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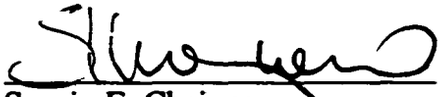

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Studies in the Conceptual Structure of Object Function

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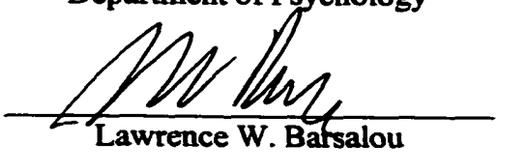

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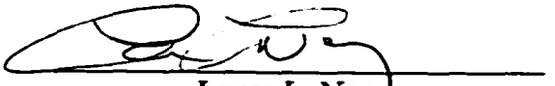

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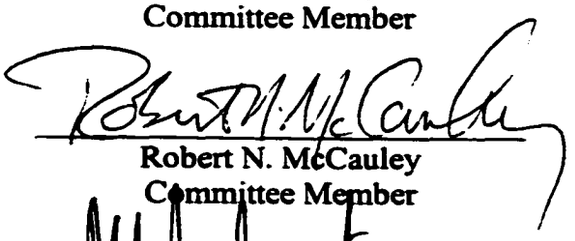

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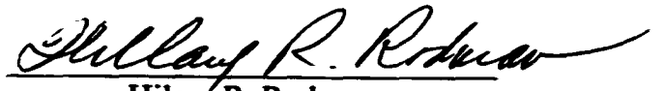

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An Abstract of
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Abstract

Three views of function are reviewed and tested. From an affordances view, function reflects an artifact's physical structure and use. From an historical view, function reflects a creator's intention. A third and more recent view—the HIPE theory—allows for both perspectives: affordances are central when people reason about functional events, with intentional creation playing a secondary role. Four experiments tested these theories' predictions. Subjects read scenarios describing an artifact's creation, physical structure, and use. After reading a scenario, subjects performed either causal, functional, or naming ratings. Scenarios had four components that could be individually compromised. An object could be accidentally rather than intentionally created; it could be unintentionally or intentionally used; it could have a sufficient or insufficient physical structure; an agent using it could exhibit sufficient or insufficient actions. In Experiments 1 and 2, scenarios compromised one or more components. Compared to a baseline scenario where all components were intact, compromising any of them decreased functional and causal ratings. Consistent with an affordances view, however, structure and use produced the greatest effect. Causal and functional ratings closely mirrored each other, showing that understanding function relies on causal relations linking conceptual components. Contrary to the historical view, intentional creation showed only a small effect in causal and functional judgments, but a greater effect in naming. People are aware that names are transmitted from creators to users, thus when intentional creation is absent, naming suffers. Experiment 3 controlled the narrative structure of scenarios, showing it cannot account for results. Finally, Experiment 4 examined recent studies suggesting that history is more central than affordances (Gelman & Bloom, 2000; Matan & Carey, 2001).

Problematically, these studies failed to provide subjects with sufficient information to determine affordances. Using a naming task, Experiment 4 found that when subjects received complete affordance information, intentional creation produced only a small effect and affordances dominated. Consistent with HIPE, these four experiments show that affordances are more central to function than intentional history. Function relies heavily on causal structures evident in object use. Intentional history plays a limited conceptual role but makes an important contribution to naming.

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It seems that an object's function should be a central aspect of its conceptualization. When needing to explain what a functional object is, most people would probably choose to talk about its use (e.g., to say that a screwdriver is *used to put screws in place*). Nevertheless, there is still much controversy regarding the role of function in object conceptualization. Researchers do not agree on whether function can be a critical component of concepts or whether it is only a by-product. Also, among those who consider function critical there is no consensus about how it should be defined.

The plan of this dissertation is first to review the literature, paying particular attention to the different theories of function that have been offered by researchers, and devoting a special interest to the HIPE theory of function (Barsalou, Sloman, & Chaigneau, in press). This theory combines diverse domains that have been signaled as relevant for the concept of function into a complex conceptual network assumed to be necessary for a competent understanding of function.

After these theories have been laid out, I will show how they can all be expressed in the common framework of causal graphs. Essentially, the argument will be that each theory's claims can be expressed as a set of causal relations. Expressing theories in this way has two important advantages. First, it allows mapping the space of possible accounts of function, including some that have not been considered by researchers yet. Second, expressing different theories in this common framework readily enables the design of experiments to test the predictions of contrasting theories.

Four experiments are designed following this strategy. They aim in general to contrast the predictions of the HIPE theory with other theories of function. The first and second experiments test different possible conceptual structures for the function of

objects. By compromising different functional components (e.g., an object's history, its physical structure), information can be derived about their relative relevance for the conceptual structure of function. The third experiment shows that obtained results are not a consequence of the particular stimuli used. Specifically, results are not produced by the narrative structure of the materials. Finally, the fourth experiment shows how HIPE can explain results predicted by an alternative theory. The HIPE theory can account for historical effects reported in the literature without the extra assumptions historical theories require.

THEORIES OF FUNCTION

This section reviews different theories regarding the nature of function. The review is organized as follows. First, several studies that make an important theoretical point about function are described. As argued in Chaigneau and Barsalou (in press), these studies illustrate that function needs to be understood as a relational system. For function to show its full effect in categorization, people need to understand these relations. This is something that has been often overlooked, as evidenced by attempts to perform experiments in which object function is varied independently from other relevant object features, mainly physical structure.

Next, three theories of function will be examined. Each of these theories signals important components of the conceptual network that underlies function. The *affordances view* of function sees it as reflecting the physical interactions that an agent has with objects in the course of using them (Gibson, 1977, 1979a, 1979b). The *intentional theory* of function stresses knowledge that people have about the origins or history of objects, assuming that an artifact's appearance and function are caused by the

designer's intention (Bloom, 1996, 1998). The last theory presented—the HIPE theory of function—merges these diverse components into a complex conceptual network assumed to be necessary for a competent understanding of an object's function (Barsalou et al., in press).

Function as an independent or as a relational feature

One of the main problems that researchers confront is how to define function. Although this is often done at a tacit level, two alternatives found in the literature are treating function either as a single unitary feature or as a relational system (Chaigneau & Barsalou, in press). When function is treated as a unitary feature, it is often assumed it can be added to an object's concept without taking into account its interactions with other features of the object. Function would be just like the color of many objects, which can be changed without worrying about the value of other features for that object. Defining function in this manner assumes that it is at the same level of other features in a concept. In contrast, when function is treated as a relational system many features have to be taken into account to understand it. Here function cannot be added to a concept independently of many of its other relevant aspects.

By reviewing the literatures on three research problems I will argue that function has a strong effect in conceptualization. Although various studies provide counterevidence to this claim, I will show that function produces an effect in categorization only when subjects are able to make sense of the multiple relations that underlie it. The definition of function as a relational system is the theme that runs through this section, allowing the reconciliation of divergent results. The three research problems are: (1) whether function can be a core feature of concepts, (2) whether a

category organized around function provides support for inductive inference, and (3) whether children can use function to guide object naming.

First research problem: Can function be a core feature?

Researchers in concepts have long disagreed about the existence of features that are necessary and sufficient for category membership. If they existed, these features would provide concepts with a *core* that could be used to decide unequivocally about category membership. If *bird* had a core feature (e.g., *being covered with feathers*), people could decide whether a previously unknown entity is a bird by simply verifying that single feature.

As hinted above, the existence of core features is a contentious issue for theories of concepts. Both, exemplar and prototype theories deny their existence. In exemplar theories, the coherence of a category results from similarity relations between its instances and not from a set of core features common to all (e.g., Estes, 1986; Heit, 1992; Hintzman, 1986; Medin & Schaffer, 1978; Nosofsky, 1986, 1991). The same is valid for prototype theories (e.g., Rosch, 1975; Rosch & Mervis, 1975; Rosch, Simpson, & Miller, 1976). For example, people would classify a novel object as a *bird* because it resembles other known birds, not because it has the core features that define the category. In contrast, theory-theories adopt the posture that similarity cannot be the basis of categorization because it is too unconstrained (e.g., Medin & Ortony, 1989; Smith & Medin, 1981). There are an infinite number of respects in which two entities can be similar. In contrast, because features are often related to each other, the correct way to understand concepts is as theories about the relations between features (e.g., *having feathers* and *being able to fly*). In this view, core features that underlie categories are

situated at the level of the theory (e.g., the genetic makeup that causes *having feathers* and *being able to fly*). Surface similarity plays a role in object recognition, and not so much in categorization.

The debate about core features has also played out in the function literature. As the theory-theory suggests, several studies show that function can indeed be a core feature. If the functions of objects were core features, then subjects should accurately categorize those objects based on their use. For example, learning that something is *used to sit on* should be sufficient to classify it as a *chair*. Two studies offer support for this view (Barton & Komatsu, 1989; Keil, 1989), which are described respectively.

In Barton and Komatsu's (1989) Experiment 1, subjects learned about objects that no longer had either a functional, molecular, or physical property. After learning about these objects, subjects were asked whether they still retained their category membership. Consistent with function being a core feature, an artifact that was unable to perform its usual function was not considered the same kind of artifact anymore (e.g., a *television* that did not *project an image* was not considered a *television*). Whereas this is evidence that function is a necessary feature of concepts, Experiment 2 showed that function is a sufficient feature of concepts. In this second experiment, subjects learned about three kinds of objects. Some shared only their physical features with members of a category. Other objects shared only their function with members of a category. Yet other objects shared only their molecular structure with members of a category. Results showed that artifacts were considered category members even if the only thing they shared with other members of the category was their function.

Keil (1989) also suggests that functions can be critical for categories. He presented subjects with graphic and verbal descriptions of variants of standard *tools*. One of the experimental conditions depicted and described these variants as similar to the standard tool, with the additional information that they could not perform the same function. For example, a *hammer* with *a hole in its head* could not be *used to put nails in place*. Another condition depicted and described the variants as different from the standard, while their structure still afforded the same function. For example, a *screwdriver* with *an unusual handle* could still be *used to put screws in place*. In both conditions subjects used function to categorize and did not base their decisions on irrelevant properties.

In contrast, Malt and Johnson (1992) claim that function is neither necessary nor sufficient to define artifacts. In their experiments subjects received descriptions where function and physical structure were independently manipulated. In Experiment 1, these descriptions combined an object's standard function with either a normal or an unusual physical appearance. In spite that objects with unusual appearances were still able to perform the normal function, subjects tended to deny them category membership. For example, a *rubber garment* was not considered a *sweater*, although an independent sample judged that it could be *used to provide warmth to the upper body when worn over a shirt* (i.e., it could perform a sweater's standard function). In Experiment 2, subjects learned about objects that combined an artifact's standard physical features with one of several possible functions (i.e., normal function, related function, bizarre function, and denial of function). For example, an object with the standard physical features of *boat* was described as *used to transport people over water* or as *used to keep criminals*

offshore. Subjects in this experiment considered that at least half the items with unusual functions (e.g., a boat used to keep criminals offshore) should be considered category members. Because subjects in both experiments used appearance to guide their categorizations, but seemed unconcerned about function, Malt and Johnson concluded that function is not only not sufficient but also not necessary for category membership.

As suggested earlier, viewing function as a relational system reconciles these clearly divergent results. Keil, and to certain extent also Barton and Komatsu, presented materials in a way that preserved structure/function relations. As objects changed function, corresponding structural features that afford function were also allowed to change. In contrast, Malt and Johnson's materials combined physical structure and function without preserving these relations. Objects with different structures were described as performing the same functions, and objects with different functions were described as having the same structural characteristics. As a result, structure and function were assumed (unjustifiably) to be independent. However, if relational systems underlie subjects' understanding of function, Malt and Johnson's subjects may have been using their prior knowledge about the relations between structure and function to make sense of the stimuli.

Subjects in Malt and Johnson's Experiment 1 may have reasoned that objects able to perform a non-standard function should not be granted category membership. For example, a *rubber garment* could be *used to dive in cold water*, and because of this should not be considered a *sweater*. Similarly, perhaps subjects in Experiment 2 were able to infer the objects' function from the standard physical features. In this experiment the objects' physical features were always the standard ones (e.g., *wedge-shaped, with a*

sail, an anchor, and *wooden sides* were the physical features for *boat*). It is possible that subjects granted category membership to some objects with unusual functions because subjects used physical descriptions to infer that objects were perfectly capable of performing the standard function. Although subjects may have always reasoned about function, they appeared not to because the experimenters implicitly assumed the independence of function and structure.

Results from Ahn (1998) support this interpretation. Drawing on prior research showing that causal properties (i.e., those considered to cause other features as opposed to being caused by other features) have a greater effect in categorization, Ahn gave her subjects Malt and Johnson's materials and asked them to judge if structure was causing function or vice versa. Their answer was that physical structure caused function, thus explaining why subjects used it and not function to classify. This is consistent with the analysis in the preceding paragraph. Subjects in Malt and Johnson's experiments were reasoning about how physical properties afforded certain functions.

In summary, differences between the studies reviewed above result from the different strategies used to combine an object's physical features with its function. When physical structure and function were varied independently, results showed that function was not conceptually important. In contrast, when physical structure and function were allowed to covary, function had an effect. The former strategy is questionable because an object's physical structure bears a causal relation to its function. On the surface, all the studies reviewed above are alike in manipulating appearance and function. However, they produce different results because, while Keil (1989) and Barton and Komatsu (1989) preserved the relation between physical structure and function, Malt and Johnson (1992)

assumed that function could be ascribed to objects independently of structure. When the causal relation between function and physical structure is recognized, function always plays a role in categorization. Most importantly, all this work shows that function is relational, that is, relations between physical structure and function are critical.

Second research problem: Can knowledge of function be used to support inferences?

Besides their obvious advantages for the cognitive economy (i.e., storage, coherence), concepts enable the cognitive system to perform several important tasks (for a review, see Solomon, Medin, & Lynch, 1999). One of these tasks is to provide support for inductive inferences, which—in the context of categorization research—means to decide if features attributed to some entity should be extended to other entities. Because people expect that objects of the same category share important features, knowledge of category membership can support these inferences (e.g., Markman, 1989; Osherson, Smith, Wilkie, Lopez, & Shafir, 1991; Yamauchi & Markman, 2000). For example, if people classify a novel entity as a dog, they may infer that it can bark (although they may in fact be wrong). This relation is strong enough that some researchers have thought that the extension of attributes from one entity to another implies that both belong to the same category (e.g., Mak & Vera, 1999; Mandler & McDonough, 1998).

Given that categories are known to support inferences, it is not surprising that one of the topics of research about function is whether categories organized around function provide full support for inferences. This is what would be expected if functional categories are true categories. Because the argument has been made that function seems to be an important feature of artifacts (e.g., tools, furniture) but not an important feature

of natural kinds (e.g., animals, plants), most of this discussion has been restricted to the artifact/natural kind distinction.

