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<td></td>
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<tr>
<td>Native American</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td></td>
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</tr>
<tr>
<td>Multiracial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER?</td>
<td></td>
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</table>

THANK YOU VERY MUCH FOR YOUR HELP. Is there anything else you would like to add?
Appendix C

Parent Recruitment Letter

Sent to parents from the Developmental Studies Child Database

Dear Parents:

In the Program for Developmental Studies at the University of Toledo we conduct studies on the development of children's learning and reasoning processes. We are currently conducting a study on children's understanding of different types of causes and the purpose of this letter is to ask your permission for you and your child to participate in this study.

Children and parents from the Toledo area have helped us conduct studies with infants for the past several years. We are aiming to extend our work beyond infancy into later childhood, but we need the cooperation of people in the community, such as your family. We are interested in finding out how children's ideas about different types of causes change over the preschool and school-age years. The current study focuses on children's ideas about what causes are involved in different types of events. Children will be asked about the useful parts of several natural and artificial items, such as mammals (e.g., squirrels), insects (e.g., butterflies) and household items (e.g., cups) and then asked about the existence of these items' parts. For example, children will evaluate answers given in earlier studies, such as whether butterflies and cups "grew their parts" or "had their parts made by somebody" (Children will not be asked about birth.) They will not have to write anything down and should find the interview fun and interesting. We are interviewing children between the ages of six and twelve years of age.

This study, like all studies conducted in the Program for Developmental Studies, has been approved by the Human Subjects Research Review Committee at the University of Toledo. The current procedure is carefully designed to conform to the highest ethical research standards. These standards include minimizing any risks to research participants and maintaining strict confidentiality concerning all aspects of an individual's participation.

If you agree to participate in the current study, you will be asked to bring your child to the University at a time that is convenient to you. The interview should take about 20 to 30 minutes per child (depending on the age of the child), during which time you will be able to observe the interview through a one-way mirror. When the entire study is complete we will send your family a brief summary of the results, in which we will report changes in children's reasoning by age group.

Participation of children and parents from the community in our research is very helpful to the advancement of our knowledge of child learning. It is through studying the development of children's concepts that we lay the groundwork for school curricula that nurture students' abilities. You will be contacted by telephone within a few days to determine whether you are willing to have your child interviewed. More information about the study will be provided then, if requested. If for any reason you prefer that we not call, please call us at (419) 530-2338. Enclosed is a map of the campus for your use if you decide to participate in this study. Thank you for your time in considering our request.

Sincerely yours,

Kristin Szymanowski Peg Smith, Ph.D.,
(419) 530-2351 (419) 530-2347
PARENT INFORMED CONSENT FORM
The Development of Causal Explanations in School-Aged Children

**Principal Investigator:** Kristin Szymanowski Price, M.A. 419-530-2351
Peg Hull Smith, Ph.D. 419-530-2347

**Purpose:** The Program for Developmental Studies at the University of Toledo conducts studies on children's learning and reasoning processes. The purpose of this letter is to ask your permission for your child to participate in the current study on children's causal explanations.

This study focuses on children's ideas about different types of causes for various events. Children will be asked about the existence of parts of several natural and artificial items, such as mammals (e.g., squirrels), insects (e.g., butterflies) and household items (e.g., cups). Children will then evaluate answers given in earlier studies, such as whether squirrels' paws and butterflies' wings were needed or were made by somebody. Finally, children will be asked to create an animal themselves out of play-dough and asked about their creative actions. They will not have to write anything down and should find the interview fun and interesting.

**Description of Procedures:** When you give written permission your child will be asked if he or she would like to participate. Your child will participate individually, in an approximately 20 minute interview, in a quiet but well-traveled area of his/her school. In order to ensure that all responses are accurately recorded, we ask permission to audio-tape the interview. The tapes will be kept for approximately five years in case further analyses need to be carried out.

“Permission to record: Will you permit the researcher to audio record during this research procedure?

**YES** [ ] **NO** [ ]

Initial [ ]

Any information that could identify your child will be separated from your child's answers and the audiotape. The principal investigator will be the only person who will have access to this information. The consent forms with signatures will be kept separate from your child's responses, which will not include names and which will be presented to others only when combined with other responses. You may request that your child not be audio-taped and your child may withdraw from this study at any time. Participation is completely voluntary. When the session is completed, any questions that you or your child have will be answered and your child will be presented with a certificate and a sticker in appreciation for his or her participation in the study.

