YOUNG CHILDREN'S ARTIFACT CONCEPTUALIZATION:

A CHILD-CENTERED APPROACH

by

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A Thesis Submitted to the Faculty of

The Charles E. Schmidt College of Science

in Partial Fulfillment of the Requirements for the

Degree of Master of Arts

Florida Atlantic University

Boca Raton, Florida

August 2011

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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Marissa Greif, Department of Psychology, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the Charles E. Schmidt College of Science and was accepted in partial fulfillment of the requirements for the degree of Master of Arts.

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ACKNOWLEDGMENTS

This project's completion is indebted to many people who, one way or another, were part of the process. First, I would like to thank my advisor, Marissa Greif, for supporting and guiding me through the journey of thesis writing, as well through my time at FAU. And, most importantly, for always encouraging me to think ambitiously while pursuing my future plans. I also thank David Bjorklund and Elan Barenholtz for raising important questions that helped better shape this project.

On a more technical note, I would like to appreciate Fernando Weno, Marina Wajnsztejn, and Carolina Rosa for helping me to edit more than 50 artifact images. Thanks also to Matthew Schultz who probably deserves a co-master's degree for all his editing work, game programming, and wizardry in Excel. I also acknowledge Tina Shankar for her effort and patience in learning a very fine-grained coding system.

I am extremely grateful to my parents, Regis and Marilia, and my brother Eduardo for their unconditional support in my new career path and late night Skype pep talks. I also wish to thank my American parents, Steve and Sara, for always caring about my endeavors and for continuously checking on my mental health and making sure I remained grounded. Finally, I could never translate into words, not even in Portuguese, how much my husband, Matthew, has nurtured me, and even made me laugh, throughout the obstacles. It is just not possible to thank him enough.

ABSTRACT

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Title:	Young Children's Artifact Conceptualization: A Child-Centered Approach
Institution:	Florida Atlantic University
Thesis Advisor:	Dr. Marissa Greif
Degree:	Master of Arts
Year:	2011

One of the most fundamental functions of human cognition is to parse an otherwise chaotic world into different kinds of things. The ability to learn what objects are and how to respond to them appropriately is essential for daily living. The literature has presented contrasting evidence about the role of perceptual features such as artifact appearance versus causal or inductive reasoning in children's category distinctions (e.g., function). The present project used a child-initiated inquiry paradigm to investigate how children conceptualize artifacts, specifically how they prioritize different types of information that typify not only novel but also familiar objects. Results underscore a hybrid model in which perceptual features and deeper properties act synergistically to inform children's artifact conceptualization. Function, however, appears to be the driving force of this relationship.

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CHAPTER 1

INTRODUCTION

Brief Overview and Problem Definition

Our environment is full of familiar and novel objects. For example, a high-tech kitchen or a medical laboratory may cause one to be curious, if not confused, by the variety of new devices and gadgets present. The ability to learn what they are and how to respond to them appropriately is essential for daily living. Grouping things of a same kind allows us to organize information about new objects that we encounter, and make useful inferences about various properties that are common to members of a category (Smith & Medin, 1981). These intuitions help inform our mental representations or concepts which, in turn, influence inductive reasoning, planning future actions on tasks, and other higher-order cognitive tasks (Barsalou, 1973, 1983, 1991; Malt, Sloman, & Gennari, 2003; Mandler, 2003; Ross & Murphy, 1999; Sloman & Malt, 2003).

While broad categorical cuts such as living versus non living things are important for reasoning about objects (Gelman & Gottfried, 1996; Gelman & Wellman, 1991; Mandler & Mc Donough, 1996; Newman, Herrmann, Wynn, & Keil, 2008; Pauen, 2002; Newman & Keil, 2008; Rakison, 2005), conceptual distinctions within a kind domain may be equally important for more advanced and sophisticated cognitive processes such as tool use (e.g., spoons, Barrett, Davis, & Needham, 2007; McCarty, Clifton, & Collard, 1999, 2001), acquisition of expertise (Tanaka & Taylor, 1991), and problem-solving (Brown, 1990; Chen & Siegler, 2000). For example, being able to distinguish among tools such as hammer, scissors or pliers when the task is to put a painting on the wall will have a considerable impact on the outcome. Moreover, in contemporary life, the ability to acquire some level of expertise with electronic devices such as computers and different types of software is likely to enhance work performance amongst other activities.

In the proposed study, I will investigate how children conceptualize artifacts, specifically how they prioritize different types of information that typify manmade objects. The main premises are: Children will ask more questions for unfamiliar artifacts than for familiar artifacts. Questions for unfamiliar artifacts will center on functional information and analogies to familiar artifacts. On the other hand, questions for familiar artifacts, because children may already know what the objects are for, will concentrate more on appearance, context of use, appropriate user, in addition to more specialized questions about function (e.g., role of a specific affordance). I will explore these hypotheses by using a child-initiated question method (Greif, Kemler Nelson, Keil, & Gutierrez, 2006; Kemler Nelson, Egan & Holt, 2004; Kemler Nelson, O'Neil, 2005) in which children will encounter images of novel and familiar artifacts and then be encouraged to ask questions about them. Understanding the properties of children's artifacts knowledge critically impacts our general knowledge of the development of object representation, but also provides relevant data for research exploring the perceptual and cognitive capacities in which artifacts play the main role.

In order to set the stage for the proposed study, first I will describe theories and evidence on general categorization of objects. Then I will narrow the discussion to artifacts, addressing issues related to their conceptualization. I will primarily address the shape versus function controversy and intended-use versus current-use perspectives in the extant literature. Next, aiming to shed light on what types questions to expect when children face familiar artifacts, there will be a brief discussion of literature on children's acquisition of expertise. Finally, I will present arguments to why child-initiated design is the right level of analysis for investigations of artifact knowledge.

Object Categorization and Conceptualization

In every moment, we encounter innumerable things in our environment: plants, animals, insects, furniture, tools, vehicles, and so on. A significant question emerges out of this experience: how do we learn about all of these objects and how do we come to differentiate them as distinct, unique entities? Partitioning objects into meaningful groups is a fundamental process of human cognition. Most importantly, it provides us with relevant information for predicting the object's behavior and how to respond to it effectively. For example, detecting the differences between a branch on the ground and a poisonous snake would be important for survival. Similarly, distinguishing silverware from scissors is relevant when one needs to cut something (Gelman & Gottfried, 1996; Gelman & Wellman, 1992, Mandler & McDonough, 1996; Newman et al., 2008; Pauen, 2002; Poulin-Dubois, Frenkiel-Fishman, Nayer, & Johnson, 2006; Rakison, 2005; Rakison & Butterworth, 1998; Rakison & Poulin-Dubois, 2001)

The field now widely accepts that infants within their first year of life succeed at forming a wide variety of categories (Booth & Waxman, 2002; Casasola, Cohen, & Chiarello, 2003; Madole & Oakes, 2005; Mandler & McDonough, 1993, 1998; Quinn, Eimas, & Rosenkrantz, 1993; Rakison & Butterworth; 1998, Younger, 1985). The mechanisms underlying such a process however, are the source of debate. The traditional view of categorization holds that children first form basic-level object categories, such as dogs and chairs, and then group them into superordinate categories such as animals and artifacts (Rosch, 1978; Rosch et. al., 1976; Rosch & Mervis, 1975; Younger, 1985, 1990). Basic-level instances of a category may be centered around "prototypes" or average representations of multiple instances of a category (Madole & Cohen, 1995; Madole, Oakes, & Cohen, 1993; Rakison & Butterworth, 1998). The "basic-level" prototype differentiates exemplars that have very few similar features, and extends membership to those that have a high rate of similar features (Malt, 1995; Minda & Smith, 2001; Quinn, 2004; Quinn & Eimas, 1997; Quinn, Schyns, & Goldstone, 2006; Tversky & Hemenway, 1984).

Nonetheless, there is accumulating evidence from recent studies that suggests that, developmentally, there is a global-to-basic level differentiation, that is, infants first parse categories into broad groups such as living and non-living things, and only then differentiate amongst subordinate category members, for example dogs, cats, furniture and vehicles (Mandler & Bauer, 1988; Mandler, Bauer, & McDonough, 1991; Mandler & McDonough, 1993; Pauen, 2002). This sequence of development takes place perhaps because it requires less effort to notice the relevant characteristics of events that define global categories than the details of the objects taking part in them. Moreover, general concepts, as opposed to more specific ones, avoid pitfalls that occur when learning is too specialized (Mandler, 2003). As an illustration, self-motion, a global property that distinguishes animals from inanimate objects, is easily perceived by infants (Arterberry & Bornstein, 2002; Arterberry & Yonas, 2000; Bertenthal, 1993; Fox & McDaniel, 1982) and can be more broadly applied than perceptual details, such as "has legs," which could be misleading considering that tables have legs and are not animals, and fish are animals, but do not have legs.

Though there is now support in the literature for global-to-basic categorization, there is a lack of consensus on the nature of how this process occurs (Poulin-Dubois et al., 2006). On one side, researchers maintain that categorization is solely based on perceptual properties, such as faces and overall shapes (Murphy & Ross, 2005; Quinn & Eimas, 1996; Quinn & Johnson, 1997, Rosch & Mervis, 1975, Welder & Graham, 2006). In contrast, others argue that this classification ability is better explained by children's use of deep abstract core inferences about causal, functional or structural properties of objects, such as motion cues to distinguish animate objects from inanimate (Gelman & Opfer, 2002; Lacroix, Giguère, & Larochelle, 2005; Mandler, 1992; Rakison & Poulin-Dubois, 2001).

To reconcile these contrasting perspectives, scholars have proposed hybrid models of categorization that integrate aspects of perceptual similarity and deeper core properties (Ashby &

O'Brien, 2005; Folstein & Petten, 2004; Keil, Smith, Simons, & Levin, 1998; Rips, 1989). This notion holds that both surface features and abstract or deeper properties play a role in categorization. Despite the conciliatory attempt, many theoretical disagreements remain; particularly with respect to the weight of similarity versus deeper features in deriving categories. Those who support similarity as basis for categorization argue that assessments of more abstract properties are not sufficient or necessary to define concepts and groups. The argument is that appearance is a more readily accessible cue, and is causally linked to deeper features. This claim is supported by evidence of the widely known shape bias, in which children as young as 2 years of age respond to categories using similarity of object shape rather than other properties (e.g., Eimas, 1994; Jones, Smith, & Landau, 1991; Jones & Smith, 1993).

Contrarily, those who have focused on the role of core knowledge in categorization (Ahn, Kim, Lassaline, & Dennis, 2000; Gelman & Markman, 1986; Keil, 1981; Murphy & Medin, 1985; Rehder & Hastie, 2001) posit that distinctions amongst objects rely on weighing the responsibility of internal and external properties in defining the objects' identities. This draws from the literature in psychological essentialism, which states that objects have core properties that make them the objects they are, and these are responsible for shared similarities amongst group members (Gelman, 2004; Locke, 1894/1975; Medin & Ortony, 1989). They contend that perceptual cues can be inaccurate, misleading, and incomplete. Observing the similarity in shape of a tennis ball and an orange, for instance, is not sufficient to infer that they have the same identity. Core features are a more reliable basis for grouping because the process involves inferences about frequently non-obvious similarities. In other words, the degree to which the presence or absence of that particular attribute impacts the object's membership in a group is more important than which features are most statistically frequent. As an illustration, almost all copy machines are gray, but this feature does not impact the device's core function of making copies; finding a non-gray copy machine is a rare event, but if it happens it will not change the apparatus' category.

It is true, however, that appearance features are usually consequences, and therefore, causally linked to deeper features, leading some to argue that the appearance of the surface is an important and more available cue in identifying a category (e.g., Davidson & Gelman, 1990; Florian, 1994; Graham, Williams, & Huber, 1999; Imai, Gentner & Uchida, 1994; Landau, Smith, & Jones, 1998). For instance, the concept 'boy' may have DNA structure as central or core attributes. Surface features such as height, face and body type, might be useful in providing crucial cues regarding the underlying essence, and thus identifying exemplars of the concept. However, as Medin and Ortony put it (1989, p.185): "the more central properties are best thought of as constraining or even generating the properties that might turn out to be useful in identification". In fact, the more that deeper causes are acknowledged, the more inductive power the concept seems to gain (Ahn et al., 2000, Anderson, 1990; Tversky & Kahneman, 1982).

With respect to cognitive development, some psychologists claim there is a shift from surface to core similarities throughout infancy to childhood, due to a change in processing surface to deep features or a refinement in attention to the types of properties that are used for grouping (Baldwin, 1992; Cohen, 1991; Imai et al., 1994; Horst, Oakes, & Madole, 2005; Madole & Oakes, 1999; Melkman, Tversky, Baratz, 1981; Merriman, Scott, Marazita, 1993; Tversky, 1985). Nonetheless, the idea that conceptual organization is based on core properties from infancy has gained wide support (Gelman, 1988; Gelman & Wellman, 1991; Keil, 1989; Mandler, 2003; Newman et al., 2008). Young children also seem to categorize living and non-living things according to causally important traits or relevant deep features that differ between these two kinds, instead of perceptual similarities (Keil, 1989; Gopnik & Wellman, 1994; Wellman & Gelman, 1992).

Comparing artifacts versus living things, children appreciate the following core distinctions: artifacts do not move on their own (R. Gelman, 1990); artifacts are made by people, whereas animals originate in nature (Gelman & Kremer, 1991); category identity can change over time for artifacts but is stable for animals (Keil, 1989; Gelman & Wellman, 1991; Siegel & Callanan, 2007); artifacts and animals have different insides, even not knowing what exactly the inside is made of (Simons & Keil, 1995). They also use more generic forms to express information about unfamiliar animals than unfamiliar artifacts, maybe signaling they predict that living things categories are more consistent and richly structured than artifacts categories (Brandone & Gelman, 2009). Finally, Newman and Keil (2008) demonstrated that by at least fourth grade, children recognize that for natural kinds, essential properties are distributed throughout the identity, whereas for artificial kinds, essential features that precisely identify the objects are possibly located on a single location of the entity.

Artifact Categorization and Conceptualization

These, however, only bear evidence of between kind (living versus non living things) categorization. What are the core properties that distinguish one category of artifacts from one another? Although some argue that essentialist reasoning is mostly found with natural kinds than with artifacts (Diesendruck & Gelman, 1999; Gelman, 2003; Gelman, 2004; Kalish, 1995), or that artifacts have no essences at all (Sloman & Malt, 2003), others suggest function, or what an artifact was designed to do, as the core essence of artifacts (Bloom, 1998; Keil, 1989; Booth & Waxman, 2002; Miller & Johnson-Laird, 1976; Rips, 1989).

In fact, there is evidence that explanation-based theories, which assume that an underlying explanation or cause drives category construction, play a much more crucial role in categorizing artificial than in biological kinds (Keil, 1987; Stibel, 2006). However, as stated before, concepts and thus categories of artifacts are inherently instable and flexible, because they can change over time or by situation (Elder, 2007; Grandy, 2007; Houkes, 2006; Thomasson, 2003). A mug originally designed to hold water that is currently being used as a pencil holder, or a chair with its back removed serving now as table, may move these artifacts from one category to another. On the other hand, natural kinds are much more stable, despite few structural changes, their identities and categories remain the same: a raccoon without its tail is still a raccoon (Keil, 1989). This characteristic of artificial kinds violates the general intuition that "a concept" should be something stable in long-term memory (Malt & Sloman, 2007). Therefore, instability and context-specificity must be taken into consideration when studying artifact categorization (Atran, 1998; Barsalou, 1983; Keil, Greif, & Kerner, 2007; Lin & Murphy, 2001).

Shape versus function. Cognitive science has increasingly studied the nature of human knowledge of man-made objects. Most researchers in this area now agree that causal or inductive reasoning plays a major role in artifact categorization in adults: those sharing a core function property are members of the same kind (German & Barrett, 2005; Keil, 1989; Miller & Johnson-Laird, 1976; Prasada, 2000; Rips, 1989; though see for an opposing view, Gentner, 1978; Landau, et al., 1998; Malt & Johnson, 1992; Sloman, Malt, & Fridman, 2001). Literature in children's category distinctions of artifacts, however, has offered conflicting evidence. Stemming from an earlier discussed issue on how children generally categorize, some believe that function becomes central to artifact categorization only later in development (e.g., not until about 6 years old). Until then, shape carries out the principal role, a phenomenon commonly referred to as "shape bias" (e.g., Gathercole & Whitfield, 2001; Gentner, 1978; Graham et al., 1999; Malt & Johnson, 1992; Merriman et al., 1993; Smith, Jones, & Landau, 1996; Tomikawa & Dodd, 1980). Others, nevertheless, propose that children are sensitive to information about function much earlier (Bloom, 2000; Diesenduck, Markson, & Bloom, 2003; Greif et al., 2006; Kemler Nelson et al., 2004; Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Kemler Nelson, Herron, & Holt, 2003; Kemler Nelson, Herron, & Morris, 2002; Kemler Nelson, O'Neil , 2005; Kemler Nelson, O'Neil, & Asher, 2008).

A broad literature bearing on this question has centered on word learning and name extension in young children. These studies, which generally find that appearance is more important than core properties, examine the weight of function versus shape when a child learns a label for a novel artifact. A typical experiment involves trials in which children are taught a novel name applied to a novel artifact. Then, participants are asked to extend that label to artifacts that either match the labeled target in shape but not in function; or have the same function, but different shape. For example, in Landau et al. (1998), children were shown simple novel target objects, which could perform functions (e.g., a "Rif" which could absorb a spill). Then, they were presented with candidate artifacts that could soak up liquids but had different shapes; and with candidate artifacts that could not perform the function, but had similar shapes. Children responded that objects shaped like "Rifs" were "Rifs" regardless of their functional ability, and artifacts not shaped like the target objects were not "Rifs" even if they could perform the same function. These results were explained by the fact that shape is a good cue to an object's identity because it does not vary to the same degree as color or size, and is easily detected and more salient than function.

Nonetheless, some recent studies have challenged this view by demonstrating that children as young as 2-years old may rely on function to guide object word extensions under specific conditions (Diesenduck et al., 2003; Kemler Nelson, 1995, 1999; Kemler Nelson, Frankenfield et al., 2000; Kemler Nelson, Russell, Duke, & Jones, 2000). Kemler Nelson, Russell, et al. (2000) reported three studies in which 2-year-olds were tested in a name generalization task. The objects, in contrast to other studies whose results favored shape over function, were designed to have functions that were causally related in simple, transparent and plausible ways to their apparent physical structure. Two year-olds extended the names to the new objects by function, despite limited opportunity to interact with them. These results were maintained even when the experimenter did not demonstrate the objects' function, and children had to discover it on their own. This gives support to the idea that when young children can make sense of the causal relation between surface features and functions of an artifact, they base their distinction more on richer high order inferences than on appearance.

How can one explain this contrasting evidence? It appears that preschoolers' categorizations are highly task and context-specific. Some accounts regarding the possible conditions involved have been provided: nature of the artifacts utilized; causal relation between artifacts' affordances and functions; tempo and number of inferences children had to make in one session; and finally, opportunity to explore and get familiar with the artifacts' function.

First, the types of materials used in the two lines of studies were very different. For example, in Landau et al. (1998) and Smith et al. (1996) the objects were very simple and looked non-professional whereas the materials used in Kemler Nelson and colleagues' studies were structurally more complex. It appears that when the stimuli used are fully credible as real, moderately complex, and intentionally designed to have "real" functions, children are more likely to give more attention to function. For instance, artifacts used in studies in which shape prevails were not plausibly designed with the intention to function in the designated way. In other words, the assigned functions sometimes seemed to be arbitrary or unnaturally independent to the objects' shape, or sometimes subordinate only to the substances that the artifacts were made of (e.g., function 'wipe up water' relied on absorbable material). This approach to function and object structure independence gives rise to somewhat uncompelling functions. This is especially true when one considers that appearances and intended functions of artifacts tend to be highly correlated in the real world, rather than arbitrary (Christie, Markson, & Spelke, 2005; Medin & Ortony, 1989; Prasada, 2000; Prasada, Ferenz, & Haskell, 2002; Tversky & Hemenway, 1984).

In the same vein, Kemler Nelson, Frankenfield et al. (2000), demonstrated that 4-year-olds displayed a stronger disposition to opt for artifacts that maintained the function of the training object when the function had been logically linked to the physical features. In another study, Asher and Kemler Nelson (2008) gave 3- and 4-year-olds the opportunity to ask questions about novel artifacts. Then, the experimenter either demonstrated a function plausible with the physical structure of the object, or an implausible function, nonetheless possible, with the artifact's affordances. Results showed that children in the implausible condition were more likely than those in the plausible condition to ask follow-up questions regarding function. This suggests that plausibility of the function according to the object's affordances was necessary for children as young as 3 years old to accept it as the true function or conceptual core for the artifacts. To be sure, there is compelling evidence that infants and toddlers are able to detect relationships between surface and non-obvious object properties, such as function, and expect that artifacts that are similar in overall appearance have the same functional features (Baldwin, Markman, & Melartin, 1993; Barnat, Klein, & Meltzoff, 1996; Booth, 2006; Brown, 1990; Caron, Caron, & Antell, 1988; DiYanni & Kelemen, 2008; Hespos & Baillargeon, 2001; Madole & Cohen, 1995; Madole et al., 1993; Mandler & McDonough, 1998; McCarell & Callanan, 1995). This evidence supports the idea that very young children make sense of how affordances of an artifact structure underwrite its functional properties, and that the absence of a causal relation between form and function in the materials used may have caused children to rely on shape rather than on function.