The inductive potential of artifacts is often portrayed as lower than that of natural kinds (e.g., Gelman & Markman, 1986). A category such as *furniture* would support fewer inferences than a category such as *animals*. The basis for this difference has been the intuition that artifacts share mainly their obvious features (e.g., their external appearance), with not much needing to be inferred. In contrast, natural kinds share many non-obvious features that must be inferred (e.g., their internal structure). Thus, natural kinds are viewed as conceptually richer than artifacts.

Gelman (1988, Exp. 1) obtained evidence that appeared to support this view. Subjects (4- and 7-year-olds) were required to make inductions with natural kinds and artifacts. Both kinds could be either simple or complex, where complex objects were those with many different parts and complicated internal workings. Subjects were taught a new fact about an object (e.g., a *carrot* is *used to make a proboscis*) and were then required to judge if this fact was true of other objects (e.g., *banana*). Although complex objects (both for natural kinds and for artifacts) generally promoted more inferences, artifacts promoted significantly fewer inferences than natural kinds in 7-year-olds.

Interestingly, these results were not replicated in a study by Farrar, Raney, and Boyer (1992, Exp. 1). When 4-, 7-, and 9-year-old children were tested, Farrar et al. found that the number of inferences drawn varied as a function of object complexity but not of kind (i.e., artifact or natural kind). Regardless of their kind, complex objects supported more inferences in 7- and 9-year-olds. In 4-year-olds in contrast, simple objects promoted more inferences.

A possible explanation for this difference in results is that for artifacts almost one out of every four features used by Gelman (1988) were functions. The high proportion of functional features gives them substantial weight in the results, especially if Gelman's subjects did not understand them (as is probably the case). In Gelman's procedure the functions of artifacts were novel and unrelated to structure. For example, *used to make a proboscis* was presented as the function for *carrot*. It is entirely possible that children did not realize which physical features of carrots support that specific function. Similarly to Malt and Johnson (1992), Gelman viewed function as independent of physical structure. It is possible that in her study artifacts promoted fewer inferences than natural kinds because so many of the features provided for artifacts (i.e., their functions) were not understood by subjects.

In contrast, Farrar et al.'s (1992) materials may have allowed children to draw on their knowledge of structure/function relations in artifacts. For example, even a small amount of knowledge about how internal features cause the behaviors of computers and televisions (e.g., that they project images on a screen because they have things inside) might have allowed children to infer that both types of objects have common insides.

A different view on the inductive potential of artifacts focuses on the importance of contexts in which they are used. People know more about artifacts than their structure. They also have knowledge of the social context in which artifacts are used (Keil, 1988). It is possible then, that if inferences directly involve the environment in which artifacts are used, their inductive potential will be at least as high as that of natural kinds.

Two studies speak to this issue. When inferences are directed to the internal features of objects, functional categories provide little support for inductions (Medin,

Lynch, Coley, & Atran, 1997). When inferences are directed to the setting in which an artifact is used, functional categories provide as much support for inductions as do natural kinds (Ross & Murphy, 1999).

Medin, Lynch, Coley, and Atran (1997) used three groups of tree experts (taxonomists, maintenance workers, and landscapers) to explore their categorizations of trees. Subjects were asked to sort 48 cards with names of tree species. Subjects' sortings were analyzed by means of a factor analysis on a matrix of intersubject agreement. Across all subjects, categories based on morphologic and scientific criteria accounted for about one third of the variance in the sorting task. Apart from this common factor, different groups of experts exhibited groupings related to their field of expertise (e.g., landscapers showed many clearly functional groupings such as *ornamental trees*, *stand-alone trees*, *weed trees*). Of interest here is that although landscapers showed many functional groupings, when they were tested in an inference task they did not use these functional criteria to guide their inferences, but resorted to morphologic or scientific categories instead. This did not happen with other two groups of experts, who used a reasoning strategy that seemed to make use of their own initial categorizations.

This suggests the conclusion that functional categories provide low inductive potential, but there are reasons to hedge. The task used by Medin et al. required making inferences about biological properties (e.g., reproduction, disease, and physiology). It is possible that subjects are sensitive to the kinds of inferences that are supported by different principles of categorization. For example, if they believe that tree biology and tree morphology are related, they may reason that inferences about tree biology must stay within the bounds of morphologic categories. Medin et al.'s results might have been

different if the inference task involved properties related to the social environment, where the functional groupings of landscapers are relevant. This is what Heit and Rubinstein (1994), and Ross and Murphy (1999) demonstrate.

For example, using food categories Ross and Murphy (1999) showed that subjects were not only able to use taxonomic categories (e.g., *vegetables*, *meats*) to guide their inferences, but also functional categories (e.g., *breakfast foods*, *snacks*). Though functional categories were not as accessible and not as automatically activated as taxonomic ones, they possessed the same power to promote inferences. In contrast to Medin et al. (1997), Ross and Murphy's subjects where required to make inferences in two separate areas: biochemical and social properties (Experiments 6 and 7). Results showed that if subjects were asked to make inferences about biochemical properties (content of food, origin, macronutrients), they used taxonomic categories to support them. In contrast, when asked to make inferences about social properties (cost, cooking methods, when eaten), they resorted to functional categories.

In conclusion, functional categories are as capable of promoting inferences as taxonomic categories or natural kinds. One factor that influences inference potential is an object's complexity. Because natural kinds are statistically more complex than artifacts, it may seem that natural kinds warrant more inferences than artifacts. The types of relations that characterize these two domains are also different. Relations between internal parts and behavior are typical of natural kinds. Consequently, natural kinds promote more inferences directed to internal characteristics. Artifacts—mainly those that are relatively simple—are characterized by their relations to typical settings in which they operate. Because of this, artifacts promote more inferences directed to their contexts of

use. When natural kinds appear to promote more inferences than artifacts, one or both factors may be responsible (i.e., complexity and direction of inference).

Again—analogous to the issue of whether function can be a core feature—this set of studies clearly shows that for function to have an effect in categorization, it is necessary that subjects make sense of relational systems that underlie it. Often the focus of artifact concepts is the social context in which the object is used, rather than its physical structure. Knowledge about when and how something gets used is also an important part of the conceptual network that underlies function.

Third research problem: Do children use function to guide naming?

For adults, objects may receive their name because of their function rather than because of their appearance. Although some types of artifacts may vary widely in their physical structure, they may be given the same name because of their function (for a detailed discussion, see Miller & Johnson-Laird, 1976; and also Rips, 1989). In contrast, the developmental literature does not provide a unique answer to the question of whether children extend names based on function. Some researchers think that using function to guide categorization should not develop early because it requires subjects to move away from global similarity, and towards relational information (Gentner & Rattermann, 1991). Consequently, infants would use simple features such as shape and color to name and categorize (e.g., Landau, Smith, & Jones, 1998; Smith, Jones, & Landau, 1996). In contrast, other researchers hold that function should be important from the start because children are constantly exposed to it (Nelson, 1974).

There are several studies that seem consistent with the position that function does not guide naming in young children. However, successive studies have set the limit for

the emergence of this ability at increasingly lower ages. If initial studies suggested a limit at around 4 to 5 years (Gentner, 1978; Tomikawa & Dodd, 1980), more recent ones set it as low as 2 years (Kemler-Nelson, Russell, Duke, and Jones, 2000). As the age limit is progressively lowered, results seem increasingly consistent with the position that young children are able to use information about function when deciding what to call an object. Interestingly, the age limit has gone down as experimenters have been increasingly successful in presenting information about function in ways that are understandable for infants. As argued before, function has an effect in categorization when subjects make sense of how the object carries out its function. People must understand the relational system that underlies function. Examining several studies in detail will provide support for this conclusion.

In early studies, novel objects were presented and their functions demonstrated, but no special effort was made to increase the likelihood that children comprehended those functions (Gentner, 1978; Tomikawa & Dodd, 1980). In Gentner's (1978) study, subjects received two novel objects for which structure (two possible structures) and function (two possible functions) were combined in a particular way. When subjects were tested with a new object that exhibited a previously unseen combination of structure and function, 2- to 5-year olds were more likely to extend the name according to appearance than according to function. In contrast, just as expected, 5- to 9-year-olds used function as a basis for naming. Similar results were obtained by Tomikawa and Dodd (1980).

Something very similar occurs in a study by Landau, Smith, and Jones (1998). In Experiments 1 and 2, subjects (2-, 3-, 5-year-olds, and adults) saw artifacts that

performed a simple function (e.g., retrieve small toys, carry water). Most functions were made possible by the objects' material (e.g., because a sponge soaks up liquids it can be used to carry water). Artifacts were simply shown to subjects, or shown and their function demonstrated. On both cases the experimenter concurrently named the object. Subjects then had to judge if a test object could perform the demonstrated function, and if a test object should be named as the original one. When judging function, results showed that 2-year-olds performed only at chance, and even though 5-year-olds were much better at it, as a group they were still not as accurate as adults. Relative to the issue of naming, children extended names according to shape. Adults were the only subjects that, when informed about an object's function, used this knowledge to extend names to test objects.

In these three studies, the assumption was made that a simple demonstration should be enough for children to grasp an object's function. Assuming that children required no extra knowledge in order to evaluate function adequately, no context was provided for the novel artifacts. In particular, Landau et al.'s (1998) materials may have made it very difficult for young children to understand functions. For example, children may not have immediately understood why being made of sponge allows an object to carry water. Although Landau et al.'s results show that younger children were neither able to correctly judge function from a static display of the experimental objects, nor to use information about function to guide naming, it is questionable if this means that 3-year-olds cannot correctly judge function per se. Instead, these results may show that young children do not have an understanding of how an object's material relates to its function. Consequently, these studies may not show that younger children use physical features to guide their categorizations, but rather that if children are not able to

understand the demonstrated functions, they will not be able to use those functions to guide their categorizations.

In fact, when children have been able to understand the functions presented to them, they have used this knowledge to guide their categorizations. In order to make functions more comprehensible for children, researchers have followed a suggestion made by Tversky (1989). She suggested that object parts might be relevant features that allow children to link objects and functions. Because parts have both appearance and functional aspects, they may play a role in the beginnings of functional categorization. When Kemler-Nelson (1995) implemented this suggestion, she was able to show that function plays a role in categorization even for subjects as young as 3 years of age. Although she followed a procedure very similar to other studies, she did make an effort to use functions that were comprehensible to children. Kemler-Nelson created novel objects that afforded two different functions (only one of which was demonstrated to an individual child). To maximize the likelihood that children would detect structure/function relations, functions were made possible by the arrangement of the object's parts (e.g., an object that had several brushes sticking out could be used to paint only when the brushes could make contact with a surface). Also, objects' functions were not only demonstrated, but children were allowed to use the objects. Later, when children were asked if a set of test objects in static display could be called the same as the standard, they were more likely to base their decisions on whether the new object afforded the demonstrated function and not on superficial appearance.

Data from a study by Smith, Jones, and Landau (1996, Experiments 2 and 4) also support the claim that, when understood, function guides categorization. In this study,

novel artifacts were constructed with a base combined with several smaller parts. Base and parts could perform a different function (e.g., the base could be used to look through like a telescope, and the parts could be used to hold pens). Interestingly, when 3-year-olds received a demonstration of one of the functions of the novel artifact, and were allowed to perform the function themselves, they categorized based on function even when not explicitly requested to do so.

More definitive data in support for the idea that children's good grasp of function can guide categorization (in naming and other tasks), comes from a study by Kemler-Nelson, et al. (2000). Three experiments were preformed with a similar procedure throughout. One novel object was used as a standard to which other objects were to be compared. The standard object was shown to subjects while the experimenter named it. Infants were allowed to manipulate the object, and were then presented with two test objects. They were then asked to hand the experimenter the test object that should be called the same name as the standard. Differently from previous studies, functions followed simple physical principles that even 2-year-olds would presumably understand (e.g., when a transparent box was turned, beads inside would run from side to side only if their path was not obstructed). Even in the absence of demonstration (i.e., allowing only exploration), 2-year-olds consistently named according to function.

In conclusion, research on children's ability to use function in object naming reveals that for function to show its effect in categorization subjects must have a grasp of the relations that underlie it (e.g., structure/function relations). The more knowledge someone has about the world, the more he or she will be able to judge the kinds of relations that underlie an object's function. This easily accommodates data showing that

older children and adults become increasingly proficient in using function to guide their categorizations (e.g., Landau, Smith, & Jones, 1998; Smith, Jones, & Landau, 1996).

Conclusion

Function shows its effect in conceptual tasks only when subjects understand the multiple relations that support it. Across different categorization tasks (e.g., classification, inductive inference, naming), when objects and their functions are presented in a way such that subjects are able to connect physical and functional knowledge (e.g., knowledge that a hammer requires a flat head in order to drive a nail in place), results consistently show that function guides subject's performance. In contrast, when functions are presented as independent features that are not meaningfully related to structural features of the object (e.g., when something such as *used to make a proboscis* is presented as a function for *carrot*), function appears not to influence subjects' performance.

Even though these issues are often overlooked, the literature on these three research problems clearly supports the following conclusions about the conceptual nature of function. Most importantly, function has to be understood as a relational system constituted by a network of features, not as a simple feature independent of others. Consequently, when a subject sees an object performing its function, there is no automatic guarantee that he or she has gained knowledge about its function. Only when subjects can link an object's function with prior knowledge that allows them to make sense of it, does the function become part of the object's concept. Precisely because of this, only when subjects understand function does it show its effect in categorization tasks.

In the next sections, I will review three theories of function. They all focus on the structure of the relational systems involved in function. The first two—function as physical interactions, and function as history—are well established. The third is new, and is the motivating force for the proposed studies.

Function as knowledge of physical interactions with objects

Probably the most common view of function defines it as a reflection of actual physical interactions with objects in the course of using them. Throughout this dissertation, this will be called the *affordances view* of function because it can be traced to Gibson's *affordance theory* (Gibson, 1977, 1979a, b). According to Gibson, functional affordances reflect the actions an object affords, given both its physical structure and the physical structure of the agent interacting with it. Functions are specified by invariant properties (i.e., properties that remain stable across transformations in space and time, such as shape, size, solidity). For an agent with the appropriate physical structure, these invariants specify the possibilities for action that an object affords (e.g., containment, graspability, supportability). Not much learning is required to understand the functions of simple artifacts such as containers. In contrast, more complex artifacts such as tools and utensils possibly require an extended learning period before their functions are understood (E. Gibson & Spelke, 1983).

A number of studies have focused on young infants' ability to understand simple functions. In general, these studies exploit infants' tendency to look longer at events that are novel or that go against expectations. If subjects look more at an "impossible" event (e.g., a vase that fails to contain liquid) compared to a "possible" one (e.g., a vase that

does contain liquid), it is considered that they understand the function in question (e.g., containment).