Any questions you may have can be answered by calling Kristin Szymanowski Price (419-530-2351) or Peg Hull Smith (419-530-2347). Should you have questions regarding your rights as a research participant that have not been answered by the investigator, please feel free to contact Dr. Jeffrey Busch, research compliance coordinator at (419) 530-2844, or the chairperson of the SBE Institutional Review Board, Dr. Barbara Chesney, in the Office of Research on the main campus at (419) 530-2844.

When the study is complete, we will send a summary of the results to you. This is not a study of individual skills; we are concerned with the average behavior of groups of children and will only
report group results. From these studies we hope to discover the kinds of knowledge that children of different ages might bring to the school setting. Thank you very much for considering this request and we hope you will agree to participate by signing the attached permission slip.

CONSENT TO PARTICIPATE: I understand the nature of the project and the nature of my child's participation. I also understand that I can stop my child participating at any time and that if my child does not wish to participate the session will be halted at that point. A decision not to participate or stop the session will in no way affect my or my child's present or future relationship with the University of Toledo. YES, I give my consent, as parent/guardian, for my child to participate.

Parent/Guardian's Signature ____________________________________________________________________________
Today's Date ____________ Parent's Name ____________________________________________________________________________
Printed _____________________________________________________________________________________________
Male/Female ____________________________________________________________________________________________
Child's Name ____________________________________________________________________________________________
Child's Birthdate (Please Circle) ____________

THE UNIVERSITY OF TOLEDO
SOCIAL, BEHAVIORAL & EDUCATIONAL INSTITUTIONAL REVIEW BOARD

The research project described in this consent form and the form itself have been reviewed and approved by the University of Toledo Social, Behavioral & Educational Review Board (SBE IRB) for the period of time specified below.

SBE IRB #: ____________________________ Approved Number of Human Subjects: ______

Project Start Date: __________________ Project Expiration Date: __________________

__________________________________________________________ Date: ________________
Barbara Chesney, Ph.D., Chair
UT Social Behavioral & Educational IRB
Appendix D

Child Verbal Assent Form

<table>
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<tr>
<th>Child's Name</th>
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<th>Time</th>
<th>Researcher's Name</th>
<th>Signature</th>
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<tbody>
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# Appendix E

## Child Interview: Study 2

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<th>Child ID:</th>
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<tbody>
<tr>
<td>Siblings in Study: IDs</td>
<td>B(a) or B(b)?</td>
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<td></td>
<td>Interviewer Name/ID:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age:</th>
<th>Birth Date:</th>
<th>Age (years/months)</th>
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</thead>
<tbody>
<tr>
<td>Ethnicity:</td>
<td>Male/Female:</td>
<td>Age (years/tenths)</td>
</tr>
<tr>
<td>Testing Place:</td>
<td></td>
<td>Tape No.</td>
</tr>
<tr>
<td>School Name:</td>
<td></td>
<td>Current Grade:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade Next Semester:</td>
</tr>
</tbody>
</table>

| Time Started & Time Finished: | Total Time Taken: |

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<th>DEMOGRAPHICS (from Parent Form if lab tested)</th>
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<tbody>
<tr>
<td>Adult</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Adult 1:</td>
</tr>
<tr>
<td>Adult 2:</td>
</tr>
<tr>
<td>Adult 3:</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>RELIGION:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>ETHNICITY:</th>
</tr>
</thead>
</table>
A. **ANIMAL NAMING TASK (WARM-UP)**

Here are some pictures of some animals and of some other things. I want you to tell me which are animals and which aren't animals (begin with a cup). Is this an animal? Can you tell me what it is called?