Other explanations may lie with the time of the experimental sessions and the opportunity to explore the artifacts. In the studies that favored shape, usually children had less time to make their decisions and a higher number of inferences, than in the studies that favored function (e.g., 32 inferences versus 9 inferences). Perhaps, the time pressure to make multiple successive inductive judgments about novel artifacts prompted children to make use of back-up cognitive strategies that reduce cognitive effort. Indeed, impulsive responses based on salient properties such as shape do not require too much reasoning, and may have been used to fulfill task requirements (Deák, Ray, & Pick, 2002, Kemler Nelson, Frankenfield et al., 2000). It is more likely that outside the laboratory, children generally learn about artifacts in a non-pressured environment, where they are allowed to access information about functional affordances. When a child encounters a new artifact she will likely be allowed to explore it, touch it, and ask about it at her own pace. Finally, in the studies that found shape bias, frequently children had very limited opportunities to interact with the objects; hence participants did not have much experience with the objects' functions. It appears that if children are given the opportunity to experience the artifact's function, they will extend labels depending on function similarity (e.g., Kemler Nelson et al., 1995). This converges with widespread evidence that children, and even adults, categorize by perceptual similarity over function, when there is lack of functional or any other information about the artifacts (Gentner, 1978; Landau et al., 1998; Malt & Johnson, 1992).

It is important to note, however, that most of these observations have occurred in the context of lexical categorization. Some may argue that what learners are willing to call an object might not be an accurate reflection of how they categorize it (Smith et al., 1996). Others scholars suggest that conceptual and lexical learning are closely connected by our beliefs about which properties and relations are central to different kinds of things (Keil, 1994). Indeed, there are several studies that do not rely on label extension or lexical categorization methods whose findings contribute to the perspective that very young children are sensitive to artifact function when conceptualizing an object's category (e.g., Booth, 2006; Golinkoff, Shuff-Bailey, Olguin, & Ruan, 1995; Kemler Nelson, Frankefield et al., 2000; Kolstad & Baillargeon, 1990; Markman & Hutchinson, 1984; Waxman & Hall, 1993).

There are, for instance, recent studies that focus on children's conceptualizations of artifacts using child-initiated discovery designs (Kemler Nelson et al., 2004; Kemler Nelson & O'Neil, 2005; Greif et al., 2006). In these experiments, participants were given the opportunity to ask about novel objects, and analyses show that requests for functional information are primary. Kemler Nelson et al. (2004), examined the purpose of 2-, 3-, and 4-year-olds' ambiguous questions such as "What is it?" about novel artifacts. They found that when answered with the artifact's name, children were more likely to ask follow-up questions prompting the object's function. On the contrary, when answered with the artifact's function, children never asked follow-up questions. In a follow-up study (Kemler Nelson & O'Neil, 2005) using a semi-naturalistic design, the authors observed how parents replied to young children's ambiguous questions about artifacts that systematically differed in familiarity. They reported that for unfamiliar artifacts parents usually responded with functional information alone or in addition to names. For atypical members of a known category (e.g., a very different looking flashlight) adults replied with only the name. Interestingly, when the questions were more specific or when there were follow-up questions, they were more likely to be related to function. To add to these findings, Greif et al. (2006) presented children with images of novel animals and artifacts aiming to find out the characteristics of information that are conceptually important to children. They reported that preschoolers were more predisposed to ask about names and functions of whole objects and their parts. These results suggest that functional information is crucial to artifacts' categorization.

The above arguments, specifically that young children appreciate function-related properties over appearance, consider developmental differences. There is converging evidence that highlights a developmental shift in attention from perceptual similarity to deeper taxonomic framing criterion. Imai et al., (1994) showed that 3-year-olds extended names based on shape, but were also predisposed to use taxonomic and thematic relations when the task required them to group similar artifacts. This trend was even stronger through 5 years of age. In another study, Deák and colleagues (2002) found that 4 year-olds, but not 3-year-olds sorted objects by function when asked to do so, and when function was evident during a grouping assignment (see also Baldwin, 1994; Kemler Nelson, Frankenfield et al., 2000). Perhaps, given greater experience, older children may know more about artifacts in general, thus they are more likely to be more confident that functional considerations are primary and that appearances can be deceiving (Kemler Nelson, 1995).

Despite some researchers supporting the idea that categorization can be based on shape, on function, or on both depending on the object (Malt, 1991; Malt et al., 1999; Malt & Sloman, 2007), the above arguments underscore a hybrid model. In this layout, preschool children categorization of artifacts is not restricted to shape or function independently. Rather, it seems that both appearance and function can inform children's artifact categorization. The presented evidence shows that children are sensitive to function/form correlations. It appears that an artifact's function directs children's attention to affordances of the object that support such function. When faced with a novel object, they may attend to these perceptible commonalities to infer its category, especially amongst younger children. In this model, there is a clear interaction between form and function, although, the latter may be the driving force, and grows stronger with age. In sum, instead of solely taking into account shallow perceptual appearances, children seem to privilege a view of essential qualities in artifact categorization and how it correlates with surface properties. Although the former is certainly the more traditional expectation, several recent studies using different methodologies converge to suggest the latter alternative (e.g., Gelman & Coley, 1990; Gelman & Markman, 1986; Gopnik & Meltzoff, 1997; Kemler Nelson et al., 1995).

Current function versus design: "do" versus "for". All arguments stated above endorse function as the core and essence of artifact categorization. However, as delineated in the introduction, artifacts' functions are inherently capricious, because they can change over time or over situation (Elder, 2007; Grandy, 2007; Houkes, 2006; Thomasson, 2003). This fact poses the following questions: (a)What is the true core of an artifact, how is it currently used or what function was it designed for originally? (b) Is there a developmental change in how function is conceptualized? (c) How do children deal with the coincidence and conflict between current and intended use while constructing mental representations of artifacts?

Developing the above argument further, a "design stance" requires inferences about the artifact's identity based on notions that an artifact is intentionally created by a designer to fulfill a function. In this sense, the intended function is the factor that originates the artifact's surface properties, the possible uses it can handle, its kind, and ultimately its essence (Bloom, 1996, 1998, 2000; Dennett, 1987; Keil, 1989; Putnam, 1973; Rips, 1989). The other notion of function is related to current use of the artifact, including those uses allowed by the structural or physical properties of the object (e.g., the properties of a coffee mug, specifically, closed at bottom, open at the top, graspable, serve perfectly the function of pencil holder). Though these two senses are likely to be highly correlated, the reason why the artifact exists, or its intended design, can conflict with its current uses.

There is considerable evidence that adults think about artifacts in terms of the intended design, thus the intended function of a man-made object drives adults' conceptualizations of artifact kinds (see review Kelemen & Carey, 2007; see also German & Johnson, 2002; Kelemen, 1999a; Matan & Carey, 2001; Richards, Goldfarb, Richards, & Hassen, 1989; Rips, 1989; though for an opposing view, see Malt & Johnson, 1992).

The literature concerning children's sensitivity to the design stance is not as clear. Increasing reports have shown that children are sensitive to the original intended use of an artifact. As an illustration, research exploring children's naming of representational artifacts like drawings, found that 3- and 4-year olds named pictures whose referents were ambiguous (e.g., lollipop vs. balloon) according to an artist's intent and distinguish drawings created on purpose from those created accidentally (e.g., Bloom & Markson, 1998; Gelman & Ebeling, 1998; but see Browne & Woolley, 2001, for evidence that young children at times prefer resemblance over intent). Interestingly, this finding has been shown also with non-representational artifacts.

Gelman and Bloom (2000) found that from 3 years of age, children are more likely to use an artifact name (e.g., hat) for familiarly shaped artifacts that were described as intentionally made, but used a material name (e.g., clay) for familiarly shaped artifacts described as accidentally produced. Additionally, when children are told that artifacts were "made for" something, they tend to group it by original intended function over affordances, current use, non-intentional contextual factors such as being found by their user or accidental use (Study 2 Diesenduck et al., 2003; DiYanni & Kelemen, 2008; Jaswal, 2006; Kelemen, 1999a; Kemler Nelson et al., 2002).

However, the question is up for discussion because there is also evidence that very young children may not favor a design stance over current use or immediate affordances accessible to solve a problem. Matan and Carey (2001), and German and Johnson (2002) found that when artifacts were described as 'made for' a particular purpose (e.g., making tea), but being presently used to serve a different goal (e.g., watering flowers), 6-year-old children and adults were more likely to use intended design to identify the objects' function. Interestingly however, 4- and 5-year old children were more likely to refer to current use (see also Defeyter & German, 2003). Others have also reported that young children and adults will favor a current new use of an artifact over the original intended function, assuming that the current use has been embraced as standard by many people (Siegel & Callanan, 2007).

Likewise, many studies aiming to understand children's reasoning about artifacts used functional fixedness paradigms. This methodology assumes that if children are not functionally fixed, then design function is not yet core to their artifact conceptions (however, see Kelemen 2001, 2006, for a contrasting view). Defeyter, Avons, and German (2007) reported that younger children (e.g., 5-years old) produced more novel functions for artifacts than older children (e.g., 7-years old) who tended to give more designed subscribed functions. In other experiments, participants were introduced to artifacts individually or in the context of their intended use, such as a pencil with paper, or a straw in a cup, and asked to solve simple problem tasks using the objects. When children were primed by a demonstration of the artifact's typical function, 5-year olds solved the problem much faster than 6- or 7-year-olds. Even when novel objects were used in the experiment, and their functions demonstrated before problem-solving task, the same results were obtained (Defeyter & German, 2003; German & Defeyter, 2000). Importantly, German & Barrett (2005) repeated this design cross-culturally in technologically limited traditional communities and found the same pattern. Thus, it appears that the development of the design stance is a universal process, becoming more entrenched with age: the notion of original intended use is central to older children's concepts of artifacts but is not yet fully developed until around age 6 (Kelemen & Carey, 2007).

Enrichment of existing artifact concepts. Most of the studies exploring how children conceptualize artifacts have been done with novel artifacts. To my knowledge, there are only two experiments involving familiar artifacts: Subrahmanyam (2001) and Kemler Nelson & O'Neil (2005). It seems that there is a gap in the literature concerning how children enrich their current mental representations of objects. For example, if indeed function is the essence in young children's reasoning about artifacts (Kemler Nelson, 1995; Mandler, 2004), when they already have functional information, what comes next?

One idea is that when the essence of the artifact is known there will be a shift from questions regarding function to more secondary features such as ownership, appearance or use context. It is possible that knowing the artifact's function, for example, a toothbrush is for cleaning teeth, children will be interested in knowing whose toothbrush that is, or why that particular one is green or has that specific shape.

Another pattern that may rise is that if children first create global categories such as animal and artificial things, to then shift to more specific categories such as dogs, cats, tools and furniture (Mandler & McDonough, 1996, 2000; McDonough & Mandler, 1998); they perhaps go through the same process with function. Elaborating this assumption, it is plausible that when children learn about a novel artifact, its function is conceived broadly at first. But with experience and growing familiarity, they will seek for more detailed information on function or specific parts associated with the global function. As an illustration, a child perhaps learns first that cars are for driving people around. Later on, she might construe that the wheels allow the car to move, and that the steering wheel is the affordance that directs where the car goes.

Findings of literature in expertise support the last argument. It has been shown that the level of differentiation of an expert in a domain is much higher than that of a novice (e.g., Canham & Hegarty, 2010; Lesgold et al., 1988). As familiarity with the objects in a category increases, people are more likely to detect relevant features, compare and create sub-groupings of those entities when faced with features that become increasingly clear in their conceptualizations (e.g., Gibson, 1969; Gibson & Gibson, 1955; Haider & Frensch, 1999).

However, how does expertise develop? It involves taking into account that changes in memory representations and in perceived similarity are concomitant elements of increasing differentiation (Blair & Somerville, 2009; Chase & Simon, 1973; Ericsson & Chase, 1980, Ericsson, Chase, & Falcon, 1982; Ericsson & Kintsch, 1995; Gobet & Simon, 1996, 1998; Holding, 1992). This process can be explained under the now widely accepted constructionist model of memory (see for a detailed review Guenther, 2002). If there is pre-existing information about an object, as is the case for familiar artifacts, when a child sees the artifact there is widespread activation of the current connections in the cognitive system. The more expert one is in a domain, the more connections are likely to exist, and thus a broader activation is likely to occur. In this situation, it is more likely that fine-grained distinctions will be processed, and assimilated, resulting in increased number and strength of the connections among elements of that cognitive system. On the contrary, when one is presented with a completely novel object, the pre-existing connections will be loose in strength and small in number, allowing only so much information in, and as explained before, broad concepts instead of fine-grained ones. For example, chess experts have much higher recall of the positions of chess pieces, if arranged in a consistent manner with the rules of the sport, than chess novices (Chase & Simon, 1973; see also Bellezza & Buck, 1988; Chiesl, Spilich, & Voss, 1979; Morris, 1988).

Likewise, children who have an extensive knowledge in specific domains such as birds, chess or baseball differ from less expert children and adults with respect to their memory of information pertaining to their area of expertise (e.g., Bjorklund, Muir-Broaddus, & Schneider, 1990; Chi & Koeske, 1983; Schneider, Gruber, Gold, & Opwis, 1993; Schneider, Korkel, & Weinert, 1989; Spilich, Vesonder, Chiesi, & Voss, 1979). More importantly for the present study, growing knowledge in a particular category influences the structure and organization of information of such domain. It has been shown that with familiarity, young children become sensitive not only to overtly given, but also to implicit elements of the entities in a domain (e.g., Carey, 1985; Chi & Koeske, 1983; Gobbo & Chi, 1986; Johnson & Mervis, 1994; Johnson, Mervis, & Boster, 1992; Solomon, 1997).

These results combined with those of other work (e.g., Hammer & Diesenduck, 2005; Rogers & McClelland, 2004) suggest that there are dissimilarities in the processing of information to be explored that occur as a function of one's previous background. Further exploration of the developmental process for acquiring new knowledge on pre-existing concepts of objects is needed and important because these mechanisms influence children's judgments and reasoning about categories of objects (Alexander, Johnson, & Schereiber, 2002; Keil, 1994; Lewandowsky & Kirsner, 2000; Little, Lewandowsky, & Heit, 2006; Proffit, Coley, & Medin, 2000; Shafto & Coley, 2003; Van de Wiel, Boshuizen, & Schmidt, 2000).

Child-Initiated Design: A Valid Method

There are many mechanisms by which we may learn about artifacts. Starting from infancy, Piaget (1952) has posited that the foundation for knowledge acquisition is early actions on objects. The development of the sensorimotor stage implicates increasingly complex successions of actions with artifacts, and consequently a better understanding of the dynamic relations driving object behavior and representation. In this sense, the personal contact and experience with objects is a pivotal element for building more and more elaborate mental representations. Vygotsky (1978) suggested a more social view in which artifacts are cultural objects whose core properties or functions are commonly shared by a community. In contrast with individual experience, he highlighted culturally and socially relevant events, such as observation, instruction, and conversation that were crucial for learning about objects. From his perspective these activities are relevant not only for personal and collective conceptual representations of artifacts, but also for strengthening the default uses and basic action sequences connected with the objects. In fact, research on early theory of mind has reported that 1-2-year-old children appreciate the importance of noticing intentional cues from others as a platform for discovering how to make an artifact function or what an artifact is for (e.g., Carpenter, Nagell, & Tomasello, 1998; Carpenter, Call, & Tomasello, 2002; Gergely, Bekkering, & Kiraly, 2002; Casler & Kelemen, 2005, 2006; DiYanni & Kelemen, 2008; Tomasello & Rakoczy, 2003).

It seems plausible that both forms, namely individual perception and contemplation of contextual cues, play important roles in children's learning about artifacts. There is evidence of both learning patterns occurring concomitantly. These reports stem from studies that are based on natural conversations between parents and children not only at home, but also at the laboratory, and at museums. Conversations with more expert partners, such as parents, may help children to review their theories and build deeper current conceptual frameworks about science topics (e.g., Crowley & Callanan, 1998; Crowley et al., 2001; Dierkin & Falk, 1994; Gentner & Ratterman, 1991; Glynn & Takahashi, 1998; Goncu & Rogoff, 1998; Goswami, 2001; Ratterman & Gentner, 1998; Snow & Kurland, 1996; Valle & Callanan, 2006).

This present study's methodology will focus on children's questions about artifacts based on above cited evidence that conversations with adults is an effective strategy for children to learn about objects, and that frequently children's questions initiate and lead such dialogues (Kelemen, Callanan, Casler, Perez-Granados, 2005). However, it is important to ask: are children's questions a tool for their cognitive development as they are for adults'? It has been demonstrated that not only are questions a powerful information-seeking mechanism for children, but the kinds of questions children ask provide adults or more knowledgeable partners with the type and degree of complexity of the information that they are looking for (Chouinard, 2007). Moreover, as children explore the world they may encounter "problems" that are gaps in their knowledge or inconsistencies between their current conceptual frameworks and new, ambiguous or anomalous incoming information (see also Frazier, Gelman, & Wellman, 2009; Graesser & Olde, 2003). Children, by producing purposefully questions to more knowledgeable individuals such as parents, achieve a change in their knowledge state, because they are able to update their conceptual framework and perhaps elaborate a more profound abstract understanding of a construct. Importantly, when the responses were not satisfying or not the information children insist with follow-up questions (Chouinard, 2007).

Wrapping up, it has been demonstrated that questions are ubiquitous in children's daily conversations, especially with more knowledgeable partners. Moreover, young children, similarly to grown-ups, make use of their queries to acquire valuable information to create, elucidate and elaborate their mental frameworks of different artifacts. Therefore, the child-initiated methodology proposed here is a sound and ecologically valid measure to understand how children learn about artifacts, due to its foundation in a spontaneous and typically manifested behavior in the real world.

CHAPTER 2

OVERVIEW AND HYPOTHESES OF THE PROJECT

The present project aimed to determine how children acquire, organize, and prioritize knowledge about artifacts. I strived to get a broader picture of children's conceptual map of artifacts by showing them images of not only novel, but also familiar artifacts. The decision to include familiar objects derived from the idea that children would already have at least primary information about that particular artifact, such as toothbrush is to clean teeth. Thus, the questions they would ask would reflect the secondary types of information demanded. For example, if indeed function is the fundamental and dominant information relevant for learning about a novel artifact, when this knowledge gap is filled, what are the next stages for conceptually mapping a particular artifact? Because most of the studies in this area of research deal strictly with novel artifacts (see for exceptions Kemler Nelson & O'Neil, 2005; Subrahmanyam, 2001) this question remains unanswered. It is likely that by exploring intuitions about both familiar and unfamiliar artifacts one can gain insight into how children prioritize different types of information that typify manmade objects.

Following the arguments guiding this study, if children already know the functions of the artifacts they encounter, they should not ask about them and instead direct their questions to other possibly important conceptual properties or more specialized information about function to enrich their current mental representation. Similarly, if function is critical for artifact representation, and information is missing from children's conceptual framework for novel artifacts, then children should ask more function questions for novel artifacts than for familiar artifacts. To achieve its goal, this project, which includes two studies, used a child-initiated discovery method to investigate the elements that children themselves consider important when conceptualizing and categorizing artifacts. In both studies, children engaged in a question-asking paradigm (Greif et al., 2006; Kemler Nelson et al., 2004; Kemler Nelson, O'Neil, 2005). In Study 1 children encountered images of familiar artifacts and were encouraged to ask questions about them, and later to tell the experimenter what they knew about the artifacts. In Study 2 children encountered novel and familiar artifacts and were encouraged to ask questions about them. Questions were used as indicators of both what children deem important for the identity of an object and also the knowledge that is missing from their current concept structure. Statements were used as indicators of both children's current knowledge and also what children deem important when telling someone about an artifact.

The experimental hypotheses for the project:

Hypothesis 1: The hybrid model will better explain children's artifact conceptualization: there will be an interaction between form and function, although function will truly be the essence of artifacts and direct the interaction.

Hypothesis 2 (Only Study 2): Novel objects will yield more utterances about intended design, current use, and produce more analogies to known objects than familiar objects. This is likely to occur considering evidence that children are especially sensitive to function when learning about artifacts.

Hypothesis 3: Familiar artifacts will prompt more utterances about appearance, context of use, ownership, and user identity. In addition, if children ask about function I expect their inquiries to be more specialized and detailed (e.g., questions that already carry information about the object's function). This is predicted because functional information about familiar objects should already be a part of children's conceptual framework.

Hypothesis 4: Children will produce more utterances about highly complex artifacts. This is likely to occur because objects that are high in complexity also have more affordances and details that should pique children's curiosity.

Hypothesis 5: Older children will produce more utterances about intended design, ownership, and user identity and younger children will produce more utterances about current use and appearance.