Using this paradigm, studies have shown that infants can grasp a simple function such as containment somewhere between 12 and 20 months of age (e.g., Caron, A., Caron, R., & Antell, S., 1988; MacLean, D., & Schuler, M., 1989; Pieraut-Le Bonniec, G., 1985). It has also been shown that learning plays a role in the emergence of this understanding. After providing 14-month-olds who did not comprehend containment with a one-month period where they could play with positive and negative instances of containers (e.g., tubes and cans), these infants performed similarly to untrained 20-month-olds (MacLean & Schuler, 1989).

Drawing from a different tradition, other researchers have also shown that infants are sensitive to function early into their second year of life (Madole & Cohen, 1995; Madole, Oakes, & Cohen, 1993). Rather than focusing on affordances, Madole and her colleagues follow Nelson (1979) in linking function with the characteristic behavior of objects, particularly with those object-behaviors that are the result of an agent's actions.

Although Madole and colleagues concur with Gibson in conceptualizing function as a reflection of actual physical interactions with objects, they do not resort to invariants to explain function. Instead they assume a correlational link exists between an object's structure, its behavior, and the actions of an agent. When infants become able to detect these correlations between different aspects of their physical environment, they come to expect certain kinds of combinations and not others.

In their studies Madole and collaborators use a habituation paradigm in which infants receive a single object or a set of objects and are later tested on a novel object

from the same or contrasting category. During habituation, infants learn a novel combination of structure, object behavior, and agent action. If during the test phase subjects dishabituate to the contrasting-category object, but not to the same-category object, this indicates that infants are treating objects categorically.

In one of their studies (Madole, Oakes, & Cohen, 1993), an object's action when used by an agent was associated with its shape (e.g., rectangular object rolled when pushed). Infants as young as 14 months of age were sensitive to an object's behavior (e.g., during test they spent more time examining a rectangular object that would not roll when pushed). It was also found that 18-month-old infants attended to the correlation between physical structure and function. For example, infants learning that an object with shape W exhibited behavior X, and an object with shape Y exhibited behavior Z, dishabituated to an object with shape W that exhibited behavior Z. In a second study where object behavior was associated with an object's salient parts (e.g., wheels), even 14-month-olds where sensitive to structure-function correlations (Madole & Cohen, 1995).

Studies falling under the affordances view are remarkably consistent in reporting a time window where children start exhibiting sensitivity to an object's function (i.e., early into their second year), and in showing that learning is necessary for the acquisition of knowledge about structure-function relations. Just as importantly, the affordances view of function can be easily extended to account for many of the functions of complex objects that adults know about (e.g., cars, computers). Presumably knowledge of complex functions accrues slowly as many relevant structure-function relations are acquired cumulatively. The idea that knowledge about function accrues slowly over

development is consistent with studies reviewed earlier showing that function becomes increasingly important as a categorization principle for older children and adults (e.g., Gentner, 1978; Landau, Smith, & Jones, 1998; Smith, Jones, & Landau, 1996).

In conclusion, the view that function is a reflection of the physical interactions that people have with objects in the course of using them has received much support. In understanding function in this manner, an object's physical structure, the behaviors it exhibits, and the actions of an agent, need all be considered.

Function as knowledge about the intentional history of objects

A contrasting view of function has received attention lately. This view holds that intentional history is central to an object's function (e.g., Bloom, 1996, 1998; Gelman & Bloom, 2000; Matan & Carey, 2001; Prasada, 1999). Throughout this dissertation this will be referred to as the *historical view* of function. A particular instantiation of this view is the *intentional theory* (Bloom, 1996, 1998). This theory assumes that designers' intentions are central to functions. The intentions of designers are the essences of artifacts.

The term "essence" derives from a philosophical tradition which holds that names and concepts are separate things. Names refer to objects extensionally, not intensionally. Names are used to refer to objects in the world, and bear a causal relation to their referents. Kripke (1980), for example, proposed that an initial speaker causally links a name to its referent, and that this relation gets passed from speaker to speaker through cultural transmission.

Putnam (1975), who coined the term "essence" in its psychological sense, argued that people believe that an object's name points to essential aspects of things in the world.

In contrast, concepts simply describe how objects *typically* are, which has no bearing on their name. For example, *yellow* and *sour* are typical properties of *lemon*, but people could still call "lemon" an object that did not have those typical features. For Putnam, names are not grounded in mental representations, but on people's intuitions about the essence of objects.

This view has been very influential in motivating research on people's beliefs about essences (see Strevens, 2000, for a critical review). In the specific case of artifacts, Bloom (1996, 1998) argues that people believe a designer's intended function is an artifact's essence. Contrary to an affordances view, the intentional theory assumes that people do not understand an artifact directly from the inspection of its actual or potential use. For example, an umbrella being used as a lampshade is believed to be an umbrella, not a lampshade, because that is what its designer intended it to be.

According to Bloom (1996), people link essences and appearance through an inferential process. He holds that people have assumptions about how a designer's intention causally constrains an artifact's appearance and function. People use these assumptions to guide their inferences as to the artifact's intended function. Specifically, an object is considered to have function X only if its appearance and potential use are best explained as the result of someone intentionally creating the object to fulfill function X. For example, when someone (e.g., a child) is shown an artifact's function, he will accept it as the essential function to the extent that it provides a causal account of how the artifact was designed (Kemler-Nelson, Frankenfield, Morris, & Blair, 2000). Only under these conditions will that specific function be used to guide categorization. In contrast, if some of an object's salient features are not explained by its function, then that function is

not considered plausible. For example, if a stapler is being used as a paperweight, people will reason that this function does not account for several salient aspects of the stapler's structure (e.g., that its interior contains staplers). Because people cannot come up with a causal account of how the object was designed, they conclude that object cannot possibly be a real paperweight.

There are several studies that have attempted to test the intentional theory, producing results that are consistent with it. For example, Gelman and Bloom (2000) showed that 3-, 5-year-olds, and adults are more likely to provide artifact names for objects if they are told a story describing these objects as intentionally created, as compared to being told a story describing the same objects as accidentally created. Similarly, Matan and Carey (2001) showed that when subjects have to choose between naming an object according to an inventor or naming it according to an opportunistic user, 6-year-olds and adults side with the inventor. For example, subjects believe an object designed to be a teapot but used as a watering can should be named "teapot", not "watering can." Finally, Kemler-Nelson, Frankenfield, et al. (2000) showed that in order for function to guide categorization, an object's function has to be credible as the intentional cause of its design. It is not enough that a function is possible given the object's structure (e.g., as an affordances view holds). More strongly, subjects must consider whether the object's function can account for the object's structure. If the object's function does not adequately explain the object's structure, subjects will disregard it as a basis for categorization.

There are certainly aspects of the intentional theory that are worthy of further discussion. Because this theory will be important later for experimental predictions,

however, I will postpone further discussion of it until other necessary conceptual elements are laid out.

The HIPE theory of function

The two views of function reviewed earlier point to different aspects that are relevant for the conceptualization of function: an artifact's actual use and its history. Clearly both these aspects are important for an adult's conceptualization of most objects that have a conventional use. Both are part of a complete account of object function. What distinguishes most clearly the different views of function presented so far is what they assume to be the *central* conceptual component of an object's function (i.e., which component has the greatest effect in categorization tasks). While an affordances view of function assumes the actual use of an object is the central conceptual component, the historical view assumes that an artifact's intentional origin is central.

A theory that views function as the actual use an object is put to, typically assumes that the relations between an object's physical structure, the behaviors it exhibits, and the actions that an agent performs must all be learned. The only way of fully learning all this information is by either witnessing an agent using the object, or by actively exploring the possibilities for action that the object offers. On both cases, subjects' final conceptualization of the object's function should be that the actions of an agent, jointly with the object's physical structure in the relevant setting, cause the outcome. If asked to describe an object's function, a given subject may describe the physical process of using the object (e.g., for *hammer*, a subject might describe that *someone swings the hammer, which—together with the hammer's particular physical structure and setting—results in a nail being driven into place*).

In contrast, if a theory views function as determined by intentional history, it typically assumes that an object's physical structure and the actual way it gets used both result from constraints imposed by its history. Even though subjects generally have not directly experienced the process by which a specific artifact was created, they may have meta-cognitive knowledge that an object's appearance and use are explained by its history. If asked to describe an object's function, a given subject may describe the process of designing that object (e.g., for *hammer*, a subject might describe that *because it was created to drive a nail in place, a hammer must have a flat and heavy head, and be swung onto a nail*).

The HIPE theory assumes both these views about function are necessary for a full account of the conceptual nature of function (Barsalou et al., in press). Someone conceptualizing an artifact's function may assume a use stance, or assume a design stance (Dennett, 1987). However, as developmental research shows, the use stance is most basic and is probably the default. As will become clear later, in contrast to both an affordances view and the intentional theory, HIPE allows for changes in stance by means of changes in subjects' purpose for categorizing.

Psychological theories of function have typically been of limited scope, dealing mostly or even exclusively with artifacts. In contrast, philosophers have dealt with function in many of its different senses (e.g., Wimsatt, 1972; Wright, 1973). In a spirit similar to these philosophical analyses, HIPE defines function broadly, such that it can cover both artifacts and natural kinds. The theory attempts to answer questions about the nature of the network of relations that constitute the concept of function, under the general assumption that a conceptual network can be described as a series of cause-effect

relations. Because different theories can be characterized in terms of different chains of cause-effect relations, causal chains will be an important topic from here on.

Most basically, the HIPE theory proposes that function is a complex relational system. Specifically, function arises out of four domains of knowledge: History, Intentional perspective, Physical environment, Events. Because so many components are included in each domain, the notation in Table 1 will be used to summarize them.

Domains of knowledge in HIPE

Three of the four domains in HIPE can be understood with some ease. These domains are, an object's history (H), the physical environment (P) involved in the object's use, and the events (E) that result from the instantiation of the appropriate causal conditions. The domain of the intentional perspective (I) requires a somewhat more detailed explanation, which will be provided below along with detailed definitions for the other domains.

Intentional perspective. For reasons developed in depth below, HIPE assumes that the intentional perspective (I) of the conceptualizer provides different entry points to someone's functional knowledge. Depending on the current intentional perspective, different functional information can be retrieved for a category, specifying a functional event that realizes a subset of the many possible underlying causal relations. As Table 1 shows, the specific notation here is I: MP, POV. What this means is that an agent's intention leads to, or breaks down into, a meta-cognitive perspective (MP) and a point of view (POV). Each is addressed in turn.

The HIPE theory assumes that the first causal element involved in representing a category is generally MP. The MP taken provides an entry into the web of functional

Table 1. Summary of the HIPE Theory Notation

	Kind	
Domain	Artifacts	Natural Kinds
History (H)	Role (R)	Role (R)
	Invention (IV)	Evolutionary/Geological/ Religious History (EGR)
	Manufacture (M)	Physical Creation (C)
	Use History (UH)	Life History (LH)
Intentional Perspective (I)	Meta-cognitive Purpose (MP)	Meta-cognitive Purpose (MP)
	Point of View (POV)	Point of View (POV)
Physical Environment (P)	Focal Object (FO) Physical Structure (FO_{PS}) Goal (FO_G*)	Focal Object (FO) Physical Structure (FO_{PS}) Goal (FO_G*)
	Setting (S)	Setting (S)
	Agent (A) Physical Structure (A_{PS}) Goal (A_G) Action (A_{ACT})	
Events (E)	Object Behavior (B)	Object Behavior (B)
	Outcome (O)	Outcome (O)

Note: * denotes an optional component. The original naming act of an inventor or a discoverer (N), and the naming acts of later conceptualizers (Nc) are not included in the HIPE domains because they are not part of the causal events that characterize object use. They are however part of the HIPE theory.

knowledge underlying a category, tracing one possible path through it, thereby producing one particular functional event that represents one particular perspective on the category (out of infinitely many possible perspectives). For example, the conceptualizer may have the goal of establishing the history of a category; the goal of determining where an instance of the category may be found; the goal of using an instance of the category; the goal of deciding what would be an appropriate name to call an instance; etc. Whatever goal the conceptualizer has becomes the meta-cognitive purpose for representing the category.

Under some circumstances, MP probably also determines the POV taken. If one wants to use a tool oneself, then that MP determines the POV of the subsequent functional event (i.e., the self). Note that in this case the agent and the goal remain constant at a number of levels, beginning with I, going into P (where the conceptualizer is the agent using the hammer), and then into E, where the relevant outcome occurs. In contrast, if one wants to imagine how some other agent might use the tool, then this MP would determine a different POV. The MP is still to retrieve representative functional information for the category. However, the POV in P and E switches to an actor who is different from the self imagining the function. Alternatively, if one wants to think probabilistically about the likelihood of a function rather than deterministically about individuals, this would appear to determine a point of view where something like an omniscient observer is looking across cases (perhaps across the distribution of situations that can be accessed).

Thus, point of view (POV) is somewhat orthogonal to the meta-cognitive purpose (MP) for representing a category, but may also be causally related. Regardless, POV

provides a more explicit way of indexing whether the goal of the conceptualizer is the same or different as the goals of agents in the physical environment (P) and events (E) domains, to be described shortly.

History. As already reviewed, there is currently evidence that an entity's history, H, is an important part of how people understand function (e.g., Gelman & Bloom, 2000; Matan & Carey, 2001). In the current literature, though, H is conceptualized mainly as the intention of the designer. In contrast, the HIPE theory is not committed to intentional creation. Accidents can also produce functional objects as long as someone notices their functionality. HIPE regards history as a specific point of view for accessing functional information. In this context, HIPE offers several components that are potentially important elements of how people understand the origin of objects. As shown in Table 1, these elements can be summarized as H: R, EGR, C, LH for natural kinds, and H: R, IV, M, UH for artifacts.

The background history of something revolves around the role (R) it serves. For artifacts, the background history, H, of something to achieve role, R, includes the process of invention (IV), and the manufacture of the artifact (M). For example, a gearbox was invented (IV) to fulfill the role (R) of transferring energy from a car's engine to the axle, and is manufactured (M) in a specialized factory. Artifacts develop a use history (UH), which can be consistent or not with their role and may come to dominate their conceptualization (e.g., a brick that has always been used as a doorstop). One could think of R and IV as the long-term history of an artifact category, whereas M and UH can be thought of as the short-term manufacturing history of an instance.

Natural kinds exhibit a parallel structure. Depending on cultural differences, background history may largely reflect religious or scientific belief systems. In any case, an evolutionary/geological/religious history (EGR) has achieved R through physical creation (C) of relevant entities. For some people, physical creation may operate through biological mechanisms in the case of animate objects (e.g., reproduction, birth), or through geological mechanisms in the case of inanimate objects (e.g., chemical reactions). For example, a shark's role (R) is being a predator, which was achieved through a process of natural selection (EGR), with new sharks being created (C) by sexual reproduction. For other people physical creation may be the result of supernatural intervention.