<table>
<thead>
<tr>
<th>ORDER</th>
<th>ITEM</th>
<th>IS THIS AN ANIMAL?</th>
<th>WHAT’S IT CALLED?</th>
<th>ANY OTHER INFORMATION?</th>
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<tbody>
<tr>
<td></td>
<td>Squirrel</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frog</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Butterfly</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Human</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>FIRST</td>
<td>Cup</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chair</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Door</td>
<td>Yes</td>
<td>No</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>A1 Animal Category Score</th>
<th>Out of 3 YES</th>
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</thead>
<tbody>
<tr>
<td>A2 Animal Naming Score</td>
<td>Out of 3</td>
</tr>
<tr>
<td>A3 Human as Animal</td>
<td>YES or NO</td>
</tr>
<tr>
<td>A4 Artifact Category Score</td>
<td>Out of 3 NO</td>
</tr>
<tr>
<td>A5 Artifact Naming Score</td>
<td>Out of 3</td>
</tr>
</tbody>
</table>

**AGREEMENT CARD PRACTICE**

These cards are for you to show me how much you agree with what I’m going to tell you. Tell me whether you agree a lot, agree a little, disagree a lot, or disagree a little about what I’m telling you. (Continue until you’re sure they understand the cards)

1) **DOG** (for **FROG**)

2) **SQUIRREL** (for **SQUIRREL**)

3) **CUP** (for **CHAIR**)

B. OPEN-ENDED QUESTIONS
(alternate A and B between participants).

Now, I want you to tell me your own ideas about how some things got their parts. There are no right or wrong answers to the questions, just different kinds of ideas. Think about what you would say if another kid asked you these questions. So if another kid asked you “[child’s name], how/why did the _____”. Now, think about the X. "How/Why do you think Xs get Xs?” (USE PHOTOS)

PROBE 1: I’d like to hear any ideas you might have, whatever you think. Remember there are no right or wrong ideas. -REPEAT QUESTION

NOTE IF YOU HAD TO USE PROBES

(B1a) **WHY** did BUTTERFLIES get wings?

(B2a) **WHY** did DEER get antlers?

(B3a) **WHY** did FROGS get webbed feet?

(B4a) **WHY** did HUMANS get hands?

(B5a) **WHY** did CHAIRS get legs?

(B1b) **HOW** did BUTTERFLIES get wings?

(B2b) **HOW** did DEER get antlers?

(B3b) **HOW** did FROGS get webbed feet?

(B4b) **HOW** did HUMANS get hands?

(B5b) **HOW** did CHAIRS get legs?
### C. CLOSED-ENDED: ADAPTATIONS OF ANIMALS AND ARTIFACTS

<table>
<thead>
<tr>
<th>ORDER</th>
<th>QUESTION and ANSWERS</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>HUMANS (PERSONS)</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HOW/WHY DID <strong>AFRICAN HUMANS</strong> GET HANDS?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3. They grew them</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>HOW/WHY DID <strong>EUROPEAN HUMANS</strong> GET HANDS?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
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<tr>
<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3. They grew them</td>
<td>1 2 3 4</td>
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<td></td>
<td>HOW/WHY DID <strong>ASIAN HUMANS</strong> GET HANDS?</td>
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<tr>
<td></td>
<td>C1. They needed them.</td>
<td>1 2 3 4</td>
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<td></td>
<td>“What do you think they needed them for?”</td>
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<td></td>
<td>C2. Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3. They grew them</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>
### HOW/WHY DID **QUEEN BUTTERFLIES** GET WINGS?

<table>
<thead>
<tr>
<th>ORDER</th>
<th>QUESTION and ANSWERS</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1.</td>
<td>They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
</tr>
<tr>
<td>C2.</td>
<td>Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td>C3.</td>
<td>They grew them.</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>

### HOW/WHY DID **SKUNK FROGS** GET WEBBED FEET?

<table>
<thead>
<tr>
<th>ORDER</th>
<th>QUESTION and ANSWERS</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1.</td>
<td>They needed them.</td>
<td>1 2 3 4</td>
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<td></td>
</tr>
<tr>
<td>C3.</td>
<td>They grew them.</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>