CHAPTER 3

PRELIMINARY VALIDATION STUDY

The purpose of this preliminary study was to validate the fit of our stimuli choices with our assumptions of the structural and functional parameters that we predicted children would attend to, either overtly or covertly, while formulating their questions.

Participants

Forty undergraduate volunteers (20 male) drawn from the Introductory Psychology subject pool in the Department of Psychology at Florida Atlantic University participated in the preliminary validation study. This sample size was chosen because data analysis was performed on separate stimulus items and used statistical modes to categorize stimuli. A sample size of 40 provided enough data to establish an obvious sample distribution with a distinct unimodal peak.

Materials

Images of artifacts of varying familiarity and physical/mechanical complexity were gathered from the Internet. A wide variety of object categories were used to increase the generalization of results, including: kitchen tools and gadgets, factory machines, entertainment and media gadgets, medical equipment, toys, and construction equipment. Images were digitally edited so that individual objects were presented on a neutral white background. As a broad conceptual division, objects selected were either "novel" or "familiar." Novel objects were those whose physical appearance and affordances did not match conventional expectations for the function of the object or were highly specific to a professional area such as chemistry, thus familiar to only a select group. For the object to be considered novel, adults could not be able to identify, label, or guess its intended function. Familiar objects were those whose function and name were easily identifiable for adults, and considered common or typical in everyday life for most participants in modern western culture.

Second, objects differed according to structural or mechanical complexity. In the selection process, the number of obvious external parts and how they were interrelated determined their complexity. “Simple” objects had few large parts that were arranged in a simple and uncomplicated way. “Complex” objects were composed of many parts arranged in a highly interrelated, labyrinthine manner. Parts were defined as segments of whole objects that are distinguished from each other by boundary contours comprised of concavities (Barenholtz & Feldman, 2003).

Procedure

The images of the objects were presented in randomized order to each participant. There was a total of 5 different randomizations, thus 8 participants (4 males) rated each set. There were a total of 103 objects, out of which 60 were intended to be novel, and 43 were intended to be familiar. Because it was anticipated to be harder to find objects that adults would not recognize than objects that are familiar to the participants, more intended novel artifacts than intended familiar artifacts were included in the validation study. Out of the 60 intended novel objects, we anticipated 34 to be rated as complex and 26 to be rated as simple. Similarly, out of the 43 intended familiar objects, we anticipated 22 to be rated as complex and 21 to be rated as simple.

Participants were asked to rate the complexity of each object on a scale from 1-not at all complex to 7-very complex, with complexity described to participants as the number of parts they perceived that made up the object and how the parts were arranged. They also rated how familiar they were with each object on a scale of 1-not at all recognizable to 7-very recognizable. Familiarity was described as reflecting the participant’s knowledge of the name and function of the object. In addition to providing ratings, participants were asked to guess the name and function of each object.

Analysis and Stimuli Selection

Table 1 summarizes the average means and modes in familiarity and complexity for each of the intended categories. A final set of stimuli was selected based on mode ratings for each object. Modes were used as they reflected the most typical intuitions about the objects. Objects with multimodal distributions were dropped from the stimulus set. For each object with a unimodal distribution, objects with a mode of 1 on complexity were included in the “simple” object set, and those with a mode of 3 or higher were included in the “complex” set. For complexity, the cut was made at mode 3 because familiar objects were, in general, rated as less complex than novel objects (see Table 1), even when objectively both types of objects displayed the same number of parts. In study 2, which included both novel and familiar objects, in order to keep both categories balanced in terms of complexity, care was taken to choose complex novel objects that were in the same range of complexity as the familiar complex set. With regards to familiarity, objects rated as 1 were classified as “novel”, and those rated as 7 were classified as “familiar.” Additionally, objects scored as novel that had more than two correctly guessed identities or functions and those within the correct range of functions were removed from the set. Lastly, if more objects than were needed for each category had the described requirements, the final decision was made based on a subjective judgment of the artifacts’ power to engage children: for example, the presence of colors, or interesting shapes. The final sets for Study 1 and 2 are shown in figures 2 and 4, respectively.

CHAPTER 4

STUDY 1: FAMILIAR ARTIFACTS

The primary purpose of this study was to explore the types of questions children ask or types of information they say about already familiar objects without the interference of novel objects in the set. Moreover, it aimed to shed light on how these inquiries may be distinct for complex and simple objects. This study also aimed to confirm that the set of familiar objects was indeed familiar to preschool children, thus validating the familiar set for Study 2.

Participants

Participants were 28, 3-, 4-, and 5-year old children (15 male; Mean age = 4.08 years, Range= 3 years, 1 month to 5 years, 2 months) recruited from preschools and through word-of-mouth in Palm Beach and Broward Counties, and areas surrounding Florida Atlantic University. For the 3-year-old participants, the mean age was 3 years, 7 months (range: 3 years, 1 month to 3 years, 11.8 months); for the 4-year-old participants, the mean age was 4 years, 5 months (range 4 years, 1.5 month to 4 years, 11.5 months); for the 5-year-old participants, the mean age was 5 years, 2 months (range 5 years, 1.4 month to 5 years, 1.9 month). Participants were required to be fluent in English. Data from three children were discarded because of shyness or unwillingness to complete the protocol, and three additional children were dropped from the sample because of experimental error.

The demographics of the sample were as follows: 42.86% were White non-Hispanic, 25% were Hispanic, 10.71% were Asian, 7.14% were Black or African American, 7.14% were Mixed, and 7.14% did not provide demographic information. The maternal education was composed as follows: 7.14% had a high-school diploma, 3.57% had a community college degree, 26.42% had a 4-year college degree, 35.71% had graduate or professional training, and 7.14% did not provide information. The paternal education was composed as follows: 14.29% had a high-school diploma or some community college experience, 14.29% had some 4-year college experience or a community college degree, 17.86% had a 4-year college degree, 42.86% had graduate or professional training, and 10.71% did not provide information.

Materials

Game presentation. Following Greif et al. (2006), we used a simple computer game to engage children and prompt them to ask questions about the stimuli. The game was constructed in Microsoft PowerPoint and presented on a notebook computer (see Figure 1). The initial game screen had a grid of colorful boxes with stars. Clicking on each star with the cursor produced an entertaining noise and advanced the game to another slide with a picture of one artifact. The slide displaying an artifact, when clicked, returned the child to the initial selection grid. When they returned to the initial selection grid, their previous selections turned red, indicating that that picture choice was no longer available. The training game screen used a 2x2 selection grid, and contained 4 pictures. The test game used a 3x4 selection grid, and contained 12 pictures. There were 4 different orientations created by randomly arranging the 3x4 grid on the horizontal, vertical, and diagonal planes. This yielded 4 possible combinations of picture placement and screen orientation. Children were randomly assigned, aiming for similar numbers of children at each age to each combination (see Table 2 for distribution of participants per game grid). It is useful to note that each child had a different strategy of “picking” stars such that virtually every child was exposed to a unique order of artifacts, even if assigned to the same game grid,

Artifacts. The set of familiar simple artifacts included 8 pictures of man-made objects judged as perceptually familiar and simple, and 8 pictures judged as perceptually familiar and complex by the preliminary validation study. Four images of familiar objects (2 complex and 2 simple) were used in the training game, and 12 images of familiar artifacts were included in the test game. The means and modes in terms of complexity and familiarity of the set of stimuli used in the test game are reported in Table 3.

Procedure

Children were first asked to sort a few wooden blocks according to their shape or color. This was used as a short warm-up task to promote rapport between the experimenter and the participants. Then, following Greif et al. (2006), children were introduced to a puppet, named KC, who was operated by the experimenter and gender-matched to the participant. The experimenter explained that KC really wanted to know about all sorts of things and s/he was going to ask the experimenter questions to learn about them. Then the computer training game, with its 4 images hidden behind the stars, was loaded on the notebook screen. KC was instructed to pick one of the stars to see what happened. After KC pointed to one of the stars, the experimenter clicked on the star and the program loaded a picture. The experimenter responded enthusiastically about the object in the picture and asked KC if s/he wanted to ask anything about it. Then KC "whispered" a question silently into the experimenter's ear. The experimenter responded out loud "Oh, I know the answer to that question!" and silently whispered the answer into KC's ear. The question-answer exchange was repeated once for a total of two training images in order to encourage the child to ask multiple questions when it was his/her turn. The whisper technique allowed the experimenter to build a sense of comfort for the child to ask questions without biasing the child towards a particular question content or format.

After KC chose two images, the child was told that it was his/her turn to ask questions and s/he was encouraged to choose one of the stars to view. For half of the participants (15), after children chose a star, the experimenter said: "Wow, that's cool! Look at it very carefully. What questions are you going to ask me about it? What's your first question?" If the child did not ask questions, the experimenter said: "Are you sure? Is there anything you want to ask me about it?" If the child still did not ask any questions, the experimenter slightly changed the game by saying:

“Ok, so now why don’t you tell me everything you know about this one?” This is referred from now on as the “without KC” condition. For the other half (13), the only change in the protocol was a third attempt to prompt children to ask questions before instructing the child to say everything s/he knew about the object. In this third attempt the experimenter said: “KC do you want to learn about this thing? KC nodded. Can you ask a question to help KC learn about it?” This is referred from now on as the “with KC condition.” Each trial ended when participants stopped asking questions or indicated that they wanted to move on to the next object. After the practice trials, the 3x4 game board was presented, and the same protocol as used in the training trials was followed.

Children’s questions were answered with appropriate information. Ambiguous questions such as “What’s this?” were answered with the artifact’s name in order to prompt more specific follow-up questions. Likewise, ambiguous questions about parts, such as “What’s this part?” were also answered with the part’s name, for example “this is a button”. This decision was made because it was more likely that children would not be satisfied with only the artifacts’ name or parts’ name and would ask more specific questions about function (see Kemler Nelson et al., 2004).

Coding

Transcripts were coded by a research assistant who was blind to the purposes of the study. This primary coder was trained intensively in the coding system to reach 100% of inter-rater agreement with the author. A second sample of 30% of the trancriptions was independently analyzed by the author. Interrater agreement on the codes assigned was 94 %.

The codes were assigned to children’s utterances. An utterance was defined as a question or statement connected by prepositions. An utterance could have one or more codes, when applicable. For example, the utterance “It’s a kite and it flies in the sky” would have two codes, one code would be name-whole (e.g., kite), and the other would be function of the whole artifact (e.g., flies in the sky).

The coding system differentiated questions from statements. The general categories included ambiguous requests for information such as "What is this?"; requests for information or statements about function such as "What does it do?" or "It cleans the floor"; requests for information or statements about the process of using the artifacts, referred to here as mechanism, such as "How does it work?" or "You sit on the seat, push your feet on the pedal, and go!"; requests for information or statements about the name or category of the artifact such as "What's this called?" or "That's a kite"; requests for information or statements about appearance such as "Why is it round?" or "This part is blue and that part is red"; requests for information or statements about context of use or appropriate user such as "When do you use it?" or "This scissors are for big people to use"; "why" questions about function and part of the object such as "Why does it fly?" or "Why does it have this thing?"; statements about personal experience such as "I fly my kite in the park with daddy" or "I had a helicopter, but it broke"; analogies to familiar artifacts such as "Like a rocking chair"; and, finally, ambiguous statements of lack of knowledge, such as "I don't know". Included in the category "other" were requests for information or statements that were not observed sufficiently to warrant a unique category code; for example, utterances about manufacture, damage, safety, utterances that could not be deciphered, and those that were only appropriate for animals, such as "How does it sleep?".

In addition, for the code categories ambiguous, name, function, mechanism, and why questions, uterrances about the whole object and about parts of the object were differentiated. Moreover, when incorrect questions or statements were made, if the utterance was appropriate or logical according to the object's appearance, it was considered as "Incorrect-Appropriate" (e.g., "It play songs" for coin sorter that looks like a radio). However, if the utterance was not appropriate or ilogical according to the object's appearance, it was considered as "Incorrect-Inappropriate" (e.g., "It shreds cheese" for a coin sorter that does not look like a shredder).

Furthermore, for function and mechanism categories, questions were differentiated by Specific or General. Specific questions were defined as questions that already had some functional information included in the query (e.g., "How does it fly?); General, on the other hand, were exploratory questions, with no exact information included in the query (e.g., "How does it work?). Finally, a distinction between Current Use and Intended Use was made in questions and statements about function of the whole object (function-whole) and function of part of the object (function-part). Current Use was defined as utterances in the present tense such as "Does it fly?" and "it cleans the floor". Intended Use was defined as utterances that used "for" or "in order to" such as "What is it for?"; "this is to cut paper". Please refer to table 4 for a detailed description of the coding system.

If participants repeated questions or statements with the same information, the repetition was not coded. For example, if the child said, while looking at the marker, "it can draw superman," then later said, " it can draw spiderman," the second phrase was not coded. However, if the action verb changed, for example "you can draw with it," and then "you can color with it," then each phrase was coded as "function-whole."

Results

Overall, 1,177 object-related utterances were observed, averaging 42.04 per child; 1,061 were statements, averaging 37.9 per child; and 116 were questions, averaging 4.14 per child. With respect to code frequency, 1,410 were observed overall with an average of 50.36 per child; 1,294 were statement codes, averaging 46.2 per child; the frequency of question codes was equal to the frequency of questions codes already described.

Question codes were excluded from the subsequent analyses, because only three children asked greater than three questions throughout the entire session. A table of the frequencies of questions and statements by code category is provided in Table 5.

Significant results and F-values are reported. Significance was determined at *p* value < .05. A Greenhouse-Geisser correction was used when tests of sphericity were significant. Bonferroni adjustments were made for all pairwise comparisons. Age, gender, and condition were always used as between-subject factors. Age was defined as younger (3 years and 1 month to 3 years and 11.8 months, *M* = 3.6 years, *SD* = .34) and older (4 years and 1.53 month to 5 years and 1.9 month, *M* = 4.57 years, *SD* = .39). Condition was defined as “without KC” and “with KC”. For the “with KC” condition, prior to asking the child to describe everything he knows about the object, the experimenter solicited questions aiming to teach the puppet about the artifact. For many of the analyses age, gender, and condition did not produce significant effects, and were thus dropped from the ANOVAs: it will only be noted when they were maintained. Follow-up analyses of the interactions were conducted using univariate ANOVAs, independent t-tests, or paired-t-tests, when appropriate. Simple box-plot analyses were conducted on the total number of statement codes per age and gender in order to identify extreme outliers. There were no extreme case children who exhibited an extremely high or extremely low code frequency according their group profile (values more than 3 times the interquartile range), so no participant was excluded from the following analyses.

Familiar artifacts: Overall patterns. To look at overarching category patterns, codes were collapsed across complex and simple object types for the analyses in this section.

A 2 (Age) X 2 (Gender) X 2 (Condition) ANOVA showed that the frequency of statement codes did not differ by Age, Gender, or Condition (all *p*s >.40). See Table 6 for code frequency per age group. Proportions of codes were used in Study 2 because there were differences in the frequency of codes produced by younger and older children. Proportions were used for Study 1 as well to keep data analysis consistent between studies. Thus, rather than look at the code frequencies produced by each child, the analysis considered how children distributed their codes across their dialogue. Therefore, the proportions equaled the frequency of codes for each statement category divided by the total number of statement codes for that particular participant.

Major categories. Aiming to explore the most popular categories of children's utterances about artifacts, ANOVAs were run on those category codes that accounted for the majority of statement codes as within-subjects factor. The major statement categories were: function-whole (e.g., "It flies"), category-name (e.g., "It's a toothbrush"), appearance (e.g., "It has a froggy on it"), function-part (e.g.,"you press this button to call someone", and name-part (e.g., "Those are buttons"). The ANOVA showed a main effect of Type of Category, $F(2.73, 73.73) = 15.03$, $p < .001$, $\eta_p^2 = .36$, indicating that the proportions of statement codes differed significantly by category. Function-whole statements were significantly more common than all codes except for category-name (all *ps* <.01). Category-name was the second most common statement type, significantly more common than all the remaining codes (all *p*s < .05). The proportions of appearance, function part, and name part codes did not yield significant differences between each other (all *p*s >.90). See table 9 for means and standard deviations. See figure X for graph.

Current use versus intended use. Another important question was whether children referred to intended use or current use of artifacts. A 2 (Age) x 2 (Gender) x 2 (condition) x 2 (Current versus Intended use) ANOVA was conducted. Current use was composed by function utterances such as "it flies"; intended use was composed by function utterances such as "it is for cleaning." The proportions of intended use and current use utterances for function-whole and function-part were within-subjects variables. Results showed a main effect of Current Use versus Intended Use where current use utterances for function-whole and function-part were more common than intended use utterances (all *p*s <.05). See table 10 for means, standard deviations and F- values.

Simple versus complex familiar artifacts. The following analyses were mixed 2 (Age) x 2 (Gender) x 2 (Condition) x 2 (Complexity) ANOVAs. Complexity (i.e., simple versus complex) was a within-subject factor, and was a different code category in each analysis (e.g., function, appearance, personal experience, etc). For the following analyses, F-values, effect sizes and means are shown in table 8; and means and standard deviations of the interactions are shown in table 9.

Before going further, it is important to acknowledge that analyses run on the following categories did not yield any significant results: ambiguous lack of knowledge (e.g., “I don’t know”), appropriate user (e.g., “Big people use those scissors”), and personal experience (e.g., “I ride my bike at the park”) (all *p*s > .25).

Finally, *other* statements included category codes that were not observed sufficiently to warrant a unique category code; for example, statements about the manufacturing, safety, or damage, as well as statements that could not be deciphered. These uncategorized statements were not analyzed.

Proportions of total statement codes by artifact type. ANOVAs were run to investigate the differences between the proportions of codes per artifact type. Results showed a main effect of Complexity such that complex artifacts produced more statements than simple artifacts (p <.01).

In addition, there was an interaction effect between Complexity and Gender, $F(1, 26) = 5.96$, $p < .03$, $\eta_p^2 = .19$. Further analyses showed that boys produced more statements for complex artifacts than for simple artifacts, $t(14) = 3.42$, $p=.004$, $d = .89$, whereas girls did not differ significantly in the proportions of statement per object type (p >.70). Moreover, boys produced more statements about complex artifacts than girls, $t(26) = 2.44$, $p = .02$, $d = .93$; and girls produced more statements about simple artifacts than boys $t(26) = -2.44$, $p = .002$, $d = -.93$.

Function. This category included statements about current use (e.g., “it flies”), intended use (e.g., “it is for cleaning”), mechanism (e.g., “you seat on it, and pedal on it”), and function/mechanism (e.g., the pinwheel spins”), differentiated by references to whole objects and to parts. There was only one entry for incorrect function-whole statements, which was discarded.

Function-whole. The ANOVA yielded a non-significant trend for a main effect of Complexity ($p = .059$), such that complex artifacts tended to promote more of this type of statement than simple artifacts.

Function-part. Results showed a main effect for Complexity indicating complex artifacts yielded more of this question type than simple artifacts ($p < .001$). Moreover, there was a main effect for Age showing older children produced more of this type of statement than younger children ($p < .03$).

Moreover, there was an interaction between Complexity and Age, $F(1, 20) = 6.97$, $p < .02$, $\eta_p^2 = .26$. When analyzed separately, both younger and older children produce more of this statement type for complex artifacts than for simple artifacts, $t(13) = 2.60$, $p = .02$, $d = .87$, younger; $t(13) = 3.46$, $p = .004$, $d = 1.12$, older. However, older children produced more function-part statements than younger children for complex artifacts, $t(15.21) = -2.93$, $p = .01$, $d = -1.11$. In addition, there was a non-significant trend suggesting that older children produce more function part statements than younger children for simple artifacts, $t(14.87) = -1.95$, $p = .07$, $d = -.74$.

There was also an interaction between Complexity and Gender, $F(1, 20) = 4.56$, $p < .05$, $\eta_p^2 = .19$. Whereas girls did not differ significantly in the proportion of function-part statements for complex and simple artifacts ($p > .10$), boys produced more of this statement type for complex artifacts than for simple artifacts, $t(14) = 3.45$, $p = .004$, $d = 1.13$. Furthermore, there was a non-significant trend suggesting that boys produced more of this statement type for complex artifacts than girls, $t(22.25) = 2.02$, $p=.056$, $d = .77$. No difference was found for simple artifacts ($p > .20$).

Lastly, there was also an four-way interaction of Complexity by Age by Gender by Condition, $F(1, 20) = 6.34$, $p < .02$, $\eta_p^2 = .25$. Older boys produced more of this statement type for complex artifacts than for simple artifacts without KC, $t(3) = 3.98$, $p=.03$, $d = 2.00$. There was no significant difference with KC ($p > .18$). Moreover, without KC older boys produced more of this statement type for complex artifacts than younger boys, $t(3.28) = -3.97$, $p=.02$, $d = -2.81$. Again, with KC there was no significant difference ($p > .50$). The analyses also yielded a non-significant trend suggesting that younger boys produced more of this statement type for complex artifacts with KC than without KC, $t(5) = -2.5$, $p=.055$, $d = -1.91$. No such trend occurred when only simple artifacts were included ($p > .70$). There were no significant effects for girls (all ps > .13)

Appearance. This category included statements and questions about color, decoration, shape, and texture (e.g., sharp, soft). Results yielded a main effect for Complexity, such that simple artifacts yielded more appearance statements than complex artifacts ($p < .01$).