Analogous to artifacts, natural kinds develop a life history (LH), which may or may not be consistent with their evolutionary/geological/religious (EGR) history and role (R). For example, cattle have acquired a life history that has come to dominate their evolutionary/geological/religious role. One could think of R and EGR as the long-term history of a natural kind category, and of C and LH as the immediate history of an instance.

Note that goals are embedded throughout the lower-level components of H for both natural kinds and artifacts. For example, goals are involved during the invention and manufacture of artifacts (IV, M). In general, these goals may often be reflections of the respective roles (R). When an inventor creates an artifact, he or she may intend to invent something that fulfills a role that has become relevant previously. Similarly, manufacturers can be thought of as intending to create a process that produces artifacts to achieve the role. Goals are also involved in an artifact's use history (UH). Occasionally,

for example, these goals do not reflect artifacts' roles (R) but instead tend to replace them. Thus a pasta claw may have been always used as a backscratcher, in which case this role may replace the object's original one.

People may be able to represent a variety of causal chains for H. Sometimes a role may lead to the creation of an entity. For example, a designer may recognize the need for a tool, an eventually manufacture it (R causes IV, which in turn causes M). Sometimes a created entity may lead to a new role. For example, an inventor may create an object and discover that it has an unexpected role, which then leads to the manufacture of new instances of the category (IV causes R, which in turn causes M). Alternatively, causal chains in H can operate in a different domain. For example, once a designer first names an invention (N), this causes that consumers—following a social convention—continue to use that same name (Nc).

Similar variety of causal chains may be possible for natural kinds. However, the question of which causal chains people do construct is an empirical one. The point is that there are a variety of causal chains that people are likely to construct about the history of an object's function.

Physical environment. As described earlier, important information about the actual use of an object comes from how its physical properties and the physical properties of an agent combine (Gibson, 1977, 1979a, 1979b). The HIPE theory assumes that a great many components in the physical environment (P) are potentially relevant to an object's function. These components can summarized with the notation P: FO(PS, G*), S, A(PS, G, ACT)* (where * designates an optional component).

The physical environment contains the focal object, FO, whose function is being described, including its physical structure, PS, and any possible internal goals that it may have (G). For living natural kinds, the focal object—an organism—can often be viewed as containing internal goals (G), along with a physical structure (PS). The default goals of a natural kind can be thought of as a particular instantiation of its role in the ecology (e.g., a vulture might have the goal of scavenging for food). For non-living natural kinds and artifacts, the focal object only has a physical structure, PS, although subjects may construe some artifacts as having internal goals (e.g., a computer trying to protect the integrity of its files). Anthropomorphism would be a classic case when conceptualizers imbue artifacts and non-living natural kinds with internal goals.

The physical environment also includes relevant aspects of the setting, S, which could include other relevant objects (different from the focal object), and locations. For natural kinds, S includes all other relevant characteristics of their ecological setting (e.g., most vultures live in places where there is an unobstructed view of the terrain so carcasses can be easily spotted). For artifacts, S includes other relevant objects and their functionally relevant spatial relations (e.g., the toothpaste's typical location is on the bristles of a toothbrush). HIPE assumes that there are a wide variety of possible S components, but does not specify them further at this stage.

Finally, P may optionally include agents (A). They have physical structures, PS, that constrain their interactions with objects. They also have goals (G) and initiate actions (ACT) to achieve them. Typically, agents are included in P for artifacts, although occasionally they may not be relevant (e.g., for a robot that initiates its own actions). Agents may also be included for non-living natural kinds, given that these kinds can be

thought of as serving functions for agents (e.g., water for animals). For living natural kinds, agents may often not be included, given that these kinds may be conceptualized as having their own internal goals, which allow them to achieve their evolutionary functions (i.e., roles, R). However agents may sometimes be relevant for living natural kinds that become human artifacts to some extent (e.g., crops and livestock).

Together, a focal object (FO), a setting (S), and an optional agent (A) constitute a physical system. When a relevant physical system is fully in place, it achieves full causal power (Cheng, 1997), thereby producing an outcome, O, as described shortly. Sometimes the outcome (O) of a causal event series achieves the focal object's historical role (R = O), namely, when all of the causal conditions for that role reside in P and there are no competing causes. However, the outcome may depart from the historical role when P takes some other form sufficient to produce an alternative outcome ($R \neq O$).

For living natural kinds, the physical structure (PS) of an organism might become altered or damaged in some way, thereby causing it to behave differently than normal. Similarly, for organisms that learn, new goals (G) enter into them from the setting (S) via learning mechanisms, thereby possibly causing them to diverge from evolutionary roles.

For artifacts, the physical environment (P) typically contains external agents (A) who are separate from the focal objects (FO) of interest. In some cases, an agent may use an artifact for a goal that differs from its created role, so that $R \neq G = O$. In these cases, the relevant aspects of S must be in place for achieving the non-historical role. Using an artifact to achieve a non-historical goal is equivalent to the construction of an ad hoc category (e.g., *things that can float*; Barsalou, 1983, 1991). For example, being a

paperweight is not the historical function of a hammer, although an agent may intentionally use one in this way.

In general, the intentional forces that produce functions typically reside within living natural kinds but outside artifacts. For geological natural kinds, intentional goals may be irrelevant to how they achieve their historical geological roles. Instead, causal forces involving the physical structure of the focal object in its natural setting may be causally sufficient (except in cases where people anthropomorphize them, or when agents use them for some non-historical purpose). Although this ultimately depends on how specific subjects conceptualize them, the immediate causal systems that produce outcomes may differ for living natural kinds (internal agency), artifacts (external agency), and geological kinds (no agency).

Events. This domain contains components signaling the end of a complete functional event, which begins with a perspective and is realized when the causal power of a represented physical environment (P) is achieved. These components are the focal object's behavior (B) and the final outcome (O), which may or may not be the same as R and G. Note that an agent's action (ACT) is not included in E but rather in P. This reflects the assumption that the agent's action is part of the necessary causal conditions in P that are required for the subsequent outcome to occur. Thus, the notation for the event domain is E: B, O.

For natural kinds, when the focal object (FO) is in the relevant setting (S), and when all necessary physical properties of FO and S are present, the role (R) of the natural kind is achieved (i.e., R = O). In contrast, for artifacts, when an agent (A) has the original historical goal (G), and performs the relevant initiating action (ACT) in the

necessary setting (S) that includes the focal object, FO, its role (R) is achieved (i.e., R = G = O).

Assumptions of the HIPE theory

HIPE is a theory about knowledge of function—it is not a theory of the physical world. The HIPE theory contains assumptions about the conceptual nature of function that are designed to be consistent with the notion that function is a relational system, but allowing at the same time for conceptualizations of function that are internally differentiated. Although the HIPE theory assumes that the concept of function includes four domains of knowledge, not all of these domains need to be present in any single conceptualization. However, the theory assumes that they are all are necessary for someone to have a full and competent understanding of object function. The HIPE theory assumes that knowing the complete function of something involves knowing everything in the HIPE domains relevant to it. Although a given person may only utilize one small part of the HIPE structure on a given occasion, the person needs to have basic knowledge about everything specified by HIPE in order to have competent knowledge about an entity's function. Just as understanding of function grows cumulatively, conceptual understanding is also increasingly hurt as a function of lack of relevant information. When attempting to understand an object's function, the more complete someone's knowledge is, the better the understanding (this is the assumption of conceptual completeness).

In contrast to conceptual understanding, causal understanding of function involves sufficiency of conditions. According to HIPE, components in the domain of physical environment are typically sufficient to produce functional outcomes. Although history

plays a causal role, it is not sufficient. In contrast, the intentional theory implies that intentional history causes physical structure and use in general. According to that view, intentional history is a sufficient cause.

Returning to the issue of conceptual understanding, although all of HIPE's components are assumed to be conceptually relevant, findings showing that causal properties have higher centrality than their effects suggest that not all HIPE components should be of equal centrality (i.e., they are not all equally important for categorization performance). This will be described in more detail below.

CAUSAL MODELS

Causal models are of importance here for several reasons. As will be argued in this section, not only can all theories of function (including HIPE) be expressed as different causal chains using various HIPE notational components, but also this causal structure should manifest itself in the specific accounts of function that subjects produce in different tasks (as described later). Additionally, this section will describe the conventions to be used in expressing different theories as causal models.

Importance of causal models

Presumably all of the reviewed theories would agree that an object's history, its physical structure, the actions and physical structure of an agent, and the outcomes that ensue are all potentially relevant to function. What most clearly distinguishes the theories is how they construct the causal model that relates these components. For example, an affordances view of function assumes physical structure and actions jointly cause an object's behavior. Alternatively, a historical view assumes that the object's intentional origin causes all the other components. In summary, much of what is

discussed about function in the literature can be conveniently presented as different causal models relating the various components of the HIPE network that underlies the full concept of function.

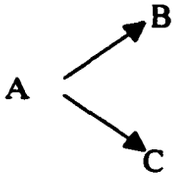
There is more to causal models, however, than the possibility to express all these theories in a common framework. Stating theories as causal models allows us to make predictions about subjects' performance in conceptual tasks. First, if subjects are asked to construct causal chains (i.e., to state the causal relations that exist between different features of a concept), they should report the same kind of causal relations that the theory assumes. For example, if a particular theory says that, for the concept *chair*, the feature *comfortable* causes the feature *has a seat*, subjects should construct that causal chain, and not say that *has a seat* causes *comfortable*. Second, the relation between causality and conceptual centrality allows the derivation of other clear predictions in conceptual tasks.

Several studies show that features from which other features depend (causally or otherwise) are more central to conceptual structure than the corresponding dependent features (Ahn, Gelman, Amsterlaw, Hohenstein, & Kalish, 2000; Sloman, Love, & Ahn, 1998). This is not a mere correlation. Changing people's notion of how causal a certain feature is changes the feature's conceptual centrality (e.g., a causal feature will be considered to be more defining of a certain entity; Ahn, 1998). Consequently, when a theory holds that feature X plays a causal role in people's conceptual structure, the theory is also holding that X is conceptually central (e.g., if an object's history is thought to cause other features associated with that object, it also means that history is considered more central than any other of the object's features). This greater centrality of a feature should become evident in different conceptual tasks. For example, if history is presumed

to be central, then objects' will be named according to the intention of the designer rather than according to their actual use.

Conventions for expressing causal models

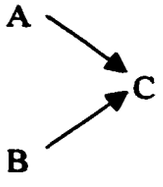
Different causal models can be conveniently depicted with causal graphs. Causal graphs follow a few simple conventions which will be described in what follows (for a complete description, see Pearl, 2000). Stated in very simple terms, a causal graph specifies how several variables relate to each other in a dependency structure, using a series of nodes linked by arrows. For example, a causal model such as:



(1)

shows that both B and C have a common cause (A).

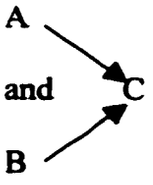
Another example is:



(2)

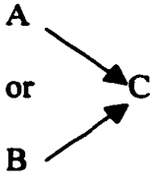
which shows that both A and B can cause C. Because there is no directed arrow between A and B, graph (2) also shows that they are independent of each other. However, a model such as this does not specify if A and B are assumed to cause C independently or jointly (i.e., if A and B are jointly necessary to cause C, or if A or B can independently

cause C). Whenever necessary, in formulating a specific model, all the necessary information to distinguish between these two alternatives will be provided (i.e., disjunctive or conjunctive causes). This will be done simply by adding the corresponding logical operator to the causal graph, which is not a convention in causal modeling and is simply adopted here for convenience of expression. For example, if the model assumes that A and B conjunctively cause C, the model will look as follows:



(3)

If the model assumes that A or B can disjunctively cause C, the model will look as follows:



(4)

A common assumption used in causal modeling is the screening-off property, which will be important in the predictions of later experiments (Salmon, 1971). Screening-off is a normative property that captures the following intuition. In a causal chain such as:

$$X \longrightarrow Y \longrightarrow Z \qquad (5)$$

if all of the causal relation between X and Z is due to Y's mediation, then Y makes X irrelevant for Z. In (5), for example, a consequence of this property is that a cause that is proximal to the effect (Y) screens-off elements that are distal from it (X). If Y is present, changes in X should be irrelevant for Z's occurrence. For instance, consider the causal chain *an agent's intention causes her arm to move, which in turn causes a hammer to pound a nail.* If *arm movement* is fixed in this causal chain (e.g., restricted only to an action that effectively causes the hammer to pound the nail), changes in a*gent's intention* should no longer be causally relevant for *pounding a nail.*

This property is not particular to causal graphs as such, but is general to any model based on causal relations. For instance, if a causal substrate is framed in terms of conditional probability, the screening-off property is a statement of conditional independence. Knowing whether X occurs does not change the probability of Z, given that the state of Y is known. This can be expressed as: P (z/x,y) = P (z/y), whenever P (x,y) > 0.

The screening-off property will be instrumental in generating predictions for Experiments 1 and 2. In a spirit similar to HIPE's assumption of causal sufficiency, screening-off suggests that in complex causal chains a property that is proximal to its effect is more relevant than a distal one, even if both bear a causal relation to their common effect. The use of this logic to derive specific predictions will become clearer later.

FORMALIZING ACCOUNTS OF FUNCTION WITH CAUSAL GRAPHS AND HIPE-NOTATION

Equipped with the tools of causal graphs, different theories about function can be put into a common framework. As the HIPE theory assumes, function presumably

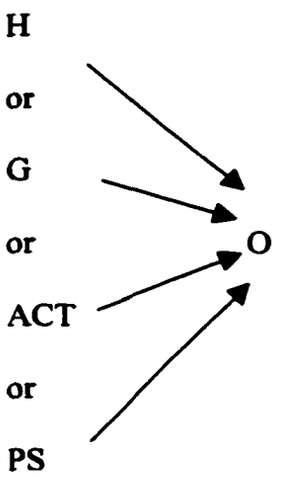
encompasses knowledge about a multitude of components and relations between them. Because the focus of this dissertation is on artifacts (as they are the most natural ground for testing theories about function), and because of the complexity of expressing the different theories, only a few essential components will be considered in the following analyses. In principle, however, more detail could be included.

The function of complex artifacts and biological entities requires understanding how they fit into a larger system of which they are part (e.g., thermostat, heart). Thus, defining their functions would require the inclusion of an important amount of setting (S) information, and perharps other components that HIPE specifies. In contrast, the function of many simple artifacts can be minimally described with five components from three of the HIPE theory's domains (i.e., H, P, and E). These components are: a focal object's history (H), its physical structure (PS), an agent's goal (G), his actions (ACT), and the outcome (O) that ensues. Using just these components, several possible theories of function can be expressed as causal models. Mapping possible accounts of function in this space elucidates commonalities and differences between theories. It also leads to the formulation of two additional models not previously considered in the literature. These new models will be used as limiting baselines for existing theories and for the experiments.