### HOW/WHY DID **SQUIRRELS** GET PAWS?

<table>
<thead>
<tr>
<th>ORDER</th>
<th>QUESTION and ANSWERS</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1.</td>
<td>They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
</tr>
<tr>
<td>C2.</td>
<td>Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
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<td><strong>WHO? OR WHAT?</strong></td>
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</tr>
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</tr>
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</tr>
<tr>
<td>-------</td>
<td>-----------------------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td><strong>ARTIFACTS</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HOW/WHY DID <strong>DOORS</strong> GET HANDLES?</td>
<td></td>
</tr>
<tr>
<td>C1.</td>
<td>They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
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<tr>
<td>C2.</td>
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<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td>C3.</td>
<td>They grew them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>HOW/WHY DID <strong>CHAIRS</strong> GET LEGS?</td>
<td></td>
</tr>
<tr>
<td>C1.</td>
<td>They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
<td></td>
</tr>
<tr>
<td>C2.</td>
<td>Somebody or something made them like that.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td><strong>WHO? OR WHAT?</strong></td>
<td></td>
</tr>
<tr>
<td>C3.</td>
<td>It grew them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>HOW/WHY DID <strong>CUPS</strong> GET HANDLES?</td>
<td></td>
</tr>
<tr>
<td>C1.</td>
<td>They needed them.</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>“What do you think they needed them for?”</td>
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<tr>
<td>C3.</td>
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</tr>
</tbody>
</table>
Appendix F
Coding Scheme: Studies 1 and 2

OPEN ENDED ADAPTATION RESPONSES (HOW/WHY): CODEBOOK

GENERAL CODING INSTRUCTIONS:

I. Each response is coded into one or more of the reasoning patterns below.

REASONING PATTERNS:

(A) IR = INTENTIONAL REASONER
(B) FR = FUNCTIONAL REASONER
(C) ER = ESSENTIALIST REASONER
(D) NNR = NON-EVOLUTIONIST NATURALISTIC REASONER
(E) ENR = EVOLUTIONIST NATURALISTIC REASONER
(O) O = OTHER

II. Each reasoning pattern is associated with a characteristic set of explanations. However, a particular response may include explanations from more than one reasoning pattern. Therefore, for any one response, a particular respondent could endorse more than one reasoning pattern (e.g., FR & ER).


REASONING PATTERNS

(A) INTENTIONAL REASONER (IR)

**Intentional Agent:** Intelligent Design

(01) \( G = \text{God} \)

God, the Lord, Jesus, the Creator

*Animal:* “That’s the way \text{God} made it.”

*Human:* “That’s the way \text{God} made them.”

*Artifact:* “That’s the way \text{God} wanted it to be made.”

(02) \( \text{Hm} = \text{Human} \)

Humans, a person, a man/woman, an inventor

*Animal:* No Examples

*Human:* No Examples

*Artifact:* “*Man* made a chair and put legs on it so that it would be taller.”

(03) \( \text{Sm} = \text{Somebody} \)

“Somebody”, no one specifically mentioned, “everybody”, “Its maker,”

*Animal:* “…*someone* drew a picture of one and they really wanted one of those butterflies honored so God was very nice and he made one for him.”

*Human:* No Examples

*Artifact:* “*Someone* built them and just put legs on them.”

(04) \( \text{Ot} = \text{Other} \)

Termites, other non-human agents, creature

*Animal:* “The *creature* made it…that, the caterpillar.”

*Human:* No Examples

*Artifact:* “*Termites* made it.”

**Intentional State/Action:**

(05) \( \text{Ms} = \text{Mental State} \)

Think, know, desire, want, believe

*Animal:* “This was all \text{decided} when the frog was still in the tadpole stage.”

*Human:* “Because God \text{wanted} them that way.”

*Artifact:* “A human \text{decided} that it needed to be higher.”

(06) \( \text{Ds} = \text{Design} \)

Made, created, built, put (together), gave them, cause

*Animal:* “Because God wanted it to have wings so he \text{designed} it to hatch from its cocoon to have wings.”

*Human:* “God \text{made} them so that you can touch stuff.”
Artifact: “Because he invented it to stand up and not fall down.”

(B) FUNCTIONAL (teleological) REASONER (FR)

Need: function or purpose “in order to” (even if the “in order to” is implied)

(01) IN = Intrinsic Need

Purpose/reason for being, to suit lifestyle, to fly, swim, eating, etc.

*Animal:* “To fly.”

*Human:* “To grab things.”