In addition, the analysis showed an interaction effect between Gender and Age, $F(1, 24) = 6.11$, $p = .03$, $\eta_p^2 = .20$. Further analyses yielded only non-significant trends suggesting that younger girls produced more of this type of statement than older girls, $t(6.86) = 2.15$, $p=.069$, $d = 1.20$, and more than younger boys, $t(6.43) = -2.22$, $p=.066$, $d = -1.19$.

Category name. This category included statements about the artifacts' names. It encompasses not only specific object names (e.g., saxophone), but also global names (e.g., instrument), and names that lie within the correct global category (e.g., flute). There was only one instance of incorrect but appropriate naming according to the object's appearance, which was discarded.

The ANOVA failed to yield a Complexity main effect ($p > .12$), nonetheless there was a main effect of Age, such that younger children produced more category name statements than older children ($p = .05$). Moreover, there was a non-significant trend for an interaction among Complexity, Age, Gender, and Condition, $F(1, 20) = 3.98$, $p = .06$, $\eta_p^2 = .17$. Further analyses, however, did not yield any trends or significant effects (all ps > .90).

Name part. This category included statements on the names of the artifacts' parts. Results indicated a main effect for Complexity, such that complex artifacts promoted more name part statements than simple artifacts ($p < .002$).

Context of use. This category included statements about when or where to use the artifacts (e.g., "you can bring it to school"). The ANOVA failed to yield any significant main effects (all ps > .080). However, it indicated a non-significant trend for an interaction between Gender and Condition, $F(1, 20) = 4.00$, $p = .059$, $\eta_p^2 = .17$, nonetheless, further analyses did not yield any trends or significant effects, (all ps > .090). Last, there was also an interaction effect among Age, Gender, and Condition, $F(1, 20) = 5.27$, $p = .03$, $\eta_p^2 = .21$. However, once again, follow-up analyses did not indicate any trends or significant effects (all ps > .080).

Discussion

The main purpose of this study was to investigate the types of questions and comments familiar artifacts evoke from children. It next explored how the object type (complex or simple) affected the nature of the inquiries. Last, it aimed to verify that the preschooler's level of familiarity of the objects used in Study 2 was indeed high.

The most striking finding was that children, when faced with familiar artifacts, did not engage in question-asking. Rather they naturally engaged in expressing their current knowledge level of the object, even before the Experimenter asked them to do so. This occurrence has never been reported in previous studies of the same design: most likely due to the presence of novel entities in previous stimuli sets. The presence of familiar artifacts may have confused the game's purpose, question asking, into a game of describing the artifacts. In an anecdotal example children would say: "My question is: it's a toothbrush!; My question is: you ride on it." This was a crucial lesson for Study 2, prompting the development of a more detailed training phase that taught what was meant by question, and how the game was to be played. In addition, it became clear that the game had to be set-up in a way that interspersed the novel and familiar artifacts, and that it was important for the first artifact to be novel. This helped children grasp the question-asking paradigm.

Nonetheless, statements provided important insights into children's current knowledge and into what children deem important when telling someone about an object. In line with previous child-initiated design studies (e.g., Kemler Nelson et al., 2004; Kemler Nelson & O'Neil, 2005; Greif et al., 2006) and my hypothesis of function being the essence of artifact conceptualization, function statements were the most common, only not significantly more common than the object's name, but decidedly more frequent than appearance remarks.

Contrary to predictions, namely that older children would produce more utterances about intended design and younger children more utterances about current design, current design statements were more common in all age groups for both function of the whole object and function of parts. These results suggest that preschool children conceptualize artifacts in terms of their current use and not according to intended design at least up to 5-years of age. This implies that the development of the design instance may occur after this age. Nonetheless, this could be a product of language difficulty. Perhaps saying "it flies" is easier than saying "it is for flying," but that does not necessarily mean that children are not reasoning about artifacts in terms of their original intended use on a deeper lever. This point is further discussed in the General Discussion.

Moreover, children recognized all artifacts present in the stimuli, and produced more statements about complex artifacts than about simple artifacts. Interestingly, boys produced more statements about complex artifacts than girls. But girls produced more statements about simple artifacts than boys. Confirming predictions, the reason why complex artifacts yielded more statements derives from the higher number of affordances they carry. This is demonstrated by the finding that complex artifact statements surpass simple artifacts in the function-part and name-part categories.

Furthermore, older children seemed to be more attentive to the functions of objects' affordances than younger children, as shown by the Age main effect found in function-part statements. This finding agrees with the expertise literature. Older children possess greater experience and are probably more familiar with the artifacts' presented. As familiarity with objects increases, they may be more likely to detect relevant features and differentiate affordances, as demonstrated by older children's eagerness to point to specific parts of the objects and explain their function, which generally was key for the whole objects' performance (Canham & Hegarty, 2010; Gibson, 1969; Gibson & Gibson, 1955; Haider & Frensch, 1999).

Another interesting pattern was the finding that boys produced more function-part statements for complex than for simple objects, while this difference was not significant for girls. In addition, there was a trend for boys to make more function-part statements for complex objects than girls. In terms of the present data, it seems that boys are more sensitive to objects' parts than girls. This is possibly explained by boys' relatively higher experience level with objects than girls. For example, studies reported that boys engage more in object-oriented play and tool-use than girls (Bock, 2005; Caldera, O'Brien, Truglio, Alvarez & Huston, 1999; Gredlein & Bjorklund, 2005; Sandberg & Meyer-Bahlburg, 1994).

Finally, the presence of KC appears to have played a role in function-part statements, but curiously only for boys. The puppet seems to have prompted older boys to produce more function-part statements for simple artifacts. The evidence showed that older boys produced more function-part statements for complex than simple artifacts in the without KC condition, whereas this significant difference disappeared in the with KC condition. Moreover, KC also appears to have prompted younger boys to produce more function-part utterances for complex artifacts. This is explained by the disappearance of a significant difference in the proportions of function-part statements for complex artifacts between older and younger boys in the with KC condition.

In terms of other categories, simple objects prompted more appearance statements than complex objects. It could be that in the absence of parts, which may allow children to talk about their names and functions, the next most appealing subject was appearance. This argument is developed further in the General Discussion. Moreover, younger girls seem to be more sensitive to appearance than older girls and younger boys. Interestingly, contrary to my predictions, there were no developmental differences in utterances about ownership and user identity.

In addition, results showed a developmental pattern indicating that younger children produced more name-whole statements than older children. This may be explained by the fact that older children have a more developed theory-of-mind (Lillard, 2001; Pellegrini & Bjorklund, 2004), and did not feel it was necessary to tell the Experimenter the name of the artifact; that is, they may have assumed the Experimenter knew what it was. Alternatively, it is possible that because younger children, as described before, were less sensitive to objects' affordances and less familiar with the objects, they relied upon the few things that they knew about the objects, name being most common. In conclusion, Study 1 illuminated what young children already know about familiar artifacts and the types of information they deem important when explaining an object to another person. Nonetheless, the study failed to demonstrate the next stages for conceptually mapping an already familiar artifact because children did not engage in question asking. Furthermore, by exploring intuitions about both familiar and novel artifacts in the same study one can gain insight into and directly compare how children prioritize different types of information that typify manmade objects that differ in their level of familiarity. These thoughts motivated the development of Study 2, including both familiar and novel artifacts, as well as adjustments in the protocol to ensure that children understood the question-asking paradigm.

CHAPTER 5

STUDY 2: NOVEL VERSUS FAMILIAR ARTIFACTS

The primary purpose of this study was to explore the types of questions children ask or types of information they know about novel and familiar artifacts. Moreover, it aimed to shed light on how these inquiries may be distinct for complex and simple objects.

Participants

Participants were 61 3-, 4-, and 5-year old children (32 male) recruited from preschools and through word-of-mouth in Palm Beach and Broward Counties surrounding Florida Atlantic University. The mean age of the sample was 4 years, 4 months (range: 3 years, 3.2 months to 5 years, 5.9 months). For the 3-year-old participants, the mean age was 3 years, 7 months (range: 3 years, 3.2 months to 3 years, 11.8 months); for the 4-year-old participants, the mean age was 4 years, 5 months (range 4 years, 0.75 month to 4 years,10.9 months), and for the 5-year-old participants, the mean age was 5 years and 2 months (range 5 years, 0.13 month to 5 years, 5.9 months). Participants were required to be fluent in English. Six additional children were dropped because of shyness or unwillingness to complete the protocol, and 12 additional children were dropped because they did not understand the instructions of the question-asking game.

The demographics of the sample were as follows: 75.05% were White non-Hispanic, 9.84% were Hispanic, 6.56% were Black or African American, 1.64% were Asian, 1.64% were Mixed, and 3.28% did not provide demographic information. The maternal education was composed as follows: 16.39% had a high-school diploma or some community college experience, 8.2% had some 4-year college experience or a community college degree, 39.34% had a 4-year college degree, 32.79% had graduate or professional training, and 3.28% did not provide information.

The paternal education was composed as follows: 1.64% had some high school experience, 18.03% had a high-school diploma or some community college experience, 11.48% had some 4-year college experience or a community college degree, 40.98% had a 4-year college degree, 21.31% had graduate or professional training, and 6.65% did not provide information.

Materials

Game presentation. The same simple computer game as the one in Study 1 was used (refer to section 4.2 Materials for details). There were 8 different screen orientations created by arranging the pictures so that an object would never be placed in the same grid position twice, and so that each row and column would display both novel and familiar artifacts. As in Study 1, children were randomly assigned, aiming for an even distribution of age groups for each combination (see Table 10). As in Study 1, each child had a different strategy of “picking” stars such that, even if assigned to the same game grid, virtually every child was exposed to a unique order of artifacts.

Artifacts. There were 12 pictures of artifacts in the test game. The set of familiar artifacts included 3 pictures of man-made objects judged as perceptually familiar and simple and 3 pictures judged as perceptually familiar and complex by the preliminary validation study. Similarly, the set of novel artifacts included 3 pictures of man-made objects judged as perceptually novel and simple, and 3 pictures judged as perceptually novel and complex by the preliminary validation study. The novel artifacts were assigned with novel invented names (e.g., Coin Sorter was renamed as Luzak) because their real names were very descriptive of their function and would give away their function. The familiar artifacts were not assigned with fantasy names for two main reasons: first, giving a invented name to a toothbrush (an every day item for children) could confuse children and lead them to think that the answers were not necessarily accurate, jeopardizing the children’s perception of the experimenter’s authority and the accuracy of her responses. Second, in Study 1 all of the children recognized the familiar artifacts and virtually none asked “What is it?” or “What is it called” for the familiar items. The means and modes in terms of complexity and familiarity of the set of stimuli used in the test game are reported in Table 6.

Animals. In the training game, four images of animals (2 novel and 2 familiar) were used. The change from artifacts to animals in the training game aimed to prompt children to ask questions and allow for a clearer game demonstration, as explained in section 6.2.3 Procedure.

Procedure

The general procedure of Study 2 was similar to Study 1. Only the differences will be outlined here. In the present study, instead of conducting a sorting blocks warm-up task, it was decided to spend more time training children on the question-asking game. This choice was made because in Study 1, most participants did not comprehend the question-asking requirement of paradigm, perhaps because of the presence of extremely familiar artifacts. After introducing KC as a friend who really wanted to know about all sorts of things, the experimenter explained that it was the participant’s job to ask her questions about the things she was going to show him/her on the computer. Second, the experimenter explained in a didactic manner what questions are, and gave examples of questions someone asks when meeting another person. As an illustration the experimenter would say “if you want to know somebody’s age, you ask the question: How old are you?” Then, the experimenter tested the participant’s comprehension of question-asking by telling them to ask KC what was her favorite color.

Next, the experimenter said that she would start the game with KC asking the questions, and then it would be the participant’s turn to ask the questions. The computer training game with four animal images was then brought up on the notebook screen. Two images were of novel animals and two images were of familiar animals. KC was instructed to pick one of the stars to see, which would always be first of a novel animal. The experimenter showed enthusiasm towards the animal in the picture and asked KC if s/he wanted to ask anything about it. Then KC “whispered” a question silently into the experimenter’s ear. Next, the experimenter said out loud “Oh, KC just asked me What does it eat?, and now I am going to answer her: it eats bugs and flies”. The question-answer exchange was delivered twice for two of the training images in order to encourage children to ask multiple questions when it was their turn. Only animals were included in the training set to allow all questions “asked” by KC to be only appropriate for animals. These questions could never be asked for artifacts, this strategy allowed the experimenter to build a sense of comfort for children to ask questions and ascertain that they understood the game without biasing children towards a particular question’s content or format.

After KC had chosen two images, the child was told that it was her turn to ask questions. Both in the training game and the test game, the experimenter chose the first star, rigged to always produce a novel entity for the first image. This was another control to prompt children to ask questions because the sight of a novel object naturally triggers curiosity and inquiries. After children chose a star, the experimenter said: “Wow, that’s cool! Look at it very carefully. What questions are you going to ask me about it? What’s your first question?” If the child did not ask questions, the experimenter said: “Look at it, it’s so cool! Is there anything you want to know about it?” If the child still did not ask any questions, the experimenter said: “KC do you want to learn about this thing? KC nodded. KC do you want (participant’s name) to help you learn about it? (Participant’s name) can you ask me a question to help KC learn about it?” Children who failed to comprehend the protocol and did not ask questions during the training or test were removed from the sample.

Coding

The same coding system as in Study 1 was employed (see Study 1 Coding section for details) for analyzing transcripts of the study sessions. The same research assistant who coded Study 1’s transcripts, blind to the purposes of the study and trained intensively on the coding system to reach 100% of inter-rater agreement, coded the 61 sessions of the present study. A sample of 30% of the trancripts was independently analyzed by the author. Interrater agreement on the assigned codes was 94.38%.

Results

Overall, 2,416 object related utterances were observed, averaging 39.61 per child. 1,485 were questions, averaging 24.34 per child; and 931 were statements, averaging 15.26 per child. 2,579 code frequencies were observed in total with an average of 42.28 per child. 4,508 were question codes, averaging 24.72 per child; and 1,071 were statement codes, averaging 17.56 per child.

Statement and question code analyses were always conducted separately. The statistical procedures for Study 2 were the same as Study 1 (see Study 1 Results section for details). However, while in Study 1 Age had two levels (younger and older), in Study 2 Age had three levels (3-, 4- and 5-year olds). In order to identify extreme outliers, simple boxplot analyses were conducted on the total number of question codes and on the total number of statement codes per age and gender. Extreme cases (3 participants for questions and 2 participants for statements) were excluded from the following analyses.

Artifacts: Overall patterns. For the analyses in this section codes were collapsed across novel and familiar, and complex and simple object types, which allowed a look at overarching category patterns.

Overall question code frequencies were analyzed with a 3 (Age) X 2 (Gender) ANOVA. There had a main effect of Age $F(2, 52) = 7.2$, $p < .003$, $\eta_p^2 = .22$, indicating that 3-year-olds produced less codable content questions than 5-year-olds. Moreover, there was an interaction of Age by Gender, $F(2, 52) = 4.64$, $p < .02$, $\eta_p^2 = .15$. While the codes produced by boys did not differ significantly between age groups, ($p > .10$), 5-year-old girls ($M = 46.00$, $SD = 27.46$) produced significantly more codes than 4-year-old girls ($M = 20.69$, $SD = 10.91$) and 3-year old girls (*M* = 11.40, *SD* = 4.88), *F*(2, 25) = 8.67, $p < .002$, $\eta_p^2 = .41$. The same analysis conducted on statement codes did not yield any significant effects (*p*s >.40).

Code proportions were deemed the most appropriate measure, because proportions corrected for biases in observed code frequencies between younger and older children. Thus, rather than examine each child's code frequencies for each code type, the analysis examined the distribution of codes across the child's dialogue. Therefore, the frequency of codes for each question category was divided by the total number of question codes for that particular participant. Similarly, the frequency of codes for each statement category was divided by the total number of statement codes for that particular participant.

Major categories. Aiming to explore the most popular categories of children's utterances about artifacts, ANOVAs were run on the category codes that accounted for the majority of question and statement codes as within-subject factors. The major question categories were ambiguous-whole (e.g., "What is it?"), ambiguous-part (e.g., "What's that part?"), function-whole (e.g., "What does it do?", "How does it work?"), function-part (e.g., "What does this part do?", "How does this part work?"), and why-part (e.g., Why does it have this part?"), which in sum accounted for 81.57% of all question codes.

A 3 (Age) x 2 (Gender) x 5 (Category) ANOVA showed a main effect of Type of Category, $F(2.66, 151.65) = 16.01$, $p < .001$, $\eta_p^2 = .22$. Ambiguous-whole questions were significantly more common than all codes except for function-whole questions. Function-whole questions were the second most common type of questions, significantly more common than all the remaining codes (all *p*s < .01). The proportions of why-part, ambiguous-part, and function-part questions did not yield significant differences amongst one another (all *p*s >.90). There were no other significant main effects or interactions (all *p*s > .11). See table 9 for means and standard deviations. See figure 4 for a graph.

The same analysis was run with the major statement categories, which were: name-whole (e.g., "It's a toothbrush"), function-whole (e.g., "It brushes your teeth"), ambiguous lack of knowledge (e.g., "I don't know") , personal experience (e.g., "I bought a vacuum at the store"), appearance (e.g., "It has a froggy on it"), and name-part (e.g., "It has buttons"). These categories accounted for 80.29% of all statement codes. The ANOVA showed a main effect for category code type, $F(3.28, 190.44) = 12.51$, $p < .001$, $\eta_p^2 = .18$. Category-name statements were significantly more common than all other codes (all *p*s < .05). Function-whole statements were the second most common statement type, yet were only significantly more frequent than name-part statements ($p <.01$). The proportions of "I don't know" ambiguous, personal experience, appearance, and name-part statements did not yield significant differences amongst one another (all *p*s >.60). There were no other significant main effects or interactions (all *p*s > .20). See table 9 for means and standard deviations. See figure 4 for a graph.

Lastly, the same analysis was performed with the major categories of questions and statements combined, which were: function-whole, ambiguous-whole, name-whole, appearance, why-part, function part, and ambiguous part. These categories accounted for 76.11% of all codes. The ANOVA indicated a main effect of type for category code type, $F(3.32, 182.54) = 17.48$, $p < .001$, $\eta_p^2 = .24$. Function-whole ($M = .24$, $SD = .18$) utterances were significantly more frequent than all the other category codes. Ambiguous-whole questions ($M = .14$, $SD = .12$) were significantly more common than ambiguous-part questions ($M = .04$, $SD = .08$), and function-part utterances ($M = .05$, $SD = .06$). Name-whole utterances ($M = .13$, $SD = .09$) were significantly more common than ambiguous-part questions, and function-part utterances. The proportions of appearance ($M = .08$, $SD = .10$), why-part ($M = .07$, $SD = .15$), function-part, and ambiguous-part did not yield significant differences.

Current use versus intended use. Another important question was whether children referred to intended use or current use of artifacts. A 3 (Age) x 2 (Gender) x 2 (Current versus

Intended Use) mixed ANOVA was conducted. Current use was composed of function utterances such as “What does it do?” and “It flies”; intended use was composed of function utterances such as “What is it for?” and “It is for cleaning”. The proportions of intended use and current use utterances for function-whole and function-part were within-subjects variables.

Both the question and statement analyses yielded a main effect of Current Use versus Intended Use for function-whole codes. Current use utterances were more common than intended use utterances (all *p*s <.001, questions and statements). Similar analyses were conducted on function-part utterances. The ANOVA on question codes of function-part did not yield any significant results (all *p*s >.40). The ANOVA on statement codes of function-part indicated a main effect of Current Use versus Intended Use, such that current use statements were more common than intended use statements (p<.001). See table 15 for F-values, effect sizes and means.

Types of artifacts. The following analyses used mixed 3 (Age) X 2 (Gender) X 2 (Familiarity) X 2 (Complexity) ANOVAs. Familiarity (i.e., novel versus familiar) and complexity (i.e., simple versus complex) were within-subjects factors. For the following analyses, F-values, effect sizes and means are shown in table 15; and means and standard deviations of the interactions are shown in table 16.

Proportions of total questions and statement codes by artifact type. ANOVAs were run on the proportions of question codes and statement codes to investigate whether the proportions of codes differed per artifact type. The ANOVA on question codes indicated a main effect of Familiarity, such that novel artifacts produced more questions than familiar artifacts (*p* <.001). There was also a main effect of Complexity, such that complex artifacts produced more questions than simple artifacts (*p* >.03).

In addition, there was a non-significant trend for an interaction of Complexity by Gender by Age, $F(2, 52) = 2.94$, $p = .06$, $\eta_p^2 = .10$. Follow-up analyses looking specifically at effects within each age group revealed that whereas 5-year-old girls asked more questions about complex artifacts than 5-year-old boys, $t(11) = -2.14$, $p = .056$, $d = -1.19$; 5-year-old boys asked more questions about simple artifacts than 5-year-old girls, $t(11) = 2.14$, $p = .056$, $d = 1.19$.