Disjunctive model

An advantage of being able to express different theories as causal models is that the space of possible accounts can be explored in a systematic way. A very simple causal model that can be formulated holds that all potential causes of the outcome (O) are able to produce O by themselves. That is, it assumes that history (H), agent goal (G), agent

action (ACT), or physical structure (PS) are all sufficient causes of functional outcomes. This model obviously does not apply to the case of an artifact's function. However, being a very loose way to conceptualize function, it can be used as a baseline to contrast the predictions of other models. This model takes the following form:

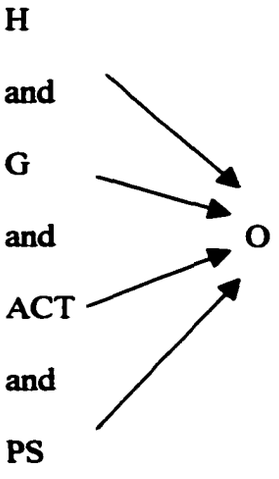


(6)

Conjunctive model

Another possible model that can be formulated is that history, H, and physical structure, P, are both conjunctively necessary to produce a functional event. Cheng (2000) extended Power PC theory to encompass conjunctive causes. When this extension is applied here to the problem of object function, a possible model is that full causal power (to explain O) can be achieved only by the conjunction of all other elements (i.e., history, goal, action, physical structure). A characteristic of this conjunctive model is that any single component is thought to have near zero causal power. Although no author has entertained this model, it seems a plausible one. It is consistent with the intuition that a complete account of an object's function requires all pieces of information that people

can have about function. In contrast to a disjunctive causes model, this is a very tight model because it does not spread causal power across all components. Thus, it offers the opposite end in the spectrum of possible models. The model takes the following form:



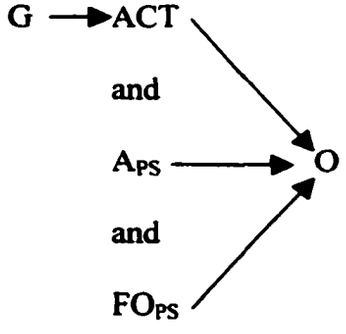
(7)

Affordances model

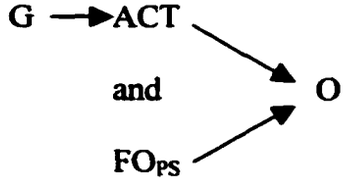
As discussed when reviewing the literature, the affordances view of function draws on a tradition that understands it as a reflection of actual or potential physical interactions with objects. Within this tradition, though, differences exist. Gibson (1977, 1979a, b) views functional affordances as resulting from the interaction of the physical structures of an agent and an object. This interaction affords specific actions, and agents perceive these possibilities for action as invariant properties. In contrast, Madole and collaborators (Madole & Cohen, 1995; Madole, Oakes, & Cohen, 1993) view function as correlated pairs of object behavior and object physical structure. An agent's action typically reveals these correlations, allowing subjects to learn them.

Although these theories differ regarding the origins of the relational system that underlies function, when both are expressed as causal graphs their affinities become

apparent. Causal graphs (8) and (9) show the implied causal structures of—respectively—an invariant and a correlational version of the affordances view. Causal graph (8) shows that the conjunction of the physical structure of both the agent, A_{PS}, and the focal object, FO_{PS}, and the agent's action, ACT,(presumably caused by a goal, G) causes an outcome, O. Causal graph (9) shows the conjunction of the focal object's physical structure, FO_{PS}, and the agent's action, ACT,(presumably caused by a goal, G) causes an outcome, O. Placing both causal graphs back to back reveals their structural similarity.



(8)



(9)

The only structural difference between both formulations is that causal graph (8) includes the agent's physical structure. Although an embodied view of cognition would consider that an agent's physical structure has important consequences for the structure of the conceptual system, taking this into account is well beyond the scope of this

dissertation. Because of this, causal graph (9) will be used to represent affordances views of function in general. This however does not imply any specific commitments about the origins of this structure.

Intentional model

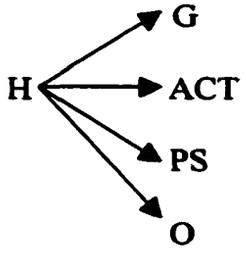
Because it is not straightforward to express the intentional theory as a causal model, now is a good opportunity to discuss it in more detail. It is first useful to reiterate some of the theory's basic tenants. The intentional theory states that subjects relate the designer's intention and the object's current use via an inferential process. Subjects consider a function plausible (and use it to guide categorization) only if it provides a convincing causal account of how an artifact's physical structure was designed. In contrast, if some of the object's salient features are not explained by the object's function, then the current function is not going to be considered as plausible (and will be less likely to guide categorization).

It is worth stressing that this account of function assumes intentional creation. Although it is quite possible for people to lack knowledge of an artifact's intentional design, the intentional theory requires that subjects have assumptions about how objects are designed, and use these assumptions to guide their reasoning process. The inferential process is insufficient by itself to account for artifact's essences, and depends crucially on people's assumptions about how artifacts are designed.

A comparison with the HIPE theory serves to illustrate this point. In the HIPE theory an artifact's history does not necessarily include intentional design. Take for example a causal chain where someone accidentally finds out that a given natural object can be used to achieve a certain goal. In contrast, according to the intentional theory the

mere plausibility of a function's causal account is not enough. It is necessary that this account includes intentional design. This is precisely what motivates the prediction that when people are informed that a certain object was accidentally created—even if its appearance closely resembles that of artifact category X—they will not consider that object to be a member of artifact category X (Gelman & Bloom, 2000).

In conclusion, the intentional theory (Bloom, 1996, 1998) assumes that any causal chain reflecting an artifact's function starts with its intentional design. The intention of the artifact's creator is the best explanation for the artifact's properties, and for its function. History (H) causes the goal (G), the action (ACT), the physical structure (PS), and the outcome (O). The following causal graph expresses the theory (where history, H, is always intentional):



(10)

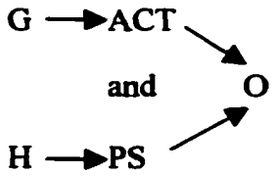
Note that this is the only way in which the intentional theory can be expressed as a causal graph. Causal graph (10) assumes that there are no restrictions on the causal power of H (i.e., its effect is not screened off by any other component, it is not part of a conjunctive cause, and there are no other potential disjunctive causes). Therefore—because of the relation between causality and conceptual centrality—H behaves as an artifact's essence.

HIPE model

The HIPE theory has several built-in constraints for expressing causal graphs that represent function. One of these constraints is that a component from the event domain (E) is always the last element of the functional event. This constraint reflects the assumption that an outcome or an object behavior ensues after all necessary components are in place and full causal power is achieved, just as happens when an artifact is actually used. In this sense, HIPE adopts an affordances view of function. An additional constraint is that all causal chains in HIPE start with an intentional perspective (I). Although for the sake of simplicity the intentional perspective will not be included in HIPE's causal graph, it should be understood as implicitly there.

Similar to the intentional theory, the HIPE theory considers that an object's history is an important component of its function. Although in the HIPE theory, an artifact's history is much less constraining than in the intentional theory. First, the HIPE theory assumes that an object's history does not have unrestricted causal power. As discussed earlier, an entity's history includes its physical creation, which—in the case of artifacts— typically corresponds to the manufacturing process. As a result of this creation process, a given artifact has a particular physical structure. However history does not necessarily guide how the object is going to be later used by any specific agent (i.e., it does not determine actual use). Second, the HIPE theory is less restrictive regarding the kind of history that is acceptable. Whereas the intentional theory requires intentional creation, the HIPE theory does not. For example, subjects can conceive a causal chain where an artifact gets accidentally created, with the inventor only later finding a role for it.

Although HIPE allows for considerable more detail and for different causal structures depending on specific intentional perspectives, the model shown next summarizes HIPE's central assumptions and constraints about function.



(11)

Causal graph (11) shows that an artifact's history (H)—which may or may not include intentional design—causes the entity to have a certain physical structure (PS) which is necessary for it to behave as it does. When an agent has a goal (G) and acts (ACT) accordingly, those actions jointly with the artifact's physical structure cause an outcome (O). Critically, however, G and H are screened-off, thereby making PS and ACT jointly the sufficient causal factor in function.

MEASURING FUNCTION

Although different theories about function can be expressed in a common framework, there is an additional problem confronting a comparison of theories. The problem is that—for practical and theoretical reasons—different measures have been used to assess the effect of function on conceptual tasks. Several studies have used classification measures (e.g., Keil, 1989; Medin, Lynch, Coley, & Atran, 1997), while others have used naming (e.g., Landau, Smith, & Jones, 1998), and yet others have used causal judgments (e.g., Ahn, 1998). As is commonly the case, this variety of measures makes comparison across studies difficult.

Although several studies use classification measures, the specific kinds of classification tasks used vary as a function of the population under study. For example, in studies where infants are the focus, habituation measures are used because they do not require the use of language (e.g., Madole, Oakes, & Cohen, 1993). In contrast, because language is not a limitation with older children and adult populations, classification tasks have often assumed the form of questions about object similarity (e.g., Smith, Jones, & Landau, 1996), or about whether something can be called an X (e.g., Malt & Johnson, 1992).

It is possible to show that how something is called (i.e., its name) can be dissociated from what people think the object really is (Malt, Sloman, Gennari, Shi, & Wang, 1999; Sloman, & Ahn, 1999). In the context of research about function, however, the question of whether something can be called an X is generally believed to reflect a subject's conception of an object's real nature.

Because differences in measures make comparisons across studies difficult, three measures will be used here (for the first time in any study). As explained below, subjects will be presented with a scenario that describes a situation concerning an object's function, and will be asked one of three questions. A given subject will be required to rate either how appropriate a certain name is for an object (i.e., *naming* question), whether the object has a certain function (i.e., *function* question), or to rate the likelihood that a certain outcome will ensue as a result of the situation described (i.e., *causality* question).

OVERVIEW OF THE EXPERIMENTS

Although HIPE is a theory of knowledge about function in general, encompassing both artifacts and natural kinds, the focus here is on artifacts, as they are the most natural ground for testing the theory. Four experiments were conducted, each seeking to test different aspects of the theory.

The paradigm used involved presenting subjects with scenarios that contain information about an object's function, and collecting ratings on three different questions: naming, function, and causality (between subjects). These scenarios were designed so that an important portion of what HIPE assumes to be relevant knowledge about function is provided. More specifically, the scenarios contained information about an object's history (H), its physical structure (PS), the goals of an agent that uses the object (G), and the actions that she performs (ACT). Though these are not all of the HIPE theory's components, they are probably enough to essentially capture many artifacts' functions, and to distinguish the relevant theories.

In the first two experiments, different hypothesis from HIPE and contrasting theories were tested by systematically compromising each component. As fully explained later, HIPE predicts naming ratings will depend critically on H, function ratings will depend on all components (although PS and ACT will have a greater effect), and causality ratings will depend only on proximal components (PS and ACT). The third experiment addressed a methodological concern. It may be that the scenarios' narrative structure accounts for results in the first two experiments. The fourth and last experiment was aimed at showing that effects of history reported in the literature (Gelman & Bloom, 2000; Matan & Carey, 2001) can be explained by the HIPE theory without assuming the

intentional theory's inferential process. Historical effects can be explained by subjects knowledge of the relational systems that underlie function (as discussed previously), and by their knowledge of the social conventions that govern naming.

EXPERIMENT 1

This experiment attempted to establish the best fitting model of the conceptual relations that hold between the critical HIPE components (i.e., H, PS, G, ACT, and O). Specifically, it attempted to distinguish if the conceptual structure of an object function is best fitted by the HIPE theory, the intentional theory, the affordances view, or by one of the two baseline models (i.e., conjunctive and disjunctive models).

The procedure is simple to explain. Subjects were presented with scenarios that provide information about an object's function. There were five types of scenarios: a baseline, were all components are intact, and four other scenarios each compromising one critical causal component (i.e., H, G, PS, or ACT). After reading each scenario, subjects were asked to do a causal, function, or naming rating. Under these conditions each theory makes different predictions. Because there are three dependent measures and five different theories, predictions require detailed discussion.

Predictions

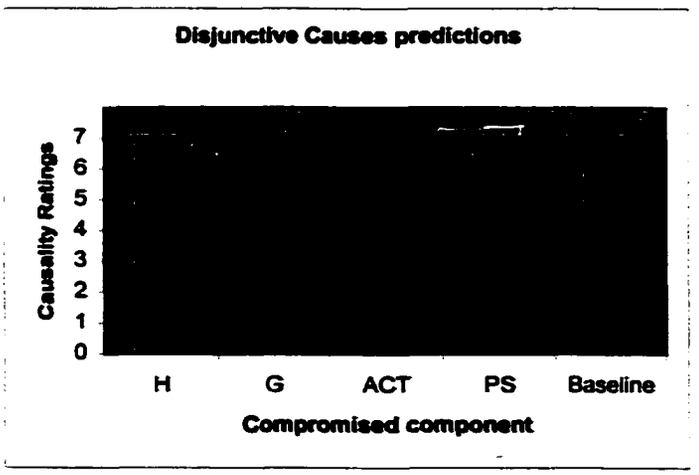
One of the advantages of expressing all five theories as causal models is that the same machinery can be used to derive predictions for all of them. To derive predictions, assumptions of causal sufficiency and of conceptual completeness will be used as auxiliary hypothesis applicable to all theories. Specifically, predictions for causal, function, and naming ratings will always be derived from a theory's causal model as follows. Because proximal causes should normatively screen-off distal ones, causality

ratings will depend exclusively on a model's proximal causes. Function ratings will depend on all components considered by a model, but more to the extent that they are causally relevant (i.e., screened-off components are predicted to make smaller contributions). Predictions for naming ratings will follow function ratings unless explicitly predicted otherwise by the theory. (Note that predictions made below are not point predictions, and that they are presented in graphical format only for ease of expression).

Disjunctive model

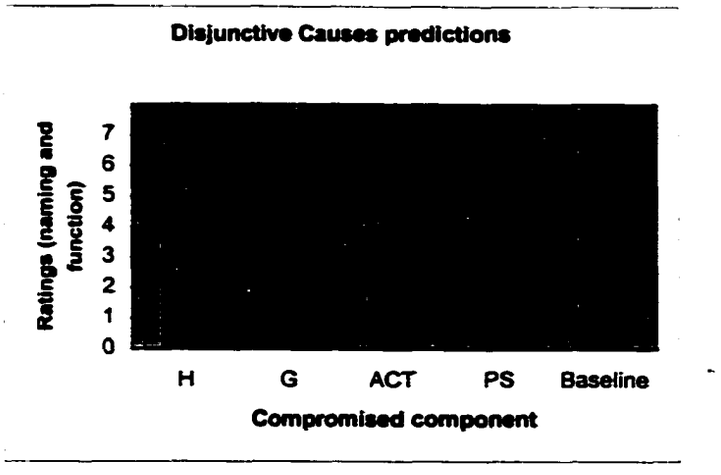
As causal graph (6) illustrates, the disjunctive model assumes that every cause of an outcome (O) can produce it on its own. Thus, this theory predicts that eliminating any of the putative causes from the compound cause will not result in a reduction of causality ratings (see Figure 1). Any cause alone should be fully sufficient to produce O.