*Artifact:* “To raise the seat higher.”, “to function at its best”

(02) Su = Survival

Intrinsic need to survive, to live longer, “to get away,” protection, defend, fighting, etc.

*Animal:* “To defend itself-able to battle.”

*Human:* “Survival.”

*Artifact:* No Examples

(03) EN = Extrinsic Need (of any kind, God, human, whatever – as long as it is not the need of the subject of the question)

“to sit on something”, “so feet don’t get tired”, “so humans could tell the difference between boys and girls,” “to pollinate.”

*Animal:* “to show female and male differences.”

*Human:* “For he can do more stuff for the earth to take care of it.”

*Artifact:* “to hold up weight”
(C) ESSENTIALIST REASONER (ER)

(01) E = Essentialist
always here, born like that, it was in their genetic make-up, that’s just the way it always was.

*Animal:* “Frogs were **born** with webbed feet.”
*Human:* “Humans were **born** with hands.”
*Artifact:* “They’ve **always been like that**”
(D) NON-EVOLUTIONIST NATURALISTIC REASONER: (NNR)

**Orthogenesis (Intrinsic Change):** Self-generated or endogenous change through the transformation of existing types (no specific mention of why the change happened (function))

1. **Gr = Growth, development**
   - Grew, developed, got older,
   - “when we are growing inside our hands develop”
   - *Animal:* “They grew them.”
   - *Human:* “They grew.”
   - *Artifact:* No Examples

2. **Mm = Metamorphosis**
   - reference to process of metamorphic change (chrysalis, cocoon, etc.)
   - *Animal:* “The butterfly…from the caterpillar and makes itself in its really long sleep…”
   - *Human:* No Examples
   - *Artifact:* No Examples

3. **SpC = species change (as in a linear transformation)**
   - specific reference to “species change” (i.e. monkeys to humans)
   - *Animal:* “Evolved from a more primitive creature.”
   - *Human:* “Before we were actually humans, chimps hands were more developed to help them get food and climb.”
   - *Artifact:* No Examples

4. **GenC = Genetic Change**
   - “Over many years the genes continued to change and pass down and down until things were different”
   - *Animal:* No Examples
   - *Human:* No Examples
   - *Artifact:* No Examples

**Adaptation:** orthogenetic change – role of environment is mentioned (even if the why is not explained).

5. **Ad = Adaptation to environment**
   - “it adapted to nature”
   - *Animal:* “It adapted to nature or it bred with another species.”
   - *Human:* “Um, an adaptation to probably swim in the water.”
   - *Artifact:* No Examples
**Hybridization**: breeding of two species

(06) \( \text{Hy} = \text{Hybridization} \)

“a moose and a girl deer made a baby and that was the first deer with antlers”

*Animal*: “It adapted to nature or it **bred with another species**.”

*Human*: No Examples

*Artifact*: No Examples

---

**(E) EVOLUTIONIST NATURALISTIC REASONER: (ENR)**

**Evolution**: Evolution using VIST framework: variation, inheritance, selection, time

(07) \( \text{V} = \text{Variation} \)

genetic variation seen across species

*Animal*: “Well in the beginning, **some had them and some didn’t**.”

*Human*: “…**some people aren’t born with hands**…”

*Artifact*: No Examples

(08) \( \text{I} = \text{Inheritance} \)

variations, along with other genetic traits, are passed to offspring through reproduction.

*Animal*: “The frogs with webbed feet **laid eggs**; the tadpoles hatched and **they also had webbed feet** when they became frogs.”

*Human*: No Examples

*Artifact*: No Examples

(09) \( \text{S} = \text{Selection} \)

the likelihood that if an organism has a trait that is advantageous to survival, that organism will be “selected” by nature to survive, reproduce, and pass genes to offspring.

*Animal*: “Because these webbed feet **gave the frog an advantage**.”

*Human*: No Examples

*Artifact*: No Examples

(10) \( \text{T} = \text{Time} \)

the geological time required for most evolutionary changes to occur.

*Animal*: “It took **many many years, like millions**, to form them like they are now.”

*Human*: “It evolved **over time**, adapting to its special environment.”

*Artifact*: No Examples

(11) \( \text{Ev} = \text{Evolution Term} \)


*Animal*: “All species **evolve** to better themselves to survive.”