The ANOVA on statement codes indicated a main effect of Familiarity, such that familiar artifacts produced more statements than novel artifacts ($p < .001$). There was no significant main effect for Complexity (p >.079). Nonetheless, the interaction between Familiarity and Complexity was significant, $F(1, 53) = 4.6$, $p < .04$, $\eta_p^2 = .08$. Familiar simple artifacts produced more statements than familiar complex artifacts, $t(58) = -2.27$, $p = .03$, $d = -.29$. In addition, reflecting the familiarity main effect, when complex and simple artifacts were analyzed separately, familiar artifacts yielded more statements than novel artifacts, $t(58) = 6.88$, $p = .000$, $d = .91$, complex; $t(58) = 6.73$, $p = .000$, $d = .87$, simple.

There was also a strong trend for an interaction of Gender by Age, $F(2, 53) = 3.13$, $p = .052$, $\eta_p^2 = .11$. Follow-up analyses did not indicate significant results explaining the trend (all *p*s >.13).

In the following sections the results will be reported by category code type. Before going further it is relevant to note that the code category why-function (e.g., “Why does it fly?”) did not yield any significant results.

Ambiguous.

Ambiguous-whole: What’s this? This category included ambiguous questions such as “What’s this?”. The ANOVA showed a main effect for Familiarity, such that novel artifacts produced significantly more questions than familiar artifacts ($p < .001$). There was no main effect for Complexity ($p > .90$), and no significant interactions (all *p*s >.90).

Ambiguous-part: What’s this part? This category included ambiguous questions such as “What’s this?” for artifacts’ parts. The ANOVA showed a main effect for Complexity, such that complex artifacts produced more questions than simple artifacts ($p < .001$). There was no main effect for Familiarity ($p > .20$).

In addition, the analysis indicated a significant interaction between Age and Gender, $F(2, 52) = 4.07$, $p < .03$, $\eta_p^2 = .14$. Five-year old girls asked more of this question type than 5-year-old boys, $t(6) = - 2.69$, $p = .036$, $d = -1.50$. Moreover, 5-year-old girls asked more of this question type than 4-year-old girls ($p < .01$), and trended to ask more of this question type than 3 year-old girls ($p = .065$), $F(2, 25) = 7.47$, $p < .004$, $\eta^2 = .37$.

Function.

Function global. This category included utterances about Current Use (e.g., "What does it do?", "It flies"), Intended Use (e.g., "What is it for?"; "It is for flying"), Mechanism (e.g., "How does it work?"; "You sit and pedal the bike"), and Function/Mechanism (e.g., "The pedal spins"). At the global level, Correct (e.g., "How does the helicopter fly?"; "The helicopter flies"), Appropriate Incorrect (e.g., "Does it play songs?", "It plays music", for coin sorter that looks like a radio), and Inappropriate Incorrect (e.g., "Does it play songs?", "It plays music", for rocking chair that does not look like a radio) utterances were combined. Furthermore, General (e.g., "What is it for?") or Specific (e.g., "How does it fly?") utterances were also concatenated. Separate analyses were run on function-whole and function-part codes, respectively.

Function-whole. The ANOVA on question codes yielded no significant effects (all *p*s >.30), that is, function-whole questions were being asked as high levels regardless of familiarity and complexity. However, when the same analysis was run on statements, there was a main effect for Familiarity, indicating that familiar artifacts produced significantly more function-whole statements than novel artifacts ($p < .001$). In terms of Complexity, the analysis yielded a non-significant trend suggesting that simple artifacts produced more of this statement type than complex artifacts ($p = .07$).

Moreover, there was a significant interaction between Familiarity and Complexity for statements only, $F(1, 58) = 5.22$, $p < .03$, $\eta_p^2 = .08$. This effect indicated that familiar simple artifacts produced more of function-whole statements than familiar complex artifacts, $t(58) = -$

2.13, p=.04, d= -.34. Moreover, mirroring the main effect for Familiarity, familiar artifacts yielded more of this statement type than novel artifacts when analyzing separately complex and simple artifacts, $t(58) = 5.14$, p=.000, d= .75, complex; $t(58) = 6.99$, p=.000, d= 1.18, simple.

Function-part. The ANOVA on question codes yielded a main effect for Complexity, indicating that complex artifacts yielded more function-part questions than did simple artifacts ($p< .001$). There was no main effect for Familiarity ($p>.10$).

Furthermore, there was a significant interaction effect between Age and Gender for questions, $F(2, 52) = 3.69$, $p < .04$, $\eta_p^2 = .12$. While there were no significant gender differences in 3- and 5-year olds ($p> .18$), 4-year-old boys asked more of this question type than 4-year-old girls, $t(22.07) = 2.16$, p=.042, r=.42.

In addition, there was a strong trend of an interaction effect for Complexity by Age by Gender, $F(2, 52) = 3.16$, $p = .051$, $\eta_p^2 = .11$. Both 4-year old boys and 4-year-old girls asked more function-part questions for complex artifacts than for simple artifacts, $t(12) = 3.39$, p=.005, d=7.07, boys; $t(15) = 2.34$, p=.034, d=.68, girls. However, 4-year old boys asked more of this question type for complex artifacts than did 4-year-old girls, $t(16.30) = 2.42$, p=.027, d=.90.

Regarding statements, there was a significant main effect for Familiarity, such that familiar artifacts yielded more function-part statement than novel artifacts (p<.01). The ANOVA did not yield a main effect for complexity (p>.078) or significant interactions (all ps >.19).

Function: General versus Specific Questions.

As a second level of analysis, questions about function, mechanism, and function/mechanism were discriminated by general inquiries (e.g., “What does it do?”, “How does it work?”) and specific inquiries (e.g., “Do the rotors spin?”; “How does it fly?). In the specific questions group, Correct, Incorrect Appropriate, and Incorrect Inappropriate were combined. This analysis was not run on statement codes because statements are always specific, so this comparison does not apply. Three (Age) X 2 (Gender) X 2 (Familiarity) X 2 (Complexity)

X 2 (Specificity) ANOVAs with Familiarity, Complexity, and Specificity as within-subjects variables were performed for function-whole and function-part codes.

Function-whole. The analysis did not yield any main effects (all *p*s > .15), however it yielded a significant interaction effect for Specificity by Familiarity, $F(1, 56) = 35.39$, $p < .001$, $\eta_p^2 = .39$. Novel artifacts produced more general function-whole questions than familiar artifacts, $t(57) = -4.55$, p=.000, d= .-.84. On the contrary, familiar artifacts produced more specific function-whole questions, $t(57) = 3.44$, p=.001, d= .54.

Moreover, there was a significant interaction effect for Specificity by Gender, $F(1, 56) = 6.5$, $p < .02$, $\eta_p^2 = .10$, showing that boys did not differ in the proportions of general and specific questions (p >.40); whereas girls produced more specific questions than general questions, $t(27) = -2.87$, p=.008, d= .-55.

Finally, there was a trend for an interaction effect for Specificity by Familiarity by Gender, $F(1, 56) = 3.65$, $p = .061$, $\eta_p^2 = .06$. Boys produced more general than specific questions about novel artifacts, $t(29) = 3.45$, p=.002, d= .77; while girls did not differ significantly in the proportions of specific and general questions for novel artifacts (p >.50). Both boys and girls produced more specific than general questions for familiar artifacts, $t(29) = -2.61$, p=.014, d= -.69, boys, $t(27) = -4.35$, p=.000, d= -1.00, girls.

Function-part. The analysis yielded a significant main effect for Complexity, such that complex artifacts yielded more of this question type than simple artifacts (p <.001). In addition, there was a trend for a main effect of Familiarity, suggesting that novel artifacts produced more of this code type than familiar artifacts ($p = .063$). Lastly, there was a strong trend for an interaction between Gender and Age, $F(2, 52) = 3.11$, $p = .053$, $\eta_p^2 = .11$; however further analyses did not reveal any other trends or significant effects (all *p*s > .08).

Function specific: Correct versus incorrect. As a third level of analysis, specific questions and statements about function, mechanism, and function/mechanism were discriminated between correct questions (e.g., “How does it fly?”, for helicopter) questions and incorrect questions (e.g., “How does it fly?”, for coin sorter). Recall that correct codes refer to utterances that contain accurate information about the objects’ function and incorrect codes refer to utterances that contain inaccurate information about the objects’ function. In the incorrect codes group, both Appropriate (“How does it play songs?”, for coin sorter that resembles a radio) and Inappropriate (“How does it play songs?”, for rocking chair that does not resemble a radio) were included. Three (Age) x 2 (Gender) x 2 (Familiarity) x 2 (Complexity) x 2 (Accuracy) ANOVAs with Familiarity, Complexity, and Accuracy as within-subjects variables were performed for function-whole and function-part codes.

Function-whole. In line with the analyses described above, the ANOVAs for both questions and statements yielded a main effect for Familiarity, such that familiar artifacts produced more specific utterances than novel artifacts (all ps < .001). Moreover, the ANOVAs also showed a main effect for Accuracy, indicating that correct utterances were more common than incorrect utterances (all ps < .001). Further, in questions there was no main effect for Complexity ($p > .20$), however, in statements there was a non-significant trend suggesting that simple artifacts promoted more specific utterances than complex artifacts ($p = .69$).

More importantly, there was a significant interaction effect between Familiarity and Accuracy, $F(1, 56) = 24.98$, $p < .001$, $\eta_p^2 = .31$, $F(1, 58) = 69.02$, $p < .001$, $\eta_p^2 = .54$, for questions and statements respectively. Familiar artifacts produced more correct utterances than incorrect utterances, $t(57) = 6.14$, p=.000, $r = .63$, questions, $t(58) = 8.42$, p=.000, $d = 1.37$, statements. The proportions of correct and incorrect questions did not differ significantly for novel artifacts ($p > .60$); but incorrect statements were more common than correct statements for novel artifacts, $t(58) = -2.27$, p=.027, $d = -.32$. In addition, when analyzing only correct questions and statements, familiar artifacts yielded more of this utterance type than novel artifacts, $t(57) = 4.71$, p=.000, $d = .73$, questions; $t(58) = 8.32$, p=.000, $d = 1.34$, statements. On the contrary, when analyzing only incorrect questions and statements, novel artifacts yielded more of this utterance type than familiar artifacts, $t(57) = -3.47$, p=.001, $r = .42$, questions; $t(58) = -2.57$, p=.013, $d = -.78$, statements.

Moreover, there was a significant interaction for Complexity by Accuracy by Gender for question codes only, $F(1, 56) = 6.88$, $p < .02$, $\eta_p^2 = .11$. Girls asked significantly more correct questions than incorrect for complex objects, $t(27) = 4.42$, p=.000, $d = 1.04$; and trended to ask more correct questions than incorrect for simple objects, $t(27) = 1.98$, p=.06, $d = .38$. Boys did not yield significant results in terms of accuracy by complexity ($p > .17$). Nonetheless, when considering only correct questions, there was a non-significant trend indicating that boys asked more correct questions for simple than for complex artifacts, $t(29) = -1.94$, p=.06, $d = -.32$.

On the other hand, there was a significant interaction effects between Familiarity and Complexity, Complexity by Accuracy, and Familiarity by Complexity by Accuracy for statement codes only, $F(1, 58) = 5.22$, $p < .03$, $\eta_p^2 = .08$, $F(1, 58) = 4.48$, $p < .04$, $\eta_p^2 = .07$, $F(1, 58) = 5.17$, $p < .03$, $\eta_p^2 = .08$; respectively. Because the two 2-way-interactions were subsumed by the three-way interaction, unpacking the latter provides insights into the former, thus only the Familiarity by Complexity by Accuracy effect will be described.

Both familiar complex and familiar simple artifacts yielded more correct than incorrect statements, $t(58) = 5.65$, p=.000, $d = .89$, complex; $t(58) = 7.37$, p=.000, $r = .70$, simple. Nonetheless, familiar simple artifacts yielded more correct statements than familiar complex artifacts, $t(58) = -2.18$, p=.03, $d = -.32$. Further, familiar complex artifacts promoted more correct statements than novel complex artifacts, $t(58) = 5.51$, p=.000, $d = .85$; and familiar simple artifacts yielded more correct statements than novel simple artifacts, $t(58) = 7.37$, p=.000, $r = .70$.

The proportions of incorrect statements did not differ between familiar complex and novel complex artifacts ($p >.07$), however novel simple artifacts yielded more incorrect statements than familiar simple artifacts, $t(58) = -2.17$, p=.03, $r = .27$. Finally, whereas novel complex artifacts did not differ significantly in the proportions of correct and incorrect statements ($p > .15$), novel simple artifacts promoted more incorrect than correct statements, $t(58) = -2.17$, p=.03, $r = .27$.

Function-part. The analyses on question and statement codes yielded a main effect for Accuracy, indicating that correct utterances were more common than incorrect utterances (ps < .001). The ANOVA conducted on question codes yielded a main effect for Complexity, such that complex artifacts produced more of this question type than simple artifacts (p <.001). The ANOVA conducted on statement codes indicated a main effect for Familiarity, showing this statement type was more common for familiar artifacts than for novel artifacts (p <.001).

Moreover, there was a significant interaction effect for Complexity by Accuracy for questions, $F(1, 57) = 12.06$, $p < .002$, $\eta_p^2 = .18$. Complex artifacts yielded more correct questions than incorrect questions $t(57) = 3.78$, p=.000, d=.84; however the proportions of correct and incorrect inquiries did not differ significantly for simple artifacts (p >.70); and complex artifacts yielded more correct questions than simple artifacts, $t(57) = 3.74$, p=.000, d=.84.

Furthermore, there was a significant interaction effect between Familiarity and Accuracy for statements, $F(1, 58) = 9.18$, $p < .005$, $\eta_p^2 = .14$. Correct and incorrect statements did not differ significantly among novel artifacts (p >.20); while familiar artifacts produced more correct statements than incorrect statements, $t(58) = 3.63$, p=.001, d=.70. Lastly, familiar artifacts promoted more correct statements than novel artifacts, $t(58) = 2.97$, p=.004, d=.43.

Appearance. This category included statements and questions about color, decoration, shape, and texture (e.g., sharp, soft). Both question and statement analyses yielded a main effect for Complexity, such that simple artifacts yielded more appearance utterances than complex artifacts (all ps <.02). In terms of Familiarity, although there was no significant main effect for questions (p >.40), there was a non-significant trend of a main effect for Familiarity in statements ($p = .056$). Familiar artifacts tended to produce more appearance statements than novel artifacts.

In addition, the analyses showed a trend of an interaction effect between Familiarity and Complexity in questions, $F(1, 57) = 3.68$, $p = .06$, $\eta_p^2 = .06$, which was a significant interaction effect in statements, $F(1, 58) = 7.08$, $p < .02$, $\eta_p^2 = .11$. Familiar simple artifacts produced more appearance utterances than familiar complex artifacts, $t(57) = -3.22$, p=.002, d= -.60; questions; $t(58) = -3.29$, p=.002, d= -.64, statements. Lastly, familiar simple artifacts yielded more appearance codes than novel simple artifacts in statements, $t(58) = 2.54$, p=.014, d= .42.

Name.

Name-whole global. At a global level, Correct (e.g., "It's a toothbrush"), Incorrect Appropriate (e.g., "It's a radio" for coin sorter that looks like a radio), and Incorrect Inappropriate (e.g., "It's a radio" for rocking chair that does not look like a radio) were combined. Because there were insufficient question codes, the analysis was run only on statements. The ANOVA indicated a main effect for Familiarity, such that familiar artifacts produced more of this statement type than novel artifacts ($p < .001$). There was also a main effect for Complexity, such that simple artifacts yielded more of this type of code than complex artifacts ($p < .02$).

Furthermore, there was a significant interaction effect between Familiarity and Complexity, $F(1, 57) = 13.48$, $p < .02$, $\eta_p^2 = .19$. Familiar simple artifacts produced more category name statements than familiar complex artifacts, $t(58) = -3.63$, p=.001, d= .70. Moreover, reflecting the Familiarity main effect, when analyzing separately complex and simple artifacts, familiar artifacts yielded more this type of statement then novel artifacts, $t(58) = 6.92$, p=.000, d= 1.07, complex; $t(58) = 8.10$, p=.000, d= 1.21, simple.

Finally, there was another interaction effect between Familiarity, Complexity, and Gender, $F(1, 57) = 5.82$, $p < .02$, $\eta_p^2 = .09$. Girls produced more of this statement type for familiar simple artifacts than for familiar complex artifacts, $t(28) = -3.30$, p=.003, d= -.75. In addition, when analyzing complex artifacts and simple artifacts separately, girls produced more category names for familiar artifacts than for novel artifacts, $t(28) = 5.4$, p=.000, d= 1.01, complex; $t(28) = 6.24$, $p=.000$, $d= 1.44$, simple. See table 14 for means and standard deviations. There were no significant effects for boys ($p >.18$), or significant effects when analyses were performed separately for familiar, novel, complex, and simple artifacts (all ps > .08).

Name-whole correct. At a second layer of analysis, statements on artifact's names were discriminated by Correct and Incorrect. The Incorrect group only included Incorrect Appropriate names after the single entry for Incorrect Inappropriate was discarded.

The ANOVA on Correct statements about artifacts' names indicated both Familiarity and Complexity main effects (ps < .004). These results show both that familiar artifacts produced more correct statements about artifacts' names than novel artifacts, and that these statement types were more common for simple artifacts than for complex artifacts. See table 13 for means, standard deviations, and ANOVA values.

Moreover, there was a significant interaction effect between familiarity by complexity, $F(1, 58) = 12.88$, $p < .002$, $\eta_p^2 = .18$. Familiar simple artifacts produced more of this statement type than familiar complex artifacts, $t(58) = -3.47$, $p=.001$, $d= -.39$. In addition, again reflecting the familiarity main effect, analyses of complex artifacts and simple artifacts by themselves showed that familiar artifacts yielded more of this statement type than novel artifacts $t(58) = 8.96$, $p=.000$, $d= 1.6$, complex; $t(58) = 9.51$, $p=.000$, $r= .78$, simple. See table 14 for means and standard deviations.

Name-whole incorrect. Next, an ANOVA was performed on incorrect appropriate statements on artifacts' names. The analysis showed a main effect for Familiarity, such that novel artifacts promoted more incorrect statements on artifacts' names than familiar artifacts ($p < .001$). There was no main effect for Complexity ($p > .80$). See table 13 for means, standard deviations, and ANOVA values.

There was also a significant interaction effect for Familiarity by Gender, $F(1, 57) = 4.96$, $p < .04$, $\eta_p^2 = .08$, showing that patterns in each gender resemble the main effects: novel artifacts promoted more incorrect names than familiar artifacts when boys and girls were analyzed separately, $t(29) = -4.54$, $p = .000$, $r = .64$, boys; $t(28) = -3.34$, $p = .002$, $d = -1.10$, girls. There were no significant effects when analyses were performed separately for familiar and novel artifacts (all ps > .08).

Name-part. This category included questions and statements on the names of the artifacts' parts. No analyses were run on questions codes due to a lack of entries. The ANOVA performed on statements indicated a main effect for Complexity, indicating that complex artifacts produced more name-part statements than simple artifacts ($p < .01$). There was no main effect for Familiarity ($p > .20$).

Lastly, there was a significant interaction between Familiarity and Complexity, $F(1, 58) = 5.77$, $p < .02$, $\eta_p^2 = .09$. Novel complex artifacts yielded more statements than novel simple artifacts, $t(58) = 3.32$, $p = .002$, $d = .72$; more than familiar complex artifacts, $t(58) = 2.11$, $p = .039$, $d = .40$; and more than familiar simple artifacts, $t(58) = 2.64$, $p = .01$, $d = .49$.

Context of use. This category included questions and statements about when or where to use the artifacts (e.g., "you can bring it to school"). The analysis was run only at a global level, that is, it included Correct (e.g., "you can bring scissors to school") and Incorrect Appropriate statements (e.g., "you use it in music class" for coin sorter that looks like a ratio) because there were too few entries in each of these separate subcodes. There were no Incorrect Inappropriate entries. Again, due to a lack of codes in questions, the ANOVA was only performed on statement entries. The results indicated a main effect for Familiarity, such that familiar artifacts yielded more context of use statements than novel artifacts ($p < .01$). There was no main effect for Complexity ($p > .40$) or significant interactions (all ps > .20).

Why-part. This category included questions such as "Why does it have this part?". The ANOVA yielded a main effect for Complexity, such that complex artifacts produced more of this question type than simple artifacts ($p < .05$). Although there was no main effect for Familiarity (p

> .65), there was a main effect for Age ($p < .05$), such that 4-year-olds produced more why-part questions than 3-year-olds ($p < .03$), but not significantly more than 5-year-olds ($p > .60$). There were no significant interactions (all ps >.12).

Statements-only categories. The following categories do not apply to questions because they are only observable in statement format.

Personal experience. This category included statements about ownership, personal stories, and liking or disliking the artifacts. The analysis yielded a main effect for Familiarity, such that familiar artifacts produced significantly more personal experience statements than novel artifacts ($p < .01$). There was no main effect for Complexity ($p > .10$) and there were no significant interactions (all ps >.10).