Figure 1. Disjunctive theory predictions for causality ratings.



In contrast function and naming ratings should decrease when any component is compromised. This because by applying the known relation between conceptual centrality and causality, it follows that all components of the description should be equally central (i.e., they are all equally proximal to their common outcome). Naming and function ratings should show partial reductions when any single component of the descriptions is compromised. Figure 2 summarizes these predictions for the disjunctive causes theory.

Figure 2. Disjunctive theory predictions for function and naming ratings.

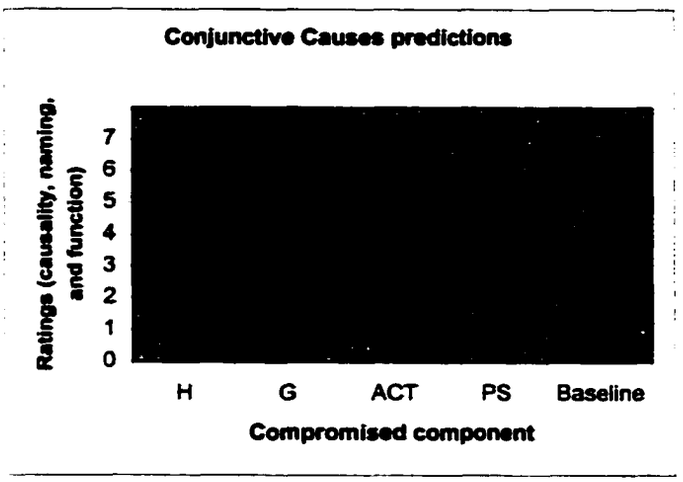


Conjunctive model

As causal graph (7) illustrates, the conjunctive model assumes that all putative causes are conjunctively necessary to produce an outcome. Consequently, any scenario that compromises a single component will reduce causal potency substantially (see Figure 3 for predictions). In the conjunctive causes model there is only a single sufficient cause, namely all causes together. Therefore, causal graph (7) also illustrates that this

compound cause is conceptually more central than any single component. Because all components are jointly necessary, naming and function ratings should also show an important reduction when any single component is compromised.

Figure 3. Conjunctive theory predictions for causality, function, and naming ratings.



Affordances model

As causal graph (9) illustrates, history (H) does not play a role in the affordances view. Instead, it assumes that an object's physical structure (PS) and an agent's actions (ACT) are the relevant causes of a functional outcome (O). Consequently the theory predicts that causal potency will be significantly affected in scenarios where either one of those components are compromised. Because goals (G) are screened-off, the presence of the relevant actions should make them causally irrelevant, i.e., they should have no effect in causal ratings (see Figure 4).

In contrast, because of the conceptual completeness assumption, all components should be important for naming and function ratings. However, being PS and ACT the

most proximal causes of a functional outcome (O), they should produce the greatest effect. Contrastingly, because goals (G) are screened-off they should be less central than other components (see Figure 5).

Figure 4. Affordances view predictions for causality ratings.

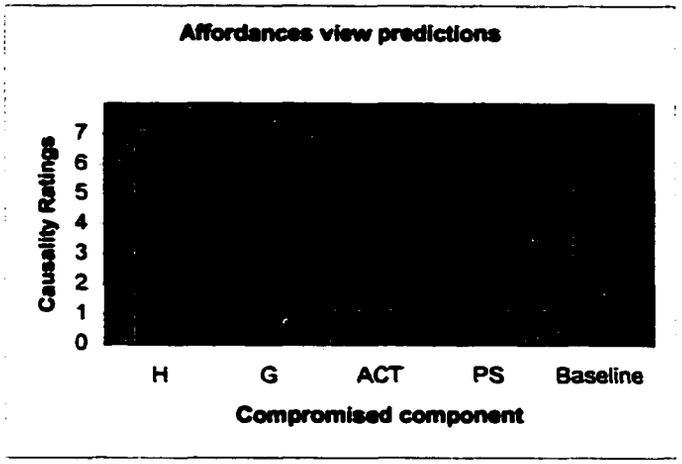
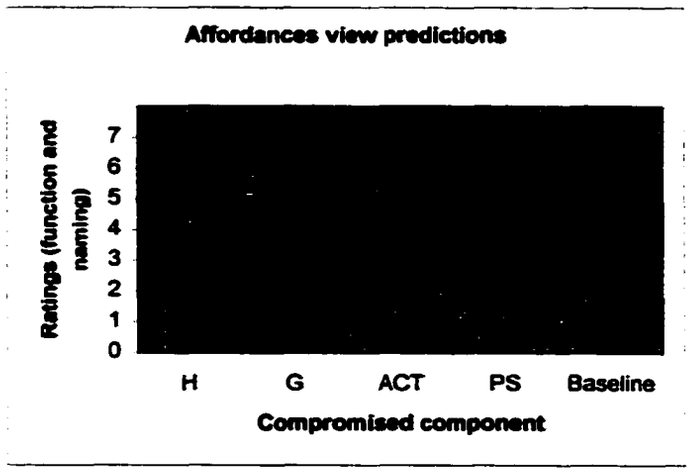


Figure 5. Affordances view predictions for function and naming ratings.



Intentional model

Although the intentional theory is not directly concerned with the problem of whether a given physical environment will be causally sufficient to produce a certain outcome, the theory's causal model does have implications for causal ratings. As causal graph (10) shows, the intentional theory holds that H causes everything else. There are no restrictions on the causal power of H (i.e., its effect is not screened-off by any other component, it is not part of a conjunctive cause, and there are no other potential disjunctive causes). Consequently the model predicts that only a scenario where intentional history is compromised will produce an effect in causality ratings (see Figure 6).

Because causal features are more central than their corresponding dependent features, H is the most central component in the conceptual network. The intentional theory, however, makes an even stronger claim: history must be intentional. The prediction is that when an artifact X is described as being accidentally created, subjects should not consider it conceptually an X and not be willing to name it an X. It is this strong claim which is tested in Experiment 1. Not simply that any history can cause function.

It is worth noting that this prediction is essentially in line with Gelman and Bloom's (2000) conjecture regarding that unintentionally created objects will not even be considered members of the artifact kind. Also, the equivalence of naming and conceptual tasks is explicitly argued by Bloom (1998). Presumably—he argues—both are based on the same inferential process by which the real nature of the artifact is apprehended (i.e., the construction of a causal account of the object's physical structure). The intentional

theory of function predicts the same pattern of results for both naming and function ratings.

The theory further predicts that when an artifact X does not have the physical structure that allows it to perform a certain function, subjects will not conceptualize it or name it as an X. Although causal graph (10) does not capture this explicitly, it has been a central part of the intentional theory. For example, if an object is described as being created with the intention of putting screws in place but does not have the critical physical features to perform its alleged function, subjects should disregard the designer's intention and consequently not classify it as a screwdriver (see Figure 7 for these predictions).

Figure 6. Intentional theory predictions for causality ratings.

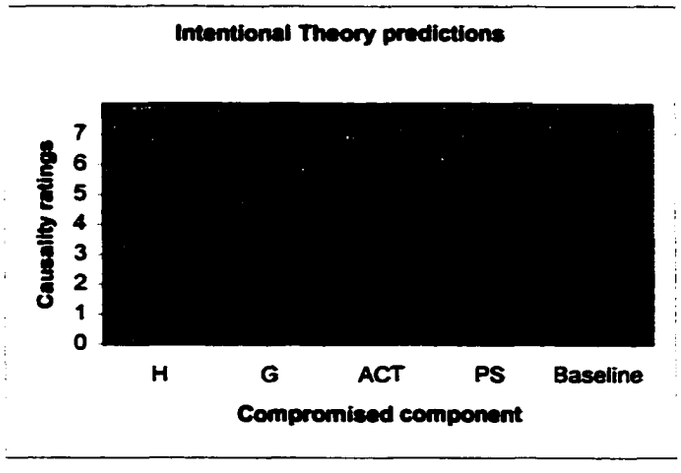
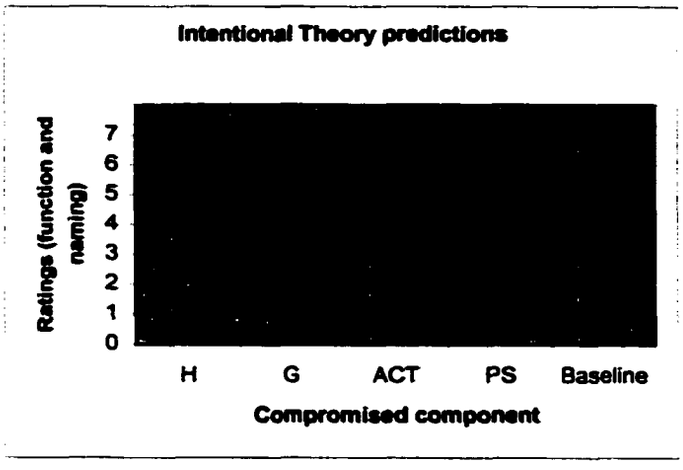


Figure 7. Intentional theory predictions for function and naming ratings.



HIPE model

As causal graph (11) illustrates, only physical structure (PS) and action (ACT) are direct causes of outcomes (O). This because—when all the components are in place—history (H) and goal (G) are screened-off. Consequently the prediction is that only those scenarios that compromise PS and ACT should result in a reduction of causality ratings (see Figure 8).

A slightly different pattern is predicted for function ratings. Causal components that are sufficient to produce an outcome will be more central than those that are distal. Again, because history and goal are screened-off, the most central conceptual components should be action and physical structure. Accordingly, the prediction for function ratings is that scenarios that manipulate history or goal should produce an effect in function ratings, although their effect will be smaller than that of scenarios that manipulate physical structure and action (see Figure 9).

Figure 8. The HIPE theory predictions for causality ratings.

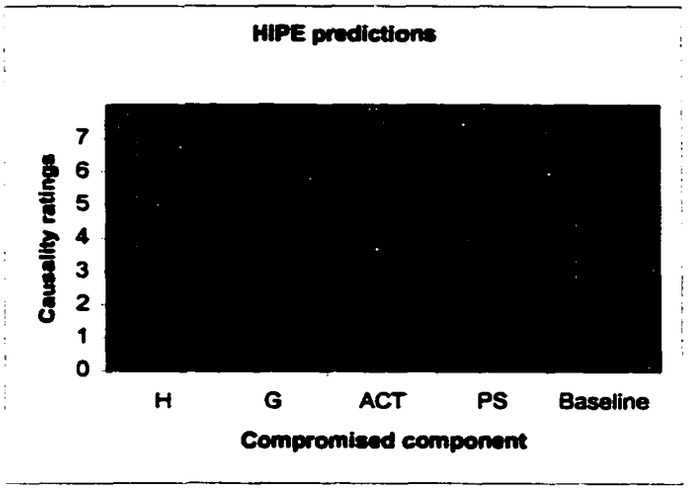
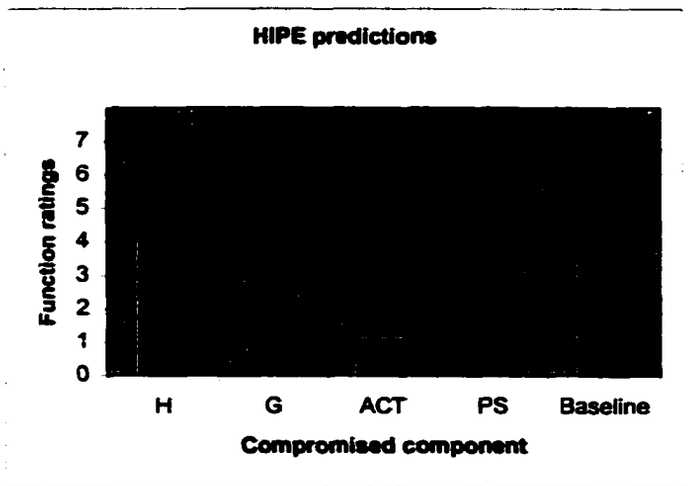


Figure 9. The HIPE theory predictions for function ratings.



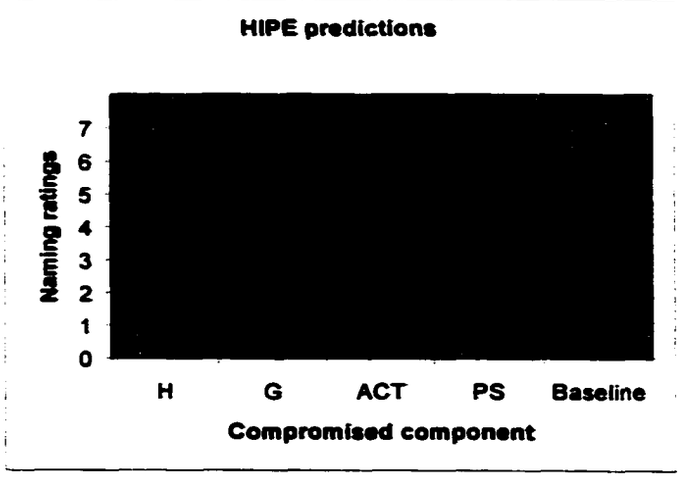
Ratings of how appropriate a certain name is, should show a different pattern. The HIPE theory views the function question as closely related to the causal question. Both reflect knowledge of the interactions that people have with objects. In contrast, the HIPE theory assumes that deciding if a certain name is appropriate for an object is a different task, and that subjects should therefore adopt a different meta-cognitive purpose

(MP). Whereas functional and causal questions require subjects to draw on knowledge about the interactions that people have with a certain object, naming requires subjects to draw on their knowledge of the social conventions that are at work when objects receive a name. One of such conventions is that artifacts are labeled by their designer and that other people continue using the same name afterwards (Kripke, 1980). This can be expressed in the following causal graph:

$$N \longrightarrow Nc \qquad (12)$$

Causal graph (12) shows that the designer's act of naming an artifact (N) directly causes the naming practices of people who later name the object (Nc). Consequently, the HIPE theory predicts that only the accidental creation scenario will result in a reduction of ratings of how appropriate a given name is for the artifact being described (see Figure 10).

Figure 10. The HIPE theory predictions for naming ratings.



Method

Design and Subjects

Seventy-four Emory University undergraduates (11 males and 61 females) participated for course credit. Subjects read 15 scenarios and performed either causal, function, or naming ratings. Each scenario describes the creation and use of an object (mop, whistle, or charcoal pencil).