*Human*: “**Evolved** for using; eating, working, etc.”
Artifact: No Examples

(O) OTHER:

(77) DK = Don’t Know
I don’t know, I have no idea, how would I know, etc.
(Only assigned if no other information/guess is also given).

(88) O = Other
A response not falling under any of the above codes but is relevant to question
“The first frog’s toes got stuck together,” “Out of wood,” “Water,”
“Because the monkeys have hands,” “Only the boy deers get antlers,”
“From the arms.”
Animal: “I don’t know it ran into a tree.”
Human: “From the arms.”

(99) M = Missing Data
Did not complete, tape broken, no transcript, etc.
(If all five questions were unanswered, participant was excluded from database).
Table 1

*Categorization of Causal explanations coded in Studies 1 and 2 and their place in a hypothesized Distal-Proximate distinction*

<table>
<thead>
<tr>
<th>Explanation</th>
<th>Distal-proximate</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intentional mental state</td>
<td>Distal</td>
<td>Mental state: “God wanted us to have hands” (mental state that motivated the action)</td>
</tr>
<tr>
<td>Intentional/ goal-directed</td>
<td>Proximate</td>
<td>Goal directed action: “God made it that way” (even though the action is made up of sub-components)</td>
</tr>
<tr>
<td>Functional- extrinsic need</td>
<td>?</td>
<td>Reason explanation: “To hold up weight” (Why do chairs have legs?)</td>
</tr>
<tr>
<td>Functional- intrinsic need</td>
<td>?</td>
<td>Reason explanation: “Webbed feet were needed so they could swim” (unclear whether it is now or in the past)</td>
</tr>
<tr>
<td>Naturalistic action or mechanism</td>
<td>Proximate</td>
<td>Mechanism: “Hands grew from our arms” (occurred immediately prior to the event)</td>
</tr>
<tr>
<td>Evolutionist natural cause</td>
<td>Distal</td>
<td>Evolutionary mechanism: “They formed wings from mutations over millions of years”</td>
</tr>
</tbody>
</table>
Table 2

Mean Number of Causes Endorsed (Standard Deviation) by Age Group for each Knowledge Domain for Open- and Closed-Ended Questions: Study 1

<table>
<thead>
<tr>
<th>Domain</th>
<th>Children</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-ended questions (0-6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td>0.87 (0.25)</td>
<td>1.20 (0.44)</td>
</tr>
<tr>
<td>Humans</td>
<td>0.89 (0.33)</td>
<td>1.30 (0.56)</td>
</tr>
<tr>
<td>Artifacts</td>
<td>0.92 (0.39)</td>
<td>1.17 (0.39)</td>
</tr>
<tr>
<td>Closed-ended questions (0-3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td>2.08 (0.63)</td>
<td>2.47 (0.53)</td>
</tr>
<tr>
<td>Humans</td>
<td>1.96 (0.64)</td>
<td>2.60 (0.55)</td>
</tr>
<tr>
<td>Artifacts</td>
<td>1.83 (0.53)</td>
<td>1.77 (0.42)</td>
</tr>
</tbody>
</table>
Table 3

*Mean number of Causes Endorsed (Standard Deviation) by Age Group for each Knowledge Domain for Open- and Closed-Ended Questions: Study 2*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Young</th>
<th>Middle</th>
<th>Old</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Open-ended questions (0-6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td>0.97 (0.20)</td>
<td>1.06 (0.20)</td>
<td>1.05 (0.28)</td>
</tr>
<tr>
<td>Humans</td>
<td>0.97 (0.18)</td>
<td>0.93 (0.37)</td>
<td>1.03 (0.38)</td>
</tr>
<tr>
<td>Artifacts</td>
<td>0.94 (0.25)</td>
<td>1.14 (0.35)</td>
<td>1.06 (0.33)</td>
</tr>
<tr>
<td></td>
<td>Closed-ended questions (0-3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td>1.84 (0.49)</td>
<td>2.21 (0.51)</td>
<td>2.24 (0.54)</td>
</tr>
<tr>
<td>Humans</td>
<td>1.67 (0.51)</td>
<td>2.00 (0.67)</td>
<td>2.11 (0.63)</td>
</tr>
<tr>
<td>Artifacts</td>
<td>1.84 (0.33)</td>
<td>1.83 (0.29)</td>
<td>1.66 (0.38)</td>
</tr>
</tbody>
</table>
Table 4