Analogies global. This category included analogies to familiar artifacts. The analysis yielded a main effect for Familiarity, such that novel artifacts produced significantly more analogy statements than familiar artifacts ($p < .05$). There was no main effect for Complexity ($p > .60$) and there were no significant interactions (all ps >.10).

Ambiguous "I don't know." This category included "I don't know" ambiguous statements. There were no main effects for Familiarity or for Complexity (ps > .20), but there was a significant interaction effect for Familiarity by Complexity, $F(1, 58) = 6.61$, $p < .02$, $\eta_p^2 = .10$. Novel simple and familiar complex artifacts produced more ambiguous "I don't know" statements than familiar simple artifacts, $t(58) = -2.02$, $p=.048$, $d=-.29$, novel-simple, $t(58) = 2.62$, $p=.011$, $d=.36$, familiar-complex. Familiar complex, novel complex, and novel simple artifacts did not differ significantly (all ps > .09).

Knowledge optimism "I know all about it." This category included knowledge optimism statements such as "I know all about scissors". The ANOVA yielded a significant main effect for Familiarity, such that familiar artifacts produced significantly more knowledge optimism statements than novel artifacts ($p <.02$). There was no main effect for Complexity ($p >.20$).

However, there was a significant interaction effect for Familiarity by Complexity, $F(1, 58) = 4.95$, $p < .04$, $\eta_p^2 = .08$. Familiar simple artifacts produced significantly more of this statement type than both novel complex artifacts, $t(58) = -2.38$, p=.021, d= - .39, and novel simple artifacts, $t(58) = -2.66$, p=.01, d=-.45. Familiar simple artifacts also tended to produce more of this code than familiar complex artifacts, $t(58) = -1.84$, p=.071, r=-.38. Similarly, familiar complex artifacts produced more "I know all about it" statements than both novel complex artifacts, $t(58) = 2.19$, p=.033, d=.29, and novel simple artifacts, $t(58) = -2.69$, p=.009, d=-.39.

Special analyses.

The role of appearance in inferences about novel artifacts. As seen in the major categories section, appearance did not emerge as a main category in questions, and emerged only as trends amongst children's statements. Nonetheless, when children inferred about an artifact's name or function they could have drawn from the object's appearance. Aiming to investigate this assumption about novel artifacts, the codes Incorrect-Appropriate and Incorrect-Inappropriate were discriminated and compared. This analysis excluded familiar artifacts not only because the questions posited is more relevant to unknown artifacts, but also because there were only 3 instances of Incorrect-Appropriate codes for familiar artifacts. As a reminder, incorrect utterances that were adequate in terms of the object's resemblance to a familiar artifact were coded as Appropriate ("How does it play songs?" for coin sorter that looks like a radio). Those that were inadequate or illogical according to the object's appearance were coded as Inappropriate. See table 17 for F-values, effect sizes, and means for the following analyses.

In order to make the analysis overarching, questions and statements were combined (proportions were calculated over the total number of question codes plus statement codes), and Incorrect-Appropriate codes of name-whole, function-whole, function-part, mechanism-whole and mechanism-part were collapsed. The same reduction was done with Incorrect-Inappropriate codes. This analysis only considered novel artifacts, thus a mixed 3 (Age) X 2 (Gender) X 2 (Complexity) X 2 (Appropriateness) ANOVA was performed with Complexity and Appropriateness as within-subjects factors.

Results indicated an Appropriateness main effect, such that appropriate utterances were more common than inappropriate utterances ($p < .001$). There was no complexity main effect (p > .10). However, there was a strong trend for an interaction between Gender and Age, $F(2, 50) = 3.13$, $p = .052$, $\eta_p^2 = .11$. Four-year-old girls ($M = .07$, $SD = .07$) tended to produce more incorrect statements than 4-year-old boys ($M = .03$, $SD = .04$), $t(27) = -1.90$, $p = .069$, $d = -.71$. In contrast, 5-year-old boys ($M = .07$, $SD = .04$) tended to produce more incorrect statements than 5-year-old girls ($M = .03$, $SD = .03$), $t(11) = 2.02$, $p = .069$, $d = 1.24$.

Next, name-whole utterances were removed from the analysis, leaving only incorrect utterances about function and mechanism. Results again indicated an Appropriateness main effect, such that appropriate utterances were more common than inappropriate utterances ($p < .02$). Differing from the previous analysis, there was a Complexity main effect, indicating that simple objects yielded more incorrect utterances than complex objects ($p < .02$).

Finally, there was a significant interaction between Complexity and Appropriateness, $F(1, 55) = 14.61$, $p < .001$, $\eta_p^2 = .21$. Simple objects produced more appropriate utterances ($M = .01$, $SD = .02$) than inappropriate utterances ($M = .001$, $SD = .01$), $t(55) = 3.66$, $p = .001$, $d = .59$, whereas no such difference was found for complex objects. Moreover, there was a strong non-significant trend suggesting that simple objects ($M = .01$, $SD = .02$) produced more appropriate utterances than complex objects ($M = .01$, $SD = .01$), $t(55) = -1.97$, $p = .054$, $d = -.26$.

Initial Question: Ambiguous-Whole versus Function-Whole.

The two most popular categories in children's inquiries about artifacts were ambiguous-whole (e.g., "What is it?") and function-whole (e.g., "How does it work?") questions. To analyze the possible relationship between these categories further, analyses contrasting these two kinds of questions were performed on the first-question children asked for each object. In other words, in this analysis only ambiguous-whole codes that were initial questions for each object were considered, and only function-whole codes that were initial questions for each object were considered. See table 18 for F-values, effect sizes, and means for the following analysis.

A 3 (Age) x 2 (Gender) x 2 (Familiarity) x 2 (Complexity) x 2 (First-question type: ambiguous-whole versus function-whole) mixed ANOVA, with Familiarity, Complexity, and First-question type as within-subjects factors was performed. Results revealed a Familiarity main effect indicating that novel artifacts produced more ambiguous-whole first and function-whole first questions ($p < .001$). There was also a non-significant trend for a Complexity main effect suggesting that complex artifacts yielded more of these types of first questions than simple artifacts ($p = .078$). In addition, there was a main effect for First-question type, such that ambiguous-whole first-questions were more common than function-whole first-questions ($p < .002$).

Interestingly, the analysis yielded an interaction between Familiarity and First-question type, $F(1, 57) = 43.97$, $p < .001$, $\eta_p^2 = .44$. Novel artifacts promoted more ambiguous-whole initial questions ($M = .20$, $SD = .20$) than function-whole ($M = .04$, $SD = .07$), $t(57) = 5.46$, $p = .000$, $d = .74$. Familiar artifacts did not yield such significant difference ($p > .11$). Lastly, ambiguous-whole initial questions were more common for novel artifacts ($M = .20$, $SD = .20$) than for familiar artifacts, ($M = .03$, $SD = .07$), $t(57) = -7.49$, $p = .000$, $d = 1.20$.

Discussion

The main goal of this study was to investigate how children acquire, organize, and prioritize knowledge about artifacts. I aimed to get a broader picture of children’s conceptual map of artifacts by showing them images of different object types across two layers of differentiation: familiarity (novel, familiar) and complexity (simple, complex).

Hypotheses were generated to test whether: (a) the hybrid model better explains children's artifact conceptualization: there is an interaction between form and function, although function is truly the essence of artifacts and directs the interaction; (b) novel artifacts yield more utterances about function and analogies than familiar artifacts; (c) familiar artifacts, because functional information is already known, yield more utterances about appearance, context of use, appropriate user, and personal experience, and more specialized and detailed questions about function; (d) complex artifacts yield more utterances than simple artifacts; (e) older children produce more utterances about intended design, ownership, and user identity; and younger children produce more utterances about current use and appearance.

Hypothesis (a): The Hybrid model. Results underscore the hypothesis that function is the backbone of artifact conceptualization (Bloom, 1998; Keil, 1989; Booth & Waxman, 2002; Miller & Johnson-Laird, 1976; Rips, 1989). This is supported by the fact that when all codes are combined (questions and statements), function-whole emerges as the most popular type of utterance, significantly more frequent than all other codes. It is noteworthy that these results are conservative considering that function-whole and function-part codes were not combined. Therefore, the finding that only function-whole codes appeared significantly more than all other codes is impressive.

When questions are analyzed separately, consistent with question-asking literature on objects (e.g., Kemler Nelson et al., 2004; Kemler Nelson & O'Neil, 2005; Greif et al., 2006), the most common question asked was "What is it?". Inquiries about function of the whole object were the second most popular type of question, significantly more common than all other codes. In terms of statements, function-whole remarks were the second most common type of remark, only behind objects' names, although not significantly more common than personal experience, appearance statements, and "I don't know".

The conclusion that function, and not appearance nor shape is at the core of children's artifact conceptualization does not, by any means, neglect the important role played by appearance. On the contrary, the results showed that incorrect utterances about function and category name were related and logical according to the objects' appearance and this underscores the hybrid model outlined in the introduction of this paper (e.g., Gelman & Coley, 1990; Gelman & Markman, 1986; Gopnik & Meltzoff, 1997; Kemler Nelson et al., 1995). This model posits that both appearance and function can influence children's artifact categorization and that children are sensitive to function/form correlations. When faced with a novel object, children may attend to familiar affordances to infer its category. Therefore, there is a clear interaction between form and function, although the latter may be the driving force, as showed by the higher proportion of codes under the function category.

Furthermore, other results also support the above claim that children make sense of causal relation between surface features and function of an artifact. Novel complex artifacts, although unknown, display several familiar parts (e.g., road builder has buttons and wheels) that cue children on their correct function and mechanism (e.g., road builder moves). As an illustration, "It moves on the streets" for road builder is a correct function-whole statement probably triggered by the presence of wheels. Children, on the other hand, cannot rely on such cues when it comes to novel simple artifacts (e.g., garlic shredder has no parts at all), thus they are left unable to make any inference. This is supported by the following findings: (1) children are more likely to state incorrect function-whole statements for novel simple artifacts, while there was no significant difference between correct and incorrect function-whole statements for novel complex artifacts; (2) familiar complex and novel complex artifacts did not differ significantly in the proportions of incorrect function-whole statements, while novel simple artifacts promoted more incorrect statements than familiar simple artifacts; (3) while correct and incorrect questions about function-part were at chance for simple artifacts, more correct than incorrect function-part questions were asked for complex artifacts. In sum, rather than focus on shallow perceptual appearances, children seem to target essential qualities in artifact categorization and how they correlate with surface properties.

As a final thought, several previous studies reported that shape is central to young children's artifact categorization, and that function only becomes relevant later in development (e.g., not until about 6 years old) (e.g., Gathercole & Whitfield, 2001; Graham et al., 1999; Malt & Johnson, 1992; Merriman et al., 1993; Smith, Jones, & Landau, 1996). Other studies reported that although function is central to young children's conceptualization, it becomes even more central to older preschool children (Baldwin, 1994; Deak et al., 2002; Kemler Nelson, 1995; Kemler Nelson, Frankenfield et al., 2000). The present study did not find strong age differences in the centrality of function, children as young as 3 years of age viewed function as central to artifact conceptualization. As it will be described later (see hypothesis (d)), the sensitivity of objects parts was the only developmental pattern observed.

Hypothesis (b) and (c): Familiar versus novel artifacts. Overall, novel artifacts yielded more questions than familiar artifacts, but fewer statements than familiar artifacts. This obviously occurred because children's current knowledge framework for novel artifacts is less extensive. Familiar objects may produce more knowledge-based statements because children have more experience with those artifacts. Therefore, children are more likely to detect and talk about relevant features (Canham & Hegarty, 2010; Gibson, 1969; Gibson & Gibson, 1955; Haider & Frensch, 1999).

Contrary to my hypothesis, novel artifacts did not produce more function utterances than familiar artifacts. There were no significant differences in the proportions of function questions for novel and familiar artifacts, and familiar artifacts produced more function statements than novel artifacts. This indicates that even when basic function is already known, children still seek out more functional information, corroborating the hypothesis of function as the essence of artifact conceptualization.

Nonetheless, there were important differences in the characteristics of function questions produced by novel and familiar artifacts. It is relevant to recall the anticipation that children just as they create first global categories such as animal and artificial things, to then differentiate more specific categories such as dogs, cats, tools, and furniture (e.g., Mandler, 2000), might do the same with artifacts' function. That is, first they seek to understand its broad function and then subsequently scale down for more detailed information. Moreover, as proposed by the literature, the level of differentiation of an expert in a domain is much higher than that of a novice (Canham & Hegarty, 2010; Lesgold, Rubinson, Feltovich, Glaser, Klopfer, Wang, 1988). Thus, as experience with objects increase, children should shift from general to specific and more differentiated inquiries. This was precisely what the results showed: function-whole questions for novel artifacts were more general (e.g., What does it do?), whereas for familiar artifacts they were more specific (e.g., How does it fly?). To further corroborate this argument, results also demonstrated that ambiguous-whole initial inquiries, which are extremely general and undifferentiated, were more common than function-whole initial inquiries for novel artifacts, but not for familiar objects.

As expected, novel artifacts yielded more "What is it?" questions, more analogies to known artifacts, and less "I know all about it", than familiar artifacts. This is in line with the literature in how expertise develops (Blair & Somerville, 2009; Chase & Simon, 1973; Chase & Ericsson 1980, 1982; Ericsson & Kintsch, 1995; Gobet & Simon, 1996, 1998; Holding, 1992). When children are presented with a completely novel object, the pre-existing conceptual connections may be weak and few in number, which explains non-specific questions such as "What is this?" and fewer remarks such as "I know all about it". Moreover, expertise development involves taking into account that changes in memory representations and in perceived similarity are concomitant elements of increasing differentiation, which explains more frequent analogies to known objects. As an illustration, when children saw the crullet (rocking chair) they had no pre-existing information encoded in memory about it, but when they discovered that it rocked back and forth when one sat on it, they were able to connect this new information with current connections in their cognitive system about rocking chairs (a familiar object).

Moving on to familiar artifacts, the emergence of two distinct patterns was anticipated; (1) because in familiar artifacts the essence (i.e., function) is already known, there would be a shift from questions about function to more secondary features such as appearance, and context of use; and/or (2) more detailed and specialized inquiries about function, which was already discussed in hypothesis (a).

Although familiar artifacts indeed promoted more context of use, personal experience, and appearance statements than novel artifacts, these remarks were definitely a minority when compared to function categories. Moreover, these were always statements; in other words, children were talking about these categories but not seeking information about them. Perhaps, when learning about artifacts young children are more concerned about their function and how they work, while secondary categories such as context of use and appropriate user are not as salient but are learned naturally after direct experience with the artifacts. To add to this argument, as stated earlier, specificity in function questions is higher with familiar than with novel artifacts. Thus, the findings so far discussed give more support to the second pattern than the first: children seek more detailed information about function as familiarity grows.

Hypothesis (d): Complex versus simple artifacts. It was hypothesized that complex artifacts, because they have more affordances, would yield more utterances than simple artifacts. Results partially corroborated this prediction. Complex artifacts indeed produced more questions than simple artifacts, but did not significantly produce more statements than simple artifacts. In fact, the interaction between Familiarity and Complexity indicated that familiar simple objects yielded more statements than familiar complex artifacts.

These findings might be explained by the differing nature of the questions and statements. Questions represent gaps in children's knowledge, thus it makes sense that objects' with more parts would be associated with more "gaps". Statements, on the other hand, represent pieces of knowledge children already have, thus it makes sense that objects that are familiar and that contain less parts would display less gaps. It is also possible that children just talked about simple artifacts, because they could not think of many questions. This latter explanation is supported by the findings that (1) name-whole and function-whole codes accounted for this higher proportion of statements for familiar simple artifacts; (2) statements such as "I know all about it" were more common for familiar simple than other types of objects presented; (3) familiar simple artifacts seemed to produce less "I don't know" statements than the other types of objects.

Furthermore, the question types produced by complex artifacts in greater abundance than simple artifacts, are all about parts: What's this part", why-part, and function-part questions. This underscores the justification that the reason why complex objects would yield more inquiries was due to their higher number of affordances, which pique children's curiosity. Similarly, in terms of statements, name-part remarks were more common for complex than for simple artifacts. Interestingly, novel complex artifacts produced significantly more name-part statements than all other types of artifacts. This may have occurred because children were relying on familiar cues to derive the objects' categories, therefore while staring at the unknown object they would say out loud what they were able to recognize in an attempt to make more accurate inferences.

One interesting pattern, although not predicted in the hypotheses, concerns appearance codes. Appearance questions and statements, similarly to Study 1, were more common for simple than for complex artifacts, especially for familiar artifacts. In addition, familiar simple artifacts yielded more appearance statements than novel simple artifacts. This argument is developed further in the General Discussion.

Moreover, some findings suggest that older and more experienced children become more sensitive to an object's affordances (as also seen in Study 1). Nonetheless, this is not conclusive considering that these differences were not found ubiquitously in all age groups, and sometimes were limited to one gender. For example, 4-year-olds produced more why-part questions than 3 year-olds, but not more than 5-year-olds. Moreover, 5-year old girls asked more ambiguous-part questions (e.g., What is this part?) than younger girls, but the same was not found for boys.

In addition, 5 year-old girls asked more ambiguous-part questions than 5-year old boys. A plausible explanation is that older boys already know more about object parts than girls. This is supported by Study 1 results, which showed that boys talked more about parts' functions than girls. Also, the fact that 4-year-old boys asked more questions about function-part than 4-year-old girls, especially for complex artifacts, suggests that boys are indeed more attentive to objects' parts than girls.

Hypothesis (e): Developmental Patterns. It was predicted that older children would produce more utterances about ownership, and user identity; and younger children produce more utterances about appearance. The results did not support this hypothesis. One possible interpretation is that, as mentioned before, those categories were not major types of utterances produced by children, which may have prevented the delineation of clear developmental patterns. In addition, these findings also substantiate the argument that function was central to artifact conceptualization to all age groups, and that those aforementioned categories were secondary.

In line with Study 1, but contrary to my prediction that older children would produce more utterances about intended design and younger children would yield more utterances about current design, all age groups produced more current design questions and statements for function- whole. In addition, current use statements were more common than intended use statements for function-part, although this difference was not significant difference for questions. These findings are developed further in the General Discussion.

CHAPTER 6

GENERAL DICUSSION AND PROJECT LIMITATIONS

The present project contributes to the extant literature on young children's conceptualization of manmade objects by exploring not only novel artifacts, as most studies in the field, but also familiar objects. Another innovation was the inclusion of complex and simple objects, adding complexity as a second layer of differentiation, in addition to familiarity.

My main hypothesis held that young children, when conceptualizing artifacts, instead of only taking into account shallow perceptual appearance cues such as shape (as proposed by Gathercole & Whitfield, 2001; Gentner, 1978; Graham et al., 1999; Malt & Johnson, 1992; Merriman et al., 1993; Smith, Jones, & Landau, 1996; Tomikawa & Dodd, 1980), would privilege deep abstract core inferences about causal and functional properties of objects (as proposed by Bloom, 2000; Diesenduck et al., 2003; Gelman & Coley, 1990; Greif et al., 2006; Kemler Nelson et al., 2004; Kemler Nelson, Frankenfield, et al., 2000; Kemler Nelson et al., 2003; Kemler Nelson et al., 2002; Kemler Nelson & O'Neil , 2005; Kemler Nelson, et al., 2008). I argued that functional information, which is more reliable and carries greater predictive power than appearance, would be the essence of artifact categorization. I, nonetheless, acknowledged that appearance would play a role in artifacts' categorization, although a secondary one. In other words, children are sensitive to form/function correlations, in the sense that an artifact's function directs children's attention to the affordances of the object that support such a function.

Both studies clearly demonstrated that function was the driving force of artifact conceptualization: utterances about function were more common than all other types of codes independent of object type (except in Study 2 where ambiguous-whole codes were more common when only questions were considered). Furthermore, Study 2 results suggest that in the case of familiar artifacts, when the function-gap is already filled, children seek out even more specific function information. Nonetheless, as demonstrated by higher proportions of incorrect utterances that are logical according to the object's appearance, children are sensitive to function/form correlations.

Appearance, however, did not emerge as a primary category in either study. Curiously, appearance codes were more common to simple artifacts in both studies. It could be that in absence of parts, which may allow children to talk about their names and functions, the next most appealing subject was appearance. Also, the finding that familiar simple objects yielded more appearance utterances than novel simple artifacts reinforces the argument of appearance as a secondary theme when nothing else is left (i.e., when the child's knowledge framework is more substantial for familiar simple artifacts than for novel simple artifacts). To be fair, these findings can also be explained by the fact that most familiar simple artifacts in the stimuli set had more appearance details to refer to than other types of artifacts. For example, the toothbrush had a frog on the handle, the scissors' thumbholes had two different colors (which was always noted as unusual), and the cowboy hat (used in Study 1) had a star on it.