This experiment follows a 5 x 3 mixed design. The factors are scenario (five types of scenarios, described below), and rating (causality, function, naming). Scenario is a within subjects factors and rating is between.

Materials

There are five types of scenarios and three objects, for a total of fifteen different scenarios (see Appendix A). Each scenario presents two characters, one involved in the object's creation and the other in its use. The objects are a mop, a whistle, and a charcoal pencil. The first type of scenario is a baseline that completely describes an artifact being intentionally created and used, including its history (H), its physical structure (PS), the goals of an agent (G), and the actions performed by the agent using the artifact (ACT). The other four types of scenarios present situations in which one critical component is compromised (i.e., either H, PS, G, or ACT). When intentional history is compromised, the scenario describes an object being accidentally rather than intentionally created (the *accidental creation* scenario). When goals are compromised, the scenario describes an agent using the artifact without intention of doing so (the *accidental use* scenario). When actions are compromised, the scenario describes an agent who does not exhibit actions relevant to producing the artifact's usual outcome (the *inadequate action* scenario).

When physical structure is compromised the scenario describes the object's physical structure as inadequate to produce the usual outcome associated with the artifact (the *inadequate object* scenario).

Each subject received all 15 possible scenarios (3 objects x 5 scenario types). To control for order effects, four different sequences were constructed. Each sequence contained three blocks of 5 scenarios, with each block containing one instance of each type of scenario (i.e., one baseline, one accidental creation, one accidental use, one inadequate action, and one inadequate object scenario). In each sequence of 15, no two consecutive scenarios described the same object or the same type of scenario.

After reading each scenario subjects were asked to provide ratings on a single dependent measure (i.e., either causality, function, or naming) and to rate how confident they were of their responses. Any given subject rated the same type of question for all scenarios she received. Ratings were done on a seven point scale, with 1 always reflecting the low- and 7 the high-end of the scale. The causality question described the outcome usually associated with using the artifact and required subjects to rate its likelihood given the information provided by the scenario. For example, when a scenario described a mop subjects had to rate how likely it was that a water spill was wiped up. The function question asked subjects to rate how well a given scenario illustrated the function of the artifact being described. For example, for a scenario describing a mop subjects had to rate how well the scenario illustrated a mop's function. Finally, the naming question required subjects to rate how appropriate it was to call the described object an X (where X was the name generally given for the artifact being described). For

example, when the scenario described a mop subjects had to rate how appropriate it was to call the object "mop."

Procedure

Subjects were tested in groups of up to three at a time. Instructions were presented in writing but were also read out loud by the experimenter. After receiving the instructions, subjects performed three practice trials. These trials were not related to function but, similarly to critical trials, involved two characters. One of these characters was described as doing something that could potentially upset his partner, and subjects had to answer a question about the partner's emotional state (see Appendix A). As a way to promote correct use of the scale, subjects were encouraged to discuss their practice ratings.

After finishing the practice trials, subjects were left to work individually. During this period they had to rate four buffer and fifteen critical trials. Buffer trials had the double aim of inducing subjects to use the full range of the scale and of acquainting them with the general structure of the critical scenarios. These trials employed two objects different from those used in critical trials (gardening fork and clothes hanger), but the critical judgment was the same (causality, function, or naming). After the four buffers, subjects received 15 critical trials as described earlier.

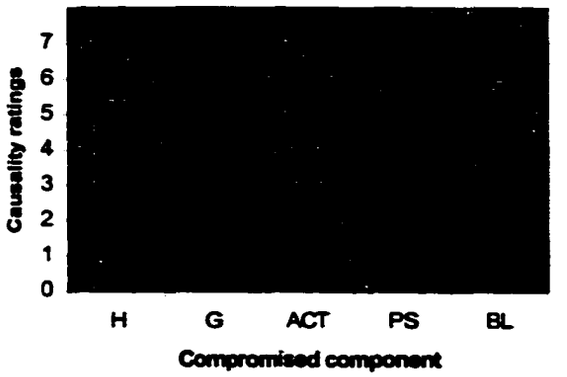
When subjects finished rating all 15 scenarios, they were asked to describe their understanding of the experiment. They were asked what they thought the experiment's hypothesis was, and how—if in any way—the different scenarios were related to each other.

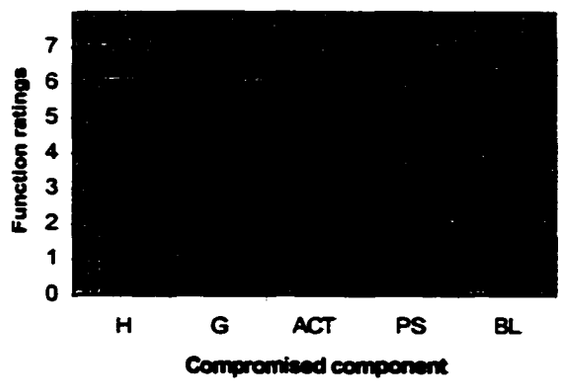
Results

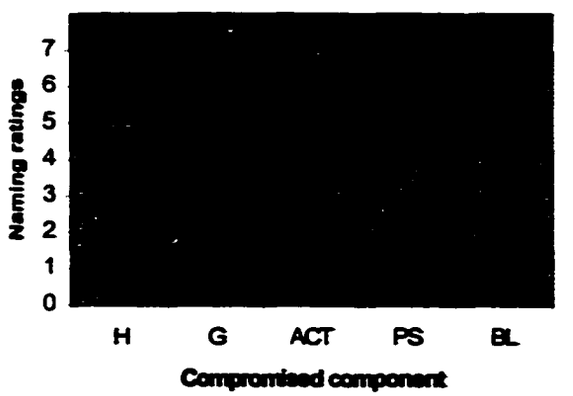
For each subject, the average rating of each scenario type was computed across all three objects. Thus, each subject contributed 5 data points, one for each type of scenario (the results can be seen in Figure 11). These data were submitted to a 5 (scenario) x 3 (rating) ANOVA, with rating as a between subjects factor. Because of sphericity violations, degrees of freedom were adjusted by Huynh-Feldt's epsilon (.671). However for clarity of presentation, degrees of freedom are presented here without adjustment. The overall analysis revealed a main effect of rating ($F(2, 69) = 5.36$, $MSe = 2.78$, $p < .007$, $R^2 = .13$, power = .83) and a main effect of scenario ($F(4, 276) = 123.28$, $MSe = 1.61$, $p < .001$, $R^2 = .64$, power = 1). There was also an interaction of rating and scenario ($F(8, 276) = 10.95$, $MSe = 1.61$, $p < .001$, $R^2 = .24$, power = 1).

For each rating the same 8 planned comparisons were carried out across scenarios. These comparisons provide a test for the most complex predicted pattern of results (i.e., the HIPE theory's predictions for function ratings), which involves all scenarios being lower than baseline and proximal components being lower than distal ones. Consequently, all other less complex predictions are covered by some subset of these eight comparisons. First, all scenarios were compared to baseline. Second, inadequate action was compared to accidental creation and accidental use. Last, inadequate object was compared to accidental creation and accidental use. Keep in mind that all scenarios other than baseline compromise one component. Accidental creation compromises intentional history, accidental use compromises agent goal, inadequate action compromises agent action, and inadequate object compromises physical structure.

Figure 11. **Results for causality, function, and naming ratings in Experiment 1 (H = history, G = agent goal, ACT = agent action, PS = physical structure, BL = baseline. Error bars are standard errors).**







For causality ratings, all 8 comparisons were significant. When compared to baseline, all the other scenarios received significantly lower ratings (for accidental creation, $F(1, 23) = 7.99$, $MSe = .18$, $p < .01$; for accidental use, $F(1, 23) = 23.84$, $MSe = .34$, $p < .001$; for inadequate action, $F(1, 23) = 116.15$, $MSe = 1.32$, $p < .001$; for inadequate object, $F(1, 23) = 54.43$, $MSe = 1.91$, $p < .001$). The inadequate action scenario received lower ratings than both the accidental creation and the accidental use scenarios (respectively, $F(1, 23) = 96.72$, $MSe = 1.29$, $p < .001$; $F(1, 23) = 61.14$, $MSe = 1.48$, $p < .001$). Finally, the inadequate object scenario also received lower ratings than the accidental creation and accidental use scenarios (respectively, $F(1, 23) = 40.57$, $MSe = 2$, $p < .001$; $F(1, 23) = 23.88$, $MSe = 2.27$, $p < .001$).

When the same comparisons were performed for function ratings, all comparisons except for accidental creation versus baseline were significant. Only the accidental creation scenario did not receive significantly lower ratings than baseline (for accidental creation, $F(1, 23) = 4.2$, $MSe = .22$, $p < .052$; for accidental use, $F(1, 23) = 22.88$, $MSe = .32$, $p < .001$; for inadequate action, $F(1, 23) = 222.18$, $MSe = .78$, $p < .001$; for inadequate object, $F(1, 23) = 97.18$, $MSe = 1.18$, $p < .001$). The inadequate action scenario received lower ratings than both the accidental creation and the accidental use scenarios (respectively, $F(1, 23) = 135.04$, $MSe = 1.11$, $p < .001$; $F(1, 23) = 91.85$, $MSe = 1.2$, $p < .001$). Finally, the inadequate object scenario also received lower ratings than the accidental creation and accidental use scenarios (respectively, $F(1, 23) = 56.39$, $MSe = 1.24$, $p < .001$; $F(1, 23) = 25.47$, $MSe = 1.73$, $p < .001$).

Aside from the analyses for grouped data, it was interesting to see if the aforementioned patterns for causal and function ratings were also present at the level of

individual subjects. For each subject, two comparisons were made. To be consistent with the grouped data, two patterns should appear. The average of accidental creation and accidental use ratings should be lower than baseline. The average of inadequate action and inadequate object ratings should be lower than the average of accidental creation and accidental use. For causal ratings, 19 subjects (79%) satisfied both comparisons. For function ratings, 17 subjects (71%) satisfied both comparisons.

While the pattern of results for causality and function ratings was markedly similar, planned comparisons revealed a different configuration for naming ratings. Accidental use was the only scenario not rated significantly lower than baseline (for accidental creation, $F(1, 23) = 7.59$, $MSe = .79$, $p < .011$; for accidental use, $F(1, 23) = 2.21$, $MSe = .34$, $p < .151$; for inadequate action, $F(1, 23) = 15.2$, $MSe = .86$, $p < .001$; for inadequate object, $F(1, 23) = 69.65$, $MSe = 1.29$, $p < .001$). Inadequate action was not rated significantly lower than accidental creation, but it was significantly lower compared to accidental use (respectively, $F(1, 23) = 1.39$, $MSe = .96$, $p < .25$; $F(1, 23) = 11.99$, $MSe = .63$, $p < .002$). Finally, the inadequate object scenario was rated significantly lower than both accidental creation and accidental use (respectively, $F(1, 23) = 29.61$, $MSe = 1.67$, $p < .001$; $F(1, 23) = 42.41$, $MSe = 1.75$, $p < .001$).

As before, it was interesting to see if the grouped data pattern held for individual subjects. Two comparisons were made for each subject. Accidental creation was expected to be lower than baseline, and inadequate object was expected to be lower than accidental history. Out of 24 subjects, 14 (58%) satisfied both comparisons.

Because HIPE predicts that intentional history should have a greater effect in naming than in causality and function ratings, the effect of compromising intentional

history was contrasted across ratings. As predicted, naming ratings when intentional history was compromised (i.e., in the accidental creation scenario) were significantly lower than the average of causality and function ratings in the same condition ($F(1, 69) = 11.67$, $MSe = 1.29$, $p < .004$).

A concern in interpreting these data is the possibility of practice effects. Subjects might have learned something about the experiment's hypothesis or the structure of the scenarios, which could have informed their ratings. However further analyses show this is not likely to be the case. As revealed by their answers during debriefing, none of the subjects discovered the hypothesis for their rating condition (i.e., causality, function, or naming). Additionally, only a few subjects learned much about the structure of the scenarios. The criterion used to decide if subjects learned scenario-structure was if they mentioned, during debriefing, that scenarios described objects being created intentionally or accidentally and later used correctly or incorrectly. Only 2 subjects out of 72 met this criterion (2.8%). When this rule was relaxed so that subjects needed only mention one opposition , i.e., either intentional vs. accidental creation or correct vs. incorrect use, 17 subjects (23.6%) showed evidence of understanding scenario structure. However when means were computed for the sample without considering these 17 subjects, the general pattern of results seen in Figure 11 remained (see Table 2). (Note that all results involving subsamples are presented in tabular form, as a way to distinguish them from analyses where the sample is intact, for which figures are used).

The fact that critical trials were organized in three blocks of 5 scenarios where each block contained one scenario of each type, offered another way to explore if results could be explained by practice. If the pattern of results was due to the effect of practice,

Table 2. Mean ratings for subjects who did not learn the structure of scenarios in Experiment 1 (standard errors in parenthesis).