Summary across all Studies: Percent Endorsement of Open-Ended, and Mean Agreement with Closed-Ended Intentional, Functional and Naturalistic Explanations for the Origins of Animal Features

<table>
<thead>
<tr>
<th></th>
<th>Open-ended Questions*</th>
<th>Closed-ended Questions**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent Endorsement (SD): Range 0-100</td>
<td>Mean Agreement (SD): Range 1-4</td>
</tr>
<tr>
<td>M.A. Study</td>
<td>(Szymanowski, 2005)</td>
<td></td>
</tr>
<tr>
<td>8-9- year-olds</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>.46</td>
<td>.40</td>
</tr>
<tr>
<td>10-12-year-olds</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>.46</td>
<td>.46</td>
</tr>
<tr>
<td>Adults</td>
<td>71</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>.46</td>
<td>.51</td>
</tr>
<tr>
<td>Study 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissertation</td>
<td>5 &amp; 6-year-olds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>00</td>
<td>03</td>
</tr>
<tr>
<td></td>
<td>(.00)</td>
<td>(.09)</td>
</tr>
<tr>
<td>Adults</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>06</td>
</tr>
<tr>
<td></td>
<td>.36</td>
<td>.19</td>
</tr>
<tr>
<td>Study 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissertation</td>
<td>5-8- year-olds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>06</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td>(.25)</td>
<td>(.08)</td>
</tr>
<tr>
<td>8-10-year-olds</td>
<td>07</td>
<td>07</td>
</tr>
<tr>
<td></td>
<td>(.19)</td>
<td>(.19)</td>
</tr>
<tr>
<td>10-14-year-olds</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>(.39)</td>
<td>(.23)</td>
</tr>
</tbody>
</table>

Note. To compare patterns of high endorsement/agreement across studies: an endorsement* of 51% or above is highlighted for the open-ended questions; a mean agreement** of 2.6 or above (agree-strongly agree) is highlighted for the closed-ended questions. Dashes indicate data not collected.
Table 5

Summary across all Studies: Percent Endorsement of Open-Ended, and Mean Agreement with Closed-Ended Intentional, Functional and Naturalistic Explanations for the Origins of Human Features

<table>
<thead>
<tr>
<th>Open-ended Questions*</th>
<th>Closed-ended Questions**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Endorsement (SD): Range 0-100</td>
<td>Mean Agreement (SD): Range 1-4</td>
</tr>
<tr>
<td>How</td>
<td>Why</td>
</tr>
<tr>
<td><strong>M.A. Study</strong> (Szymanowski, 2005)</td>
<td>Not asked in this study</td>
</tr>
<tr>
<td>8-9-year-olds</td>
<td>24 (0.44)</td>
</tr>
<tr>
<td>10-12-year-olds</td>
<td>54 (0.51)</td>
</tr>
<tr>
<td>Adults</td>
<td>77 (0.43)</td>
</tr>
<tr>
<td><strong>Study 1</strong> Dissertation</td>
<td></td>
</tr>
<tr>
<td>5 &amp; 6-year-olds</td>
<td>23 (0.44)</td>
</tr>
<tr>
<td>Adults</td>
<td>33 (0.49)</td>
</tr>
<tr>
<td><strong>Study 2</strong> Dissertation</td>
<td></td>
</tr>
<tr>
<td>5-8-year-olds</td>
<td>50 (0.52)</td>
</tr>
<tr>
<td>8-10-year-olds</td>
<td>33 (0.49)</td>
</tr>
<tr>
<td>10-14-year-olds</td>
<td>47 (0.51)</td>
</tr>
</tbody>
</table>

Note. To compare patterns of high endorsement/agreement across studies: an endorsement* of 51% or above is highlighted for the open-ended questions; a mean agreement** of 2.6 or above (agree-strongly agree) is highlighted for the closed-ended questions. Dashes indicate data not collected.
Table 6

Summary across all Studies: Percent Endorsement of Open-Ended, and Mean Agreement with Closed-Ended Intentional, Functional and Naturalistic Explanations for the Origins of Artifact Features