Another interesting pattern emerged for intuitions about current and intended use. Research on how children conceptualize function in terms of current use or intended use leads us to believe that as children grow older the intended use stance becomes more entrenched, becoming fully developed at age six (Defeyter & German, 2003; German & Barret, 2005; German & Defeyter, 2000; Kelemen & Carey, 2007). Taking this into account, I predicted that older children would produce more utterances about intended design and younger children more utterances about current design. Nonetheless, in both studies, current use utterances were more common than intended use utterances in all age groups, except for function-part questions in Study 2, which yielded no significant differences between the two formats.

It is difficult to unravel whether these results reflect young children’s immunity to intended design as core to their artifact conceptions or if these findings are purely a product of a language barrier. Maybe saying “it flies” is easier than saying “it is for flying”, but that does not necessarily mean that on a covert and deeper level, children are not reasoning about artifacts in terms of their original intended use. Furthermore, all 5-year-old participants were at the most 5 years and 2 months old; it is possible that intended design would be more frequent if older 5-year olds were included. This limitation does not only apply to this issue, in fact, perhaps no stronger development patterns were found for other codes due to a strict range of very young 5-year olds.

One limitation to interpreting these results concerns the uncertainty around the purpose of the children's questioning of familiar artifacts: did the questions really reflect their knowledge gaps, or were they only complying with the proposed question-asking game? If children did indeed know the answer to some questions and were only playing along with the game, this does not preclude the validity of the results, considering that the findings still mirror what children deem most important when conceptualizing artifacts. Nonetheless, the levels of specificity of the questions suggest that children’s inquiries on familiar artifacts did in fact reflect missing knowledge from their current concept structure.

Finally, this project demonstrated that child-initiated paradigms are a powerful tool to understand how children make sense of the things present in their environment. The open-ended character of such a methodology allows for a non-biased design that reflects what types of information children understand as most valuable to acquire, in the case of questions, or to share, in the case of statements.

APPENDICES

Table 1

Average Means and Average Modes of Total Validation Stimuli

Category Type	Familiarity Score		Complexity Score	
	Mode	Mean	Mode	Mean
Familiar Simple	7	6.89	1.05	1.38
Familiar Complex	7	6.81	3.73	3.79
Novel Simple	1.58	2.59	2.04	2.64
Novel Complex	1.18	2.32	5.06	4.86

Table 2

Study 1: Distribution of Participants by Game Grid Arrangement

Age	Grid A	Grid B	Grid C	Grid D
3	3	4	4	3
4	3	1	4	3
5	0	1	1	1
Total	6	6	9	7

Table 3

Study 1: Average Means and Average Modes of Stimuli

Category Type	Familiarity Score		Complexity Score	
	Mode	Mean	Mode	Mean
Familiar Simple	7	6.94	1	1.48
Familiar Complex	7	6.9	4.5	4.38

Note. Table does not include training artifacts.

Table 4

Coding System: Code Categories and Examples

Category Code Name	Example	Format		Incorrect Appropriate/ Inappropriate	Part
		Question	Statement		
Ambiguous	What's this?	Yes	No	No	Yes
Ambiguous lack of knowledge	I don't know.	No	Yes	No	No
Name	What is this called? / That's the pedal. It's a bike.	Yes	Yes	Yes	Yes
Function current use general	What does it do?	Yes	No	No	Yes
Function intended use general	What is it for?	Yes	No	No	Yes
Function current use specific	Does it fly really high? / It flies really high.	Yes	Yes	Yes	Yes

Table 4 *(continued)*

Category Code Name	Example	Format		Incorrect Appropriate/ Inappropriate	Part
Function intended use specific	Is for cutting? / This is to cut paper.	Yes	Yes	Yes	Yes
Mechanism general	How does it work?	Yes	No	No	Yes
Mechanism specific	How does it fly? / You run with it, and let it go, then it flies.	Yes	Yes	Yes	Yes
Function/mechanism	Does the pinwheel spin? / The pinwheel spins with the wind.	Yes	Yes	Yes	Yes
Why function	Why does it fly?	Yes	No	Yes	Yes
Why part	Why does it have this here?	Yes	No	No	Yes
Appearance	Why is it curvy like that? / There is a froggy on the toothbrush.	Yes	Yes	No	No
Context of use	When / where do you use it?/ You brush your teeth before going to bed.	Yes	Yes	Yes	No
Appropriate user	Who uses this? / Mommys use it to clean the floor.	Yes	Yes	Yes	No
Personal Experience	I had one, but it broke./ I really like to fly kites. / I will get one for my birthday.	No	Yes	No	No
Analogy to familiar artifact	*Crullet* - It looks like toothpaste.	No	Yes	No	No
Other (e.g. manufacture, safety, damage, non-codable, animal)	How do you make one? / You have to be careful with scissors. / How does it not break?	Yes	Yes	No	No

Note. The column "Format" indicates if the category code was assigned to question and/or statement. The column "Incorrect Appropriate / Inappropriate" indicates if the category code was differentiated between Incorrect-Appropriate and Incorrect-Inappropriate. The column "Part" indicates if the category code was differentiated for whole and part.

Table 5

Study 1: Frequencies and Proportions by Category Code

Category Code	Questions				Statements			
	Complex		Simple		Complex		Simple	
	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.
Ambiguous whole	3	.03	2	.02	--	--	--	--
Ambiguous part	18	.16	5	.04	--	--	--	--
Function whole global	19	.16	12	.10	215	.17	187	0.14
Function part global	10	.09	5	.04	76	.06	24	0.02
Appearance	6	.05	16	.14	43	.03	89	0.07
Name Whole	5	.04	0	.00	119	.09	104	0.08
Name Part	3	.03	0	.00	73	.06	19	0.01
Context of Use	0	.00	0	.00	20	.02	31	0.02
Why part	3	.03	2	.02	--	--	--	--
Why function	0	.00	0	.00	--	--	--	--
Personal experience	--	--	--	--	41	.03	32	0.02
Appropriate User	2	.02	0	.00	19	.01	14	0.01
Analogies	--	--	--	--	1	.001	1	0.00
"I don't know"	--	--	--	--	39	.03	37	0.03
I know all!	--	--	--	--	0	.00	0	0.00
Other	1	.01	4	.03	58	.04	54	0.04
Total	70	.60	46	.40	704	.54	592	.46

Note. There were incorrect questions, and only one function incorrect statement, which is not shown. There were no name whole incorrect questions or utterances. Dashes (--) mean that there is no such category for that particular utterance type (i.e., questions or statement).

Fr. = Frequency and Pr. = Proportion.

Table 6

Study 1: Mean Frequencies of Statements Codes by Age Group

Age	*M*	
Younger	43.5	(18.16)
Older	48.93	(19.42)
Total	46.21	(18.66)

Note. Standard Deviations are in parenthesis.

Table 7

Study 1: Mean Proportions of Codes by Major Category

Category	*M*	
Function Whole	.31	(.18)
Category Name	.20	(.12)
Appearance	.09	(.12)
Function Part	.08	(.11)
Name Part	.07	(.08)

Note. Standard Deviations are in parenthesis.

Table 8

Study 1: Analyses of Variance for Statements

Code Type	Main Effect	*df*	*F*	η_p^2	*p*	*M*		
Current vs. Intended Use Whole	Current vs. Intended Use	(1, 27)	61.42**	.70	.000	CU	.18	(.11)
						IU	.01	(.01)
Current vs. Intended Use Part	Current vs. Intended Use	(1, 27)	5.23	.16	.03	CU	.03	(.07)
						IU	.01	(.02)
Artifact Type	Complexity	(1, 26)	7.85**	.23	.009	CX	.55	(.09)
						SP	.45	(.09)
Function Whole	Complexity	(1, 27)	3.88	.13	.059	CX	.16	(.11)
						SP	.14	(.09)
Function Part	Complexity	(1, 20)	21.91**	.52	.000	CX	.06	(.08)
						SP	.02	(.04)
	Age	(1, 20)	6.43*	.24	.02	Y	.03	(.04)
						O	.13	(.14)
Category Name	Complexity	(1, 20)	2.52	.11	.13	CX	.11	(.07)
						SP	.09	(.05)
	Age	(1, 20)	4.34	.18	.05	Y	.24	(.14)
						O	.15	(.06)
Appearance	Complexity	(1, 24)	12.14*	.34	.002	CX	.03	(.05)
						SP	.07	(.08)
Name Part	Complexity	(1, 27)	13.94**	.34	.001	CX	.06	(.06)
						SP	.02	(.03)
Context of Use	Complexity	(1, 20)	3.32	.14	.08	CX	.01	(.03)
						SP	.02	(.03)
Appropriate User	Complexity	(1, 27)	1.15	.04	.29	CX	.01	(.03)
						SP	.01	(.02)
Personal Experience	Complexity	(1, 27)	1.3	.05	.26	CX	.03	(.05)
						SP	.02	(.04)
"I don't know"	Complexity	(1, 27)	.97	.04	.33	CX	.04	(.07)
						SP	.03	(.05)

Note. Standard Deviations in parenthesis. CX = complex; SP = simple, CU = current use; IU = intended use; Y = younger; O = older. *p <.05. **p <.01

Table 9

Study 1: Interaction Means for Statements

Code Type	Interaction	Subsample		*M*	
Artifact Type	Com*Gender	CX	B	.58	(.09)
			G	.51	(.07)
		SP	B	.42	(.09)
			G	.49	(.07)
Function Part	Com*Age	CX	Y	.02	(.03)
			O	.10	(.09)
		SP	Y	.01	(.01)
			O	.04	(.05)
	Com*Gender	CX	B	.08	(.09)
			G	.03	(.05)
		SP	B	.03	(.05)
			G	.01	(.02)
	Com*Age*Gender*CTN	B, Y, CX	NKC	.01	(.02)
			KC	.05	(.03)
		B, Y, SP	NKC	.01	(.02)
			KC	.01	(.02)
		B, O, CX	NKC	.17	(.08)
			KC	.10	(.11)
		B, O, SP	NKC	.05	(.08)
			KC	.04	(.06)
Appearance	Age*Gender	B	Y	.04	(.03)
			O	.11	(.13)
		G	Y	.18	(.16)
			O	.04	(.04)

Note. Standard Deviations are in parenthesis. CX = complex; SP = simple; Com = complexity; Fam = familiarity; B = boys; G: girls; Y = younger; O = older, CTN = condition; NKC = without KC, KC = with KC.

Table 10

Study 2: Distribution of Participants by Game Grid Arrangement

Age	Grid A	Grid B	Grid C	Grid D	Grid E	Grid F	Grid G	Grid H
3	3	1	3	2	3	3	2	2
4	3	5	3	5	2	3	3	5
5	1	1	2	1	3	1	2	2
Total	7	7	8	8	8	7	7	9

Table 11

Study 2: Average Means and Average Modes of Stimuli

Category Type	Familiarity Score		Complexity Score	
	Mode	Mean	Mode	Mean
Familiar Simple	7	7	1	1.45
Familiar Complex	7	6.87	5.33	4.79
Novel Simple	1	1.77	1	1.87
Novel Complex	1	1.63	5.67	5.27

Note. The table does not include training pictures

Table 12

Study 2: Frequencies and Proportions by Category Code

Category Code	Questions								Statements							
	Familiar				Novel				Familiar				Novel			
	Complex		Simple		Complex		Simple		Complex		Simple		Complex		Simple	
	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.
Ambiguous whole	16	.01	8	.01	117	.09	134	.10	--	--	--	--	--	--	--	--
Ambiguous part	37	.03	19	.01	87	.07	19	.01	--	--	--	--	--	--	--	--
Function whole																
Global	87	.07	70	.05	91	.07	96	.07	67	.06	96	.09	11	.01	8	.01
General	20	.02	11	.01	58	.04	52	.04	--	--	--	--	--	--	--	--
Specific	67	.05	59	.04	33	.02	44	.03	--	--	--	--	--	--	--	--
Correct	67	.05	59	.04	24	.02	24	.02	66	.06	96	.09	2	.002	0	.00
Incorrect appropriate	0	.00	0	.00	6	.005	18	.01	1	.001	0	.00	8	.01	8	.01
Incorrect inappropriate	0	.00	0	.00	3	.002	2	.002	0	.00	0	.00	1	.001	0	.00

Table 12 (Continued)

Category Code	Questions								Statements							
	Familiar				Novel				Familiar				Novel			
	Complex		Simple		Complex		Simple		Complex		Simple		Complex		Simple	
	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.
Function part																
Global	36	.03	11	.01	51	.04	10	.01	25	.02	9	.01	9	.01	0	.00
General	15	.01	8	.01	27	.02	8	.01	--	--	--	--	--	--	--	--
Specific	21	.02	3	.002	24	.02	2	.002	--	--	--	--	--	--	--	--
Correct	21	.02	3	.002	23	.02	0	.00	25	.02	8	.01	7	.01	0	.00
Incorrect appropriate	0	.00	0	.00	1	.001	2	.002	0	.00	1	.001	2	.002	0	.00
Incorrect inappropriate	0	.00	0	.00	0	.00	0	.00	0	.00	0	.00	0	.00	0	.00
Appearance	11	.01	49	.04	21	.02	25	.02	19	.02	51	.05	18	.02	25	.02
Name Whole																
Global	3	.002	1	.001	8	.01	10	.01	95	.09	123	.12	26	.02	24	.02
Correct	--	--	--	--	--	--	--	--	95	.09	122	.11	2	.002	0	.00
Incorrect appropriate	--	--	--	--	--	--	--	--	0	.00	1	.001	24	.02	23	.02
Incorrect inappropriate	--	--	--	--	--	--	--	--	0	.00	0	.00	0	.00	1	.001
Category Guess	3	.002	0	.00	6	.003	6	.01	--	--	--	--	--	--	--	--
Name Part	1	.001	2	.002	3	.002	2	.002	15	.01	11	.01	30	.03	9	.01

Table 12 (Continued)

Category Code	Questions								Statements							
	Familiar				Novel				Familiar				Novel			
	Complex		Simple		Complex		Simple		Complex		Simple		Complex		Simple	
	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.	Fr.	Pr.
Context of Use																
Global	2	.002	5	.004	3	.002	3	.002	8	.01	12	.01	2	.002	0	.00
Correct	2	.002	5	.004	2	.002	3	.002	8	.01	12	.01	0	.00	0	.00
Incorrect appropriate	0	.00	0	.00	1	.001	0	.00	0	.00	0	.00	2	.002	0	.00
Why part	62	.05	39	.03	53	.04	32	.02	--	--	--	--	--	--	--	--
Why function	7	.01	10	.01	5	.004	6	.004	--	--	--	--	--	--	--	--
Personal experience	--	--	--	--	--	--	--	--	38	.04	50	.05	5	.01	10	.01
Analogies	--	--	--	--	--	--	--	--	13	.01	0	.00	18	.02	23	.02
"I don't know"	--	--	--	--	--	--	--	--	36	.03	23	.02	32	.03	37	.04
I know all!	--	--	--	--	--	--	--	--	11	.01	16	.02	4	.004	1	.001
Other	17	.01	17	.01	12	.01	21	.02	22	.02	16	.02	13	.01	9	.01
Total	282	.21	231	.17	457	.34	364	.27	349	.33	407	.38	168	0.16	146	0.14

Note. Dashes (--) mean that there is no such category for that particular utterance type (i.e., questions or statement). Fr. = Frequency and Pr. = Proportion.

Table 13

Study 2: Mean Frequencies of Codes by Age Group

Age	Questions		Statements		Total	
3	12.81	(5.54)	17.53	(8.02)	31.50	(9.03)
4	22.66	(14.05)	18.03	(11.99)	41.00	(18.24)
5	34.62	(24.81)	19.15	(12.35)	54.46	(27.22)
Total	22.62	(17.16)	18.14	(10.91)	41.75	(20.39)

Note. Standard Deviations are in parenthesis.

Table 14

Study 2: Mean Proportions of Codes by Major Category

Category	Questions		Statements	
Ambiguous Whole	.33	(.30)	--	--
Function Whole	.27	(.26)	.14	(.12)
Category Name	--	--	.27	(.20)
"I don't know"	--	--	.13	(.23)
Personal Experience	--	--	.10	(.12)
Why Part	.09	(.19)	--	--
Ambiguous Part	.09	(.19)	--	--
Appearance	--	--	.08	(.11)
Name Part	--	--	.06	(.10)
Function Part	.06	(.08)	--	--

Note. Standard Deviations are in parenthesis. Dashes (--) mean that it was not a major category for that type of utterance (i.e., questions, statements).

Table 15

Study 2: Analyses of Variance

Code Type	Main Effect	*df*	*F*	η_p^2	*p*	*M*		
Questions								
Whole								
Artifact Type	Familiarity	(1, 52)	37.32**	.42	.000	FM	.32	(.20)
						NV	.68	(.20)
	Complexity	(1, 52)	6.00*	.10	.02	CX	.53	(.10)
						SP	.47	(.10)
Ambiguous	Familiarity	(1, 57)	59.41**	.51	.000	FM	.03	(.07)
						NV	.31	(.28)
	Complexity	(1, 57)	0.02	.000	.90	CX	.17	(.18)
						SP	.17	(.14)
Appearance	Familiarity	(1, 57)	.58	.01	.45	FM	.03	(.07)
						NV	.02	(.05)
	Complexity	(1, 57)	13.12**	.19	.001	CX	.01	(.04)
						SP	.04	(.07)
Function Whole								
Global	Familiarity	(1, 57)	0.83	.01	.37	FM	.12	(.14)
						NV	.14	(.16)
	Complexity	(1, 57)	0.05	.001	.83	CX	.14	(.15)
						SP	.13	(.13)
Generic vs Specific	Familiarity	(1, 56)	.78	.01	.38	FM	.12	(.14)
						NV	.14	(.16)
	Complexity	(1, 56)	.05	.001	.82	CX	.14	(.15)
						SP	.13	(.13)
	Specificity	(1, 56)	1.96	.03	.17	GEN	.12	(.16)
						SPE	.15	(.17)
Specific: Correct vs Incorrect	Familiarity	(1, 56)	11.58**	.17	.001	FM	.10	(.12)
						NV	.05	(.07)
	Complexity	(1, 56)	1.22	.02	.28	CX	.07	(.09)
						SP	.08	(.10)
	Accuracy	(1, 56)	32.70**	.37	.000	COR	.13	(.15)
						INC	.02	(.05)
Current vs. Intended Use	Do vs. For	(1, 57)	19.07**	.25	.000	CU	.11	(.17)
						IU	.01	(.16)
Part								
Ambiguous	Familiarity	(1, 52)	1.40	.03	.24	FM	.03	(.10)
						NV	.05	(.11)
	Complexity	(1, 52)	8.97**	.15	.004	CX	.07	(.13)
						SP	.02	(.05)
Why Part	Familiarity	(1, 55)	.18	.003	.67	FM	.05	(.10)
						NV	.04	(.10)
	Complexity	(1, 55)	4.17*	.07	.046	CX	.06	(.12)
						SP	.04	(.08)
						3y	.00	(.00)
	Age	(2, 55)	3.80*	.12	.03	4y	.15	(.22)
						5y	.08	(.17)

Table 15 (Continued)

Code Type	Main Effect	*df*	*F*	η_p^2	*p*	*M*		
Global	Familiarity	(1, 52)	2.78	.05	.10	FM	.02	(.04)
						NV	.04	(.06)
	Complexity	(1, 52)	22.84**	.31	.000	CX	.05	(.06)
						SP	.01	(.03)
Generic vs Specific	Familiarity	(1, 52)	3.60	.10	.063	FM	.02	(.04)
						NV	.03	(.06)
	Complexity	(1, 52)	17.98**	.26	.000	CX	.04	(.06)
						SP	.01	(.03)
	Specificity	(1, 52)	.56	.01	.46	GEN	.03	(.06)
						SPE	.02	(.04)
Specific: Correct vs Incorrect	Familiarity	(1, 57)	1.27	.02	.27	FM	.01	(.02)
						NV	.01	(.03)
	Complexity	(1, 57)	14.93**	.21	.000	CX	.02	(.03)
						SP	.002	(.01)
	Accuracy	(1, 57)	15.21**	.21	.000	COR	.02	(.03)
						INC	.002	(.01)
Current vs. Intended Use	Do vs. For	(1, 57)	0.62	.01	.44	CU	.02	(.04)
						IU	.01	(.03)
Statements								
Whole								
Artifact Type	Familiarity	(1, 53)	58.03**	.52	.000	FM	.69	(.23)
						NV	.28	(.19)
	Complexity	(1, 53)	3.23	.06	.08	CX	.45	(.18)
						SP	.51	(.18)
Appearance	Familiarity	(1, 58)	3.82	.06	.056	FM	.05	(.08)
						NV	.03	(.05)
	Complexity	(1, 58)	6.25*	.10	.02	CX	.03	(.06)
						SP	.06	(.08)
Context of Use	Familiarity	(1, 58)	11.21**	.16	.001	FM	.01	(.03)
						NV	.001	(.01)
	Complexity	(1, 58)	.48	.01	.49	CX	.01	(.02)
						SP	.01	(.02)
Personal Experience	Familiarity	(1, 58)	28.72**	.33	.000	FM	.09	(.12)
						NV	.01	(.03)
	Complexity	(1, 58)	2.38	.04	.13	CX	.04	(.07)
						SP	.06	(.08)
Analogies	Familiarity	(1, 58)	4.74*	.08	.03	FM	.01	(.04)
						NV	.05	(.14)
	Complexity	(1, 58)	.16	.003	.70	CX	.03	(.06)
						SP	.04	(.13)
"I don't know"	Familiarity	(1, 58)	1.57	.03	.22	FM	.05	(.10)
						NV	.08	(.16)
	Complexity	(1, 58)	1.70	.03	.20	CX	.07	(.13)
						SP	.06	(.12)
"I know all!"	Familiarity	(1, 58)	6.73*	.10	.02	FM	.03	(.07)
						NV	.004	(.02)
	Complexity	(1, 58)	1.29	.02	.26	CX	.01	(.04)
						SP	.02	(.05)
Function Whole								
Global	Familiarity	(1, 58)	64.51**	.53	.000	FM	.13	(.12)
						NV	.01	(.03)
	Complexity	(1, 58)	3.42	.06	.07	CX	.06	(.08)
						SP	.08	(.09)