<table>
<thead>
<tr>
<th>Open-ended Questions*</th>
<th>Percent Endorsement (SD): Range 0-100</th>
<th>Closed-ended Questions**</th>
<th>Mean Agreement (SD): Range 1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>How</td>
<td>Why</td>
<td>How</td>
<td>Why</td>
</tr>
<tr>
<td>M.A. Study (Szymanowski, 2005)</td>
<td>Not asked in this study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-9-year-olds</td>
<td>86 (0.36) 19 (0.40) 0.00 44 (0.51) 67 (0.49) 0.00</td>
<td>– – – – – –</td>
<td>– – – – – –</td>
</tr>
<tr>
<td>10-12-year-olds</td>
<td>83 (0.38) 33 (0.48) 0.00 23 (0.43) 86 (0.35) 0.00</td>
<td>– – – – – –</td>
<td>– – – – – –</td>
</tr>
<tr>
<td>Adults</td>
<td>97 (0.18) 26 (0.45) 0.00 55 (0.51) 75 (0.44) 0.00</td>
<td>– – – – – –</td>
<td>– – – – – –</td>
</tr>
<tr>
<td>Study 1 Dissertation</td>
<td>54 &amp; 6-year-olds</td>
<td>15 (0.38) 69 (0.48) 0.00</td>
<td>3.64 (0.50) 3.67 (0.85) 1.67 (1.07)</td>
</tr>
<tr>
<td>Adults</td>
<td>100 (0.00) 25 (0.45) 0.00 36 (0.51) 73 (0.47) 0.00</td>
<td>3.79 (0.34) 2.76 (1.00) 1.09 (0.22)</td>
<td>3.70 (0.38) 3.23 (0.55) 1.07 (0.21)</td>
</tr>
<tr>
<td>Study 2 Dissertation</td>
<td>5-8-year-olds</td>
<td>19 (0.34) 81 (0.40) 0.00</td>
<td>3.67 (0.57) 3.50 (0.63) 1.00 (0.63)</td>
</tr>
<tr>
<td>8-10-year-olds</td>
<td>87 (0.35) 20 (0.41) 0.00 07 (0.27) 100 (0.00) 0.00</td>
<td>3.84 (0.25) 3.56 (0.50) 1.02 (0.09)</td>
<td>3.71 (0.45) 3.29 (0.73) 1.11 (0.40)</td>
</tr>
<tr>
<td>10-14-year-olds</td>
<td>77 (0.44) 41 (0.51) 0.00 11 (0.32) 84 (0.38) 0.00</td>
<td>3.86 (0.29) 2.86 (0.77) 1.02 (0.08)</td>
<td>3.61 (0.45) 3.15 (0.79) 1.00 (0.00)</td>
</tr>
</tbody>
</table>

Note. To compare patterns of high endorsement/agreement across studies: an endorsement* of 51% or above is highlighted for the open-ended questions; a mean agreement** of 2.6 or above (agree-strongly agree) is highlighted for the closed-ended questions. Dashes indicate data not collected.
Figure Captions

*Figure 1.* Open-ended animal questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.

*Figure 2.* Open-ended human questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.

*Figure 3.* Open-ended artifact questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.

*Figure 4.* Closed-ended animal questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.

*Figure 5.* Closed-ended human questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.

*Figure 6.* Closed-ended artifact questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.

*Figure 7.* Open-ended animal questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.

*Figure 8.* Open-ended human questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.

*Figure 9.* Open-ended artifact questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.

*Figure 10.* Closed-ended animal questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.

*Figure 11.* Closed-ended human questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.
Figure 12. Closed-ended artifact questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.
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Figure 3. Open-ended artifact questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.
Figure 4. Closed-ended animal questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.
Figure 5. Closed-ended human questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.
Figure 6. Closed-ended artifact questions in Study 1: mean endorsement (+SE) of each explanation by age and question type.
Figure 7. Open-ended animal questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.
Figure 8. Open-ended human questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.
Figure 9. Open-ended artifact questions in Study 2: mean endorsement (+SE) of each explanation by age and question type.
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