Table 15 (Continued)

Code Type	Main Effect	*df*	*F*	η_p^2	*p*	*M*		
Specific: Correct vs Incorrect	Familiarity	(1, 58)	64.51**	.53	.000	FM	.13	(.12)
						NV	.01	(.03)
	Complexity	(1, 58)	3.42	.06	.07	CX	.06	(.08)
						SP	.08	(.09)
	Accuracy	(1, 58)	68.00**	.54	.000	COR	.13	(.12)
						INC	.01	(.02)
Current vs. Intended Use	Do vs For	(1, 58)	55.40**	.49	.000	CU	.10	(.10)
						IU	.003	(.01)
Name Whole								
Global	Familiarity	(1, 57)	71.01**	.56	.000	FM	.23	(.18)
						NV	.04	(.06)
	Complexity	(1, 57)	7.18*	.11	.01	CX	.12	(.10)
						SP	.15	(.12)
Correct	Familiarity	(1, 58)	101.98**	.64	.000	FM	.23	(.17)
						NV	.001	(.01)
	Complexity	(1, 58)	11.07**	.16	.002	CX	.10	(.08)
						SP	.13	(.11)
Incorrect	Familiarity	(1, 57)	30.82**	.35	.000	FM	.002	(.02)
						NV	.04	(.06)
	Complexity	(1, 57)	.042	.001	.84	CX	.02	(.04)
						SP	.02	(.04)
Function Part								
Global	Familiarity	(1, 58)	8.41**	.13	.005	FM	.03	(.06)
						NV	.01	(.02)
	Complexity	(1, 58)	3.20	.05	.08	CX	.03	(.04)
						SP	.01	(.04)
Specific: Correct vs Incorrect	Familiarity	(1, 58)	8.41**	.13	.005	FM	.03	(.06)
						NV	.01	(.02)
	Complexity	(1, 58)	3.20	.05	.08	CX	.02	(.04)
						SP	.01	(.04)
	Accuracy	(1, 58)	15.74**	.21	.000	COR	.03	(.06)
						INC	.002	(.01)
Current vs. Intended Use	Do vs For	(1, 58)	13.24**	.19	.001	CU	.02	(.03)
						IU	.001	(.004)
Name part								
Name	Familiarity	(1, 58)	1.21	.02	.28	FM	.02	(.06)
						NV	.03	(.06)
	Complexity	(1, 58)	11.75**	.17	.001	CX	.04	(.07)
						SP	.02	(.02)

Note. Standard Deviations are in parenthesis. FM = familiar; NV = novel; CX = complex; SP = simple. ; GEN = general; SPE = specific; COR = correct; INC = incorrect; CU = current use; IU = intended use; 3y = 3-year-olds; 4y = 4-year-olds; 5y = 5-year-olds.

*p <.05. **p <.01

Table 16
Study 2: Interaction Means

Code Type	Interaction	Subsample		*M*	
Questions					
Whole					
Artifact Type	Com*Gender*Age	CX, 5y	B	.48	(.05)
			G	.57	(.01)
		SP, 5y	B	.53	(.05)
			G	.43	(.01)
Appearance	Fam*Com	FM	CX	.004	(.02)
			SP	.02	(.05)
Function Whole					
General vs. Specific	Fam*Spec	GEN	FM	.03	(.04)
			NV	.09	(.13)
		SPE	FM	.10	(.12)
			NV	.05	(.07)
	Gender*Spec	B	GEN	.15	(.19)
			SPE	.12	(.16)
		G	GEN	.08	(.13)
			SPE	.18	(.18)
	Fam*Gender*Spec	FM, B	GEN	.03	(.05)
			SPE	.09	(.13)
		FM, G	GEN	.02	(.04)
			SPE	.11	(.11)
		NV, B	GEN	.12	(.16)
			SPE	.03	(.06)
		NV, G	GEN	.06	(.09)
			SPE	.07	(.08)
Specific: Correct vs. Incorrect	Fam*Acc	FM	COR	.10	(12)
			INC	.00	(.00)
		NV	COR	.03	(.05)
			INC	.02	(.05)
	Com*Gender*Acc	CX, B	COR	.05	(.07)
			INC	.003	(.01)
		CX, G	COR	.08	(.09)
			INC	.01	(.03)
		SP, B	COR	.07	(.08)
			INC	.01	(.02)
		SP, G	COR	.06	(.08)
			INC	.03	(.06)
Part					
Ambiguous	Gender*Age	5y	B	.00	(.00)
			G	.21	(.21)
		G	3y	.05	(.08)
			4y	.02	(.04)

Table 16 (Continued)

Code Type	Interaction	Subsample		*M*	
Function Part					
Global	Gender*Age	4y	B	.09	(.08)
			G	.03	(.06)
	Gender*Age*Com	4y, B	CX	.08	(.07)
			SP	.01	(.02)
		4y, G	CX	.03	(.03)
			SP	.01	(.03)
Specific: Correct vs. Incorrect	Com*Acc	CX	COR	.02	(.03)
			INC	.001	(.004)
		SP	COR	.001	(.01)
			INC	.001	(.01)
Statements					
Whole					
Artifact Type	Fam*Com	FM	CX	.31	(.15)
			SP	.38	(.17)
		NV	CX	.14	(.11)
			SP	.14	(.15)
Appearance	Fam*Com	FM	CX	.01	(.03)
			SP	.04	(.06)
		NV	CX	.01	(.04)
			SP	.02	(.03)
"I don't know"	Fam*Com	FM	CX	.03	(.01)
			SP	.02	(.01)
		NV	CX	.04	(.08)
			SP	.04	(.09)
"I know all!"	Fam*Com	FM	CX	.01	(.03)
			SP	.02	(.05)
		NV	CX	.003	(.01)
			SP	.001	(.01)
Function Whole					
Function Global	Fam*Com	FM	CX	.05	(.07)
			SP	.08	(.08)
		NV	CX	.01	(.02)
			SP	.004	(.01)

Table 16 (Continued)

Code Type	Interaction	Subsample		*M*	
Specific: Correct vs Incorrect	Fam*Acc	FM	COR	.13	(.12)
			INC	.001	(.01)
		NV	COR	.002	(.01)
			INC	.01	(.02)
	Fam*Com	FM	CX	.05	(.07)
			SP	.08	(.08)
		NV	CX	.01	(.02)
			SP	.004	(.01)
	Com*Acc	CX	COR	.05	(.07)
			INC	.01	(.02)
		SP	COR	.08	(.08)
			INC	.004	(.01)
	Fam*Com*Acc	FM, CX	COR	.05	(.07)
			INC	.001	(.01)
		FM, SP	COR	.08	(.08)
			INC	.00	(.00)
		NV, CX	COR	.002	(.01)
			INC	.01	(.02)
		NV, SP	COR	.00	(.00)
			INC	.004	(.01)
Name Whole					
Global	Fam*Com	FM	CX	.10	(.08)
			SP	.13	(.11)
		NV	CX	.02	(.04)
			SP	.02	(.03)
	Fam*Com*Gender	G, FM	CX	.08	(.06)
			SP	.14	(.11)
		G, NV	CX	.02	(.05)
			SP	.01	(.02)
Correct	Fam*Com	FM	CX	.10	(.08)
			SP	.13	(.11)
		NV	CX	.01	(.01)
			SP	.00	(.00)
Incorrect	Fam*Gender	B	FM	.00	(.00)
			NV	.05	(.06)
		G	FM	.004	(.02)
			NV	.03	(.05)
Function Part					
Specific: Correct vs Incorrect	Fam*Acc	FM	COR	.03	(.06)
			INC	.001	(.003)
		NV	COR	.004	(.02)
			INC	.001	(.01)
Name Part					
Name	Fam*Com	FM	CX	.01	(.03)
			SP	.01	(.03)
		NV	CX	.03	(.05)
			SP	.01	(.02)

Note. Standard Deviations are in parenthesis. FM = familiar; NV = novel; CX = complex; SP = simple; Com = complexity; Fam = familiarity; Acc = accuracy; Spec = specificity; B = boys; G: girls; 3y = 3-year-olds; 4y = 4-year-olds, 5y= 5-year-olds, COR = correct; INC = incorrect; GEN = general; SPE = specific. *p <.05. **p <.01

Table 17

Study 2: Incorrect-Appropriate vs. Incorrect Appropriate Utterances - Novel Artifacts

Analysis	Main Effect	*df*	*F*	η_p^2	*P*	*M*		
General	Complexity	(1, 50)	2.02	.04	0.16	CX	.02	(.03)
						SP	.03	(.04)
	Appropriateness	(1, 50)	28.45**	.36	.000	IA	.05	(.05)
						II	.01	(.02)
Functional	Complexity	(1, 55)	6.23*	.10	.02	CX	.01	(.03)
						SP	.01	(.03)
	Appropriateness	(1, 55)	6.76*	.11	.01	IA	.02	(.03)
						II	.004	(.02)

Note. Standard Deviations are in parenthesis. CX = complex; SP = simple; IA = incorrect-appropriate; II = incorrect inappropriate.

*p <.05. **p <.01

Table 18.

Study 2: Initial Question - Ambiguous-whole versus Function-whole

Main Effect	*df*	*F*	η_p^2	*p*	*M*		
Familiarity	(1, 57)	44.90**	.44	.000	FM	.08	(.12)
					NV	.24	(.19)
Complexity	(1, 57)	3.22	.05	.078	CX	.17	(.16)
					SP	.15	(.13)
Ambiguous-whole vs. Function-whole	(1, 57)	13.25*	.001	.001	AW	.23	(.24)
					FW	.09	(.15)

Note. Standard Deviations are in parenthesis. FM = familiar; NV = novel; CX = complex; SP = simple; AW = ambiguous-whole; FW = function-whole

*p <.05. **p <.01

Figure 1. Test game grid.

Simple Artifacts		Function	Complex Artifacts		Function
Kite		Flies in the air	Saxophone		Plays music
Hat		Protects head from the sun	Vaccum		Cleans floors
Toothbrush		Cleans Teeth	Helicopter		Flies in the air
Pinwheel		Spins with wind or when blown	Camera		Takes pictures
Scissors		Cuts paper	Bike		You ride it to places
Marker		Colors drawings	Telephone		Allows you to talk to people who are far away
Whistle[a]		Makes sound	Stereo[a]		Plays songs
Backpack[a]		Carries things around	Guitar[a]		Plays music

[a] Refers to artifacts used in the training set.

Figure 2. Study 1: Pictures and descriptions of stimuli.

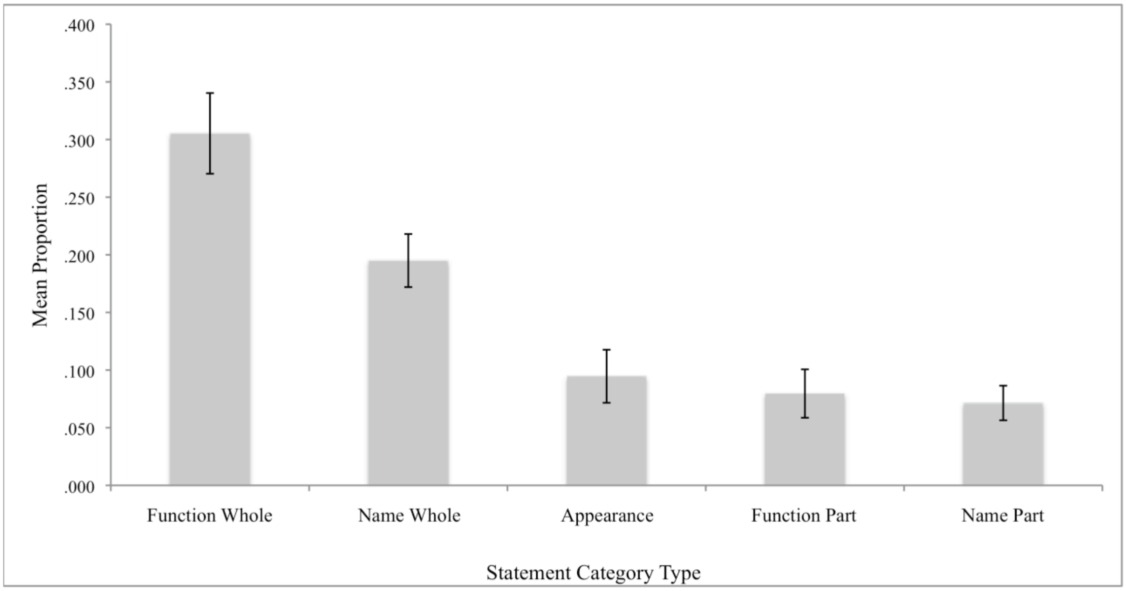

Figure 3. Study 1: Mean proportions by major statement category.

Familiar Simple Artifacts		Function	Familiar Complex Artifacts		Function
Kite		Flies in the air	Saxophone		Plays music
Toothbrush		Cleans Teeth	Vaccum		Cleans floors
Scissors		Cuts paper	Helicopter		Flies in the air
Novel Simple Artifacts		**Function**	**Novel Complex Artifacts**		**Function**
Crullet		You sit on it and it rocks back and forth	Taiffel		Makes streets and roads
Riepank		Smashes and shreds garlic	Becket		Makes tiny things look bigger so you can see them better
Garflom		Cleans the dust from the air	Luzak		Separates coins according to their size or how much they are worth
Familiar Animals		**Behavior**	**Novel Animals**		**Behavior**
Frog[a]		It hops, it is a grown-up frog	Pangolin[a]		It has a long tongue that catches flies for it to eat, rolls into a ball when it sleeps
Zebra[a]		Eats grass, lives in Africa	Tarsier[a]		Likes to climb trees, has big eyes that help it see

[a] Refers to animals used in the training set.

Figure 4. Study 2: Pictures and descriptions of stimuli.

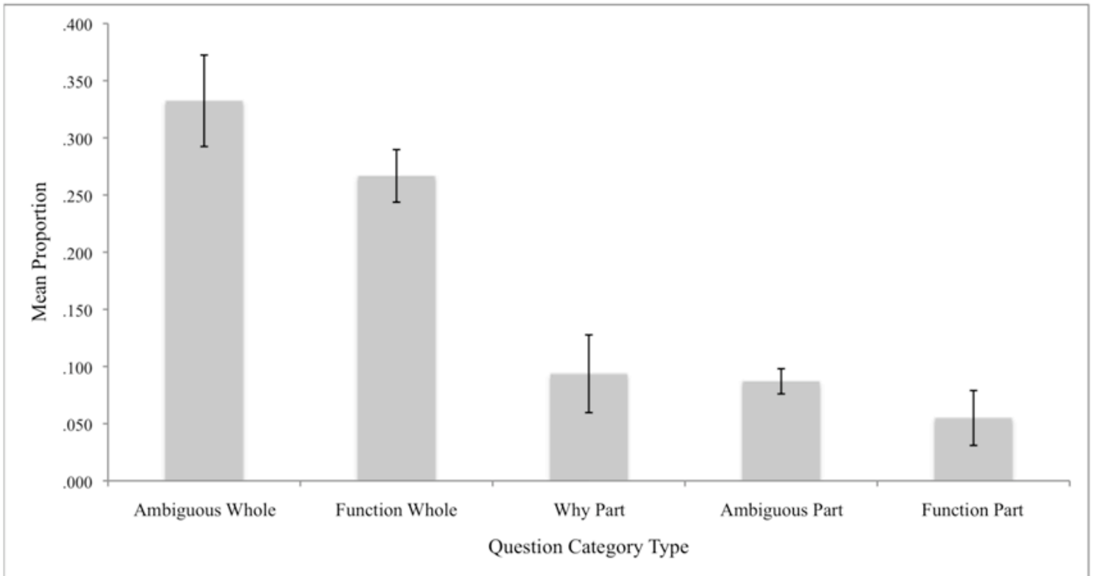

Figure 5. Study 2: Mean proportions by major question category.

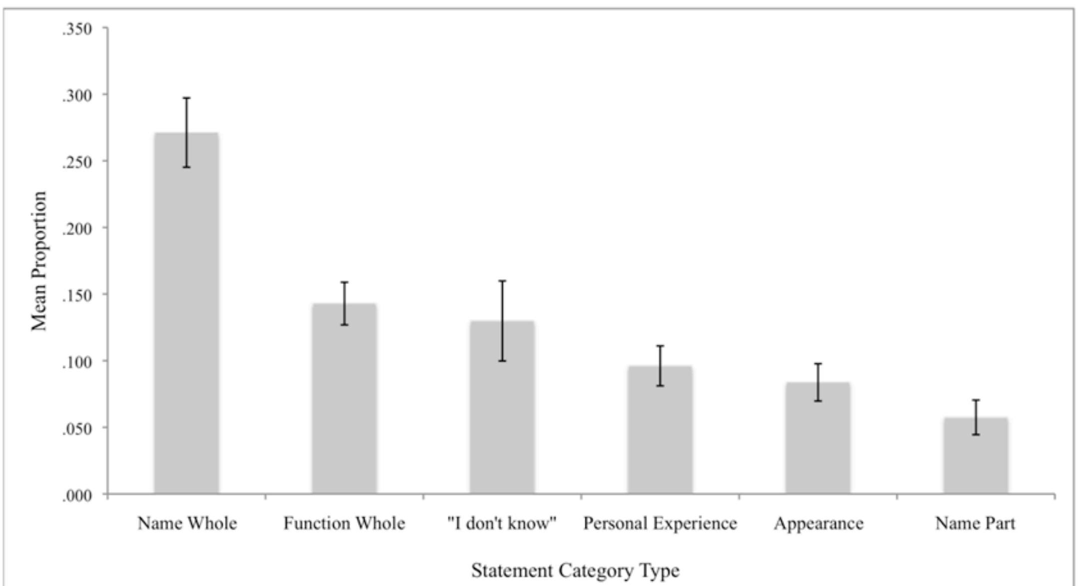

Figure 6. Study 2: Mean proportions by major statement category.

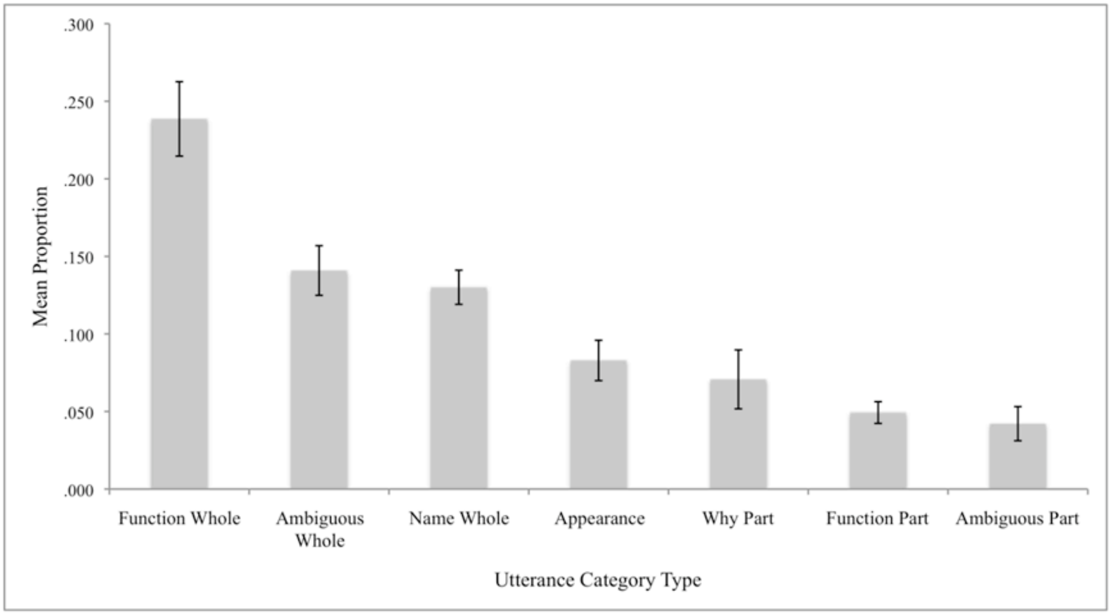

Figure 7. Study 2: Mean proportions by major utterance (question & statements) category.

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