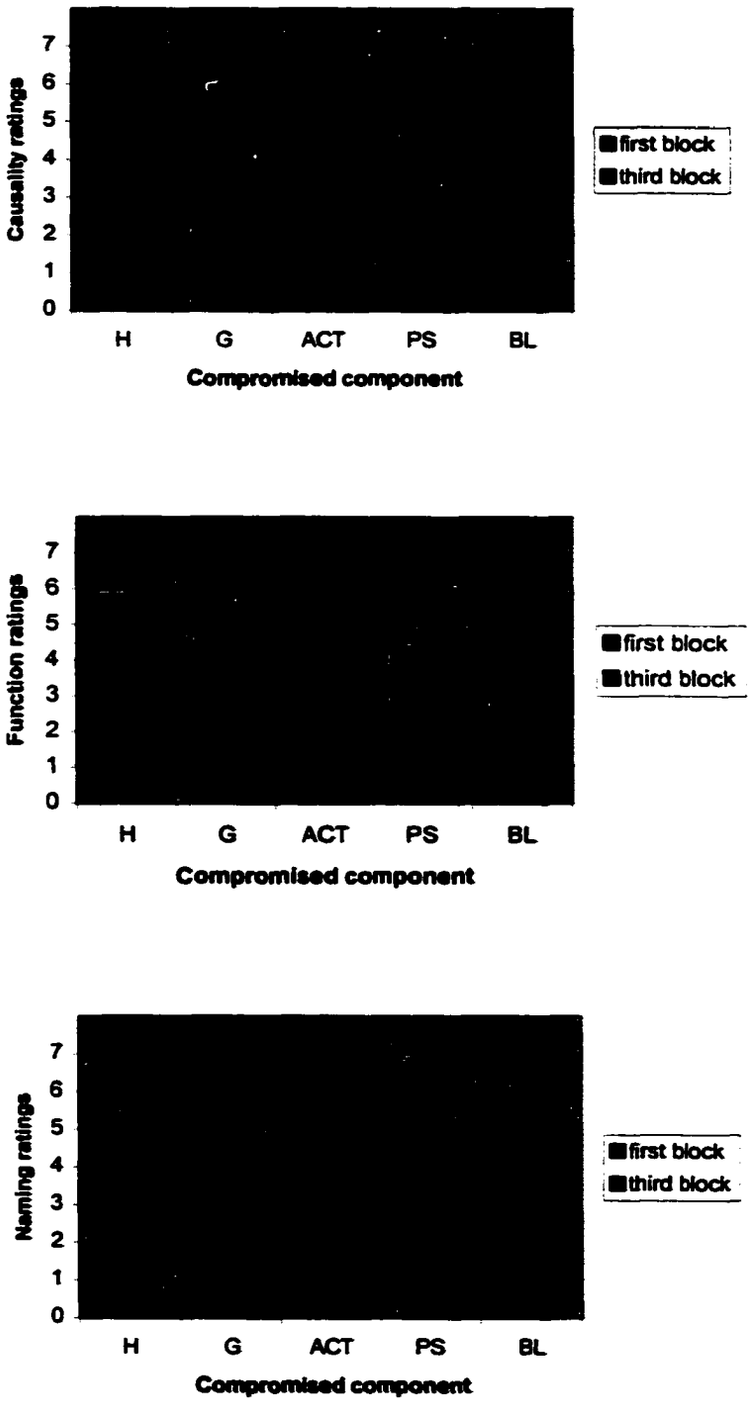
	Compromised component				
Rating	H	G	ACT	PS	BL
Causality	5.25 (.27)	4.75 (.28)	2.10 (.26)	2.74 (.31)	5.59 (.26)
Function	5.92 (.24)	5.51 (.23)	2.73 (.26)	3.73 (.39)	6.24 (.14)
Naming	4.73 (.33)	5.13 (.29)	4.18 (.38)	2.87 (.25)	5.58 (.29)

Note: H = history, G = agent goal, ACT = agent action, PS = physical structure, BL = baseline.

comparing the first and third blocks for each rating should reveal two different patterns. The first block should exhibit a relatively flat pattern, and the third block a more pronounced pattern much like the one observed in the analysis for the complete design. The first and last blocks should show dissimilar results. As can be seen Figure 12, both blocks showed similar patterns.

The same 8 comparisons performed for the whole design were repeated for the first block of scenarios only. As a reminder, these tests compare all scenarios to baseline, then compare inadequate action to accidental creation and accidental use, and finally compare inadequate object to accidental creation and accidental use. For causality ratings, only inadequate action and inadequate object were rated significantly lower than baseline (respectively, $F(1, 23) = 27.13$, $MSe = 3.55$, $p < .001$; $F(1, 23) = 17.83$, $MSe = 3.16$, $p < .001$). Accidental creation and accidental use were lower but not significantly so relative to baseline (respectively, $F(1, 23) = 1.77$, $MSe = 1.7$, $p < .197$; $F(1, 23) = .4$,

Figure 12. **Pattern of results from first and third blocks of Experiment 1 (H = history, G = agent goal, ACT = agent action, PS = physical structure, BL = baseline. Clear bars = first block trials, dark bars = third block trials).**



MSe = 2.54, $p < .533$). Inadequate action was rated significantly lower than both accidental use and accidental creation (respectively, $F(1, 23) = 19.6$, *MSe* = 3.96, $p < .001$; $F(1, 23) = 20.4$, *MSe* = 3.2 , $p < .001$). Inadequate object was also rated lower than both accidental creation and accidental use (respectively, $F(1, 23) = 8.95$, *MSe* = 3.72, $p < .007$; $F(1, 23) = 10.4$, *MSe* = 4.06, $p < .004$).

When the same 8 comparisons were performed on function ratings, only the accidental creation scenario did not receive significantly lower ratings than baseline (for accidental creation, $F(1, 23) = 1.96$, *MSe* = .68, $p < .175$; for accidental use, $F(1, 23) = 6.76$, *MSe* = .52, $p < .016$; for inadequate action, $F(1, 23) = 41.51$, *MSe* = 1.99, $p < .001$; for inadequate object, $F(1, 23) = 18.86$, *MSe* = 2.04, $p < .001$). The inadequate action scenario received lower ratings than both the accidental creation and the accidental use scenarios (respectively, $F(1, 23) = 23.97$, *MSe* = 2.63, $p < .001$; $F(1, 23) = 21.81$, *MSe* = 2.39, $p < .001$). Finally, the inadequate object scenario also received lower ratings than the accidental creation and accidental use scenarios (respectively, $F(1, 23) = 10.68$, *MSe* = 2.39, $p < .003$; $F(1, 23) = 6.61$, *MSe* = 2.84, $p < .017$).

The analysis for the first block of the naming condition provided the following results. All scenarios were rated lower than baseline. However inadequate action was the only scenario not rated significantly lower than baseline (for accidental creation, $F(1, 23) = 8.12$, *MSe* = 1.48, $p < .009$; for accidental use, $F(1, 23) = 13.71$, *MSe* = .74, $p < .001$; for inadequate action, $F(1, 23) = 2.04$, *MSe* = 2.3, $p < .167$; for inadequate object, $F(1, 23) = 30.58$, *MSe* = 2.97, $p < .001$). Inadequate action was rated higher than accidental creation and accidental use scenarios, but on both cases not significantly so (for accidental creation, $F(1, 23) = .42$, *MSe* = 4.04, $p < .524$; for accidental use $F(1, 23)$

= .39, *MSe* = 2.59, $p < .536$). Finally, the inadequate object scenario was rated significantly lower than both accidental creation and accidental use (respectively, $F(1, 23) = 11.86$, *MSe* = 3.1, $p < .002$; $F(1, 23) = 12.1$, *MSe* = 3.33, $p < .002$).

The same analysis plan was repeated now for the third block. As expected if there were no important practice effects, causality and function ratings showed almost the same pattern exhibited in the first block. The only difference was the accidental creation scenario in the causality condition, which was rated higher than baseline (although nonsignificantly so). For causality ratings, inadequate action and inadequate object were rated significantly lower than baseline (respectively, $F(1, 23) = 54.97$, *MSe* = 5.48, $p < .001$; $F(1, 23) = 24.23$, *MSe* = 8.43, $p < .001$). Relative to baseline, accidental creation was rated higher and accidental use lower. None of these differences was significant (for accidental creation, $F(1, 23) = 2.62$, *MSe* = 1.29, $p < .119$; for accidental use, $F(1, 23) = 4.03$, *MSe* = 3.74 , $p < .057$). Inadequate action was rated significantly lower than both accidental creation and accidental use (respectively, $F(1, 23) = 80.01$, *MSe* = 4.6, $p < .001$; $F(1, 23) = 37.11$, *MSe* = 4.89 , $p < .001$). Finally, inadequate object too was rated lower than accidental creation and accidental use (respectively, $F(1, 23) = 28.9$, *MSe* = 8.99, $p < .001$; $F(1, 23) = 14.27$, *MSe* = 3.8, $p < .001$).

Same as found in the first block, for third block function ratings all scenarios were rated lower than baseline. Only for the accidental creation scenario was this difference not significant (for accidental creation, $F(1, 23) =$, 1.87 *MSe* = .80, $p < .185$; for accidental use, $F(1, 23) = 4.97$, *MSe* = 2.72, $p < .036$; for inadequate action, $F(1, 23) = 203.34$, *MSe* = 2.35, $p < .001$; for inadequate object, $F(1, 23) = 49.6$, *MSe* = 4.48, $p < .001$). The inadequate action scenario received lower ratings than both the accidental

creation and the accidental use scenarios (respectively, $F(1, 23) = 163.05$, $MSe = 2.61$, $p < .001$; $F(1, 23) = 69.67$, $MSe = 4.74$, $p < .001$). Finally, the inadequate object scenario also received lower ratings than accidental creation and accidental use scenarios (respectively, $F(1, 23) = 43.92$, $MSe = 4.26$, $p < .001$; $F(1, 23) = 18.71$, $MSe = 3.37$, $p < .001$).

In contrast to causality and function ratings, which showed almost exactly the same pattern of significant differences in the first and last block of trials, naming showed some differences. However these differences are confined to accidental use and inadequate action scenarios. When scenarios where compared to baseline, accidental creation was rated lower (non-significant), accidental use was rated higher (non-significant), inadequate action was rated lower (also non-significant), and inadequate object was the only scenario rated significantly lower than baseline (for accidental creation, $F(1, 23) = 1.17$, $MSe = 5.13$, $p < .291$; for accidental use, $F(1, 23) = 2.94$, $MSe = 2.78$, $p < .1$; for inadequate action, $F(1, 23) = 1.8$, $MSe = 5.2$, $p < .193$; for inadequate object, $F(1, 23) = 11.71$, $MSe = 9.62$, $p < .002$). Inadequate action was rated lower than both accidental creation and accidental use, although only the comparison against accidental use achieved significance (for accidental creation, $F(1, 23) = .067$, $MSe = 5.59$, $p < .798$; for accidental use, $F(1, 23) = 11.2$, $MSe = 3.13$, $p < .003$). Finally, inadequate object was rated significantly lower than both accidental creation and accidental use (respectively, $F(1, 23) = 6.81$, $MSe = 9.8$, $p < .016$; $F(1, 23) = 23.65$, $MSe = 3.84$, $p < .001$).

As these analyses and Figure 12 show, the pattern of results in first and third block trials is stable. This argues against practice effects. However, from inspecting

Figure 12 it does seems that there is a trend for differences to increase in the last block of trials. An analysis of effect sizes confirmed this appreciation. Although not significant, the effect size for the main effect of scenario increased from the first to the third block of trials (first block $R^2 = .27$, third block $R^2 = .47$, p of the difference $< .13$).

One final concern to address is whether subjects used the scale correctly. As expected, if the task was not ambiguous or unnatural to subjects, their confidence ratings should be high. On a 1- to 7-point scale, the mean confidence rating was 5.94 ($SD = .67$). However there was another possibility of incorrect scale use. Subjects may have used intermediate scale-values to indicate not being sure of how to answer rather than to signal a medium level of whatever it was they were evaluating (i.e., causal sufficiency, function completeness, or naming appropriateness). If subjects were using the scale in this way, intermediate ratings should be the ones where subjects showed less confidence.

To test this possibility, each subject's ratings (i.e., causality, function, or naming) were recomputed by taking the absolute difference of each score to his or her own mean rating. This transformation expressed every score as a deviation from a subject-specific intermediate rating. The correlation of these new scores and subjects' confidence ratings signals incorrect use of the scale. This correlation should be positive for subjects who interpreted intermediate scale-values to mean being unsure. A significant positive correlation was obtained for 22 subjects or 30.6% of the sample ($\alpha = .05$, $df = 13$). However when these subjects were excluded and means recomputed, the overall pattern for each rating remained (as Table 3 shows).

Table 3. Mean ratings for subjects who interpreted the scale correctly in Experiment 1 (standard errors in parenthesis).

	Compromised component				
Rating	H	G	ACT	PS	BL
Causality	5.06 (.47)	4.42 (.44)	2.11 (.44)	2.69 (.53)	5.36 (.45)
Function	6.07 (.20)	5.57 (.22)	2.60 (.24)	3.77 (.34)	6.23 (.13)
Naming	4.98 (.30)	5.48 (.22)	4.63 (.35)	2.89 (.37)	5.72 (.21)

Note: H = history, G = agent goal, ACT = agent action, PS = physical structure, BL = baseline.

Discussion

This complex set of results provides support for different predictions of the HIPE theory. In contrast, alternative theories (mainly the intentional theory) have problems accounting for it. The overall pattern is too complex to be accounted for by any of the limiting case models (i.e., conjunctive and disjunctive models). Results for each type of rating will be discussed separately, comparing them to predictions of the intentional theory, the affordances view, and the HIPE theory of function.

Causality ratings show a pattern where compromising any component reduces the likelihood of obtaining the expected outcome. However not all components are equally important. When either an object's physical structure or the actions of an agent are compromised, subjects consider the outcome much less likely than when the object's intentional history or the agent's goal are compromised.

This is not what the intentional theory predicts. According to this theory, only an object's intentional history should be relevant for causal ratings. Results are much closer

to predictions of both the affordances view and the HIPE theory. Both predict that physical structure and agent action should be relevant for causal judgments. However both have problems in explaining that intentional history and goals also have an effect, although weaker. An affordances view does not predict that history will have an effect simply because history is not part of the conceptual structure of function. Hence there is no way in which an affordances view can explain these results other than by adding intentional history as a component of function. Although an affordances view could be supplemented with intentional history, it would only be done as a way of dealing with the present results. Contrastingly, HIPE offers theoretical reasons to include history. If it does not predict effects of intentional history and goals, it is because HIPE assumes that subjects are able to completely screen-off these distal causes. Agent action and object physical structure are presumed sufficient to produce functional outcomes.

Although causality results do open question marks for the HIPE theory, they are not contrary to HIPE's framework. The problem for HIPE is that—interestingly—the pattern of results obtained for causality ratings is precisely what the theory predicts for function ratings: an effect of physical structure and agent action, and a smaller effect of intentional history and agent goal. It could be that because subjects are making judgments about function, they are not able to fully filter out this conceptual knowledge. As a result, they incorrectly assume that intentional history and goals should be causally relevant even when the causally sufficient components are present. Conceptual knowledge may be leaking into causal judgments. Where the screening-off property normatively prescribes the correct way to make these causal judgments, leakage may render subjects only able to partially screen-off distal causes. This would be comparable

to much evidence showing that subjects are generally not able to perform as prescribed by normative theories and resort to simpler strategies instead (e.g., Tversky & Kahneman, 1974).

A different interpretation of these results is that subjects are in fact able to produce a causal account where intentional history and goals are relevant. Rather than the screening-off assumption being the problem, the causal model is wrong (i.e., causal graph 11). It may be that subject infer accidents generally do not produce precise and controlled results. An object created by accident may have a physical structure that is less than optimal to afford its usual function. Similarly, an agent accidentally using an object may not act with the necessary precision to achieve the object's usual function. Under these conditions unintentional scenarios would warrant lower causal ratings.

Function ratings show a similar pattern to causal ratings. Except for intentional history, compromising any other component is considered by subjects to decrease the quality of a scenario's illustration of function. Note however that though history is not significant, it is only marginally not so ($p < .052$). Also, and again just as happens for causal ratings, physical structure and agent action produce the greatest decrease in ratings. While also significant, agent goal produces a lesser effect.

Again, this pattern does not correspond to the intentional theory's predictions. According to this theory, goals and agent actions should not have an effect. Only intentional history and physical structure should. Also, this theory cannot explain why compromising intentional history produced a weaker effect than compromising physical structure. Results are much more like those predicted by the affordances view and the HIPE theory. Every component is conceptually important. Compromising any of them

produces an effect. However compromising components associated to an object's affordances produces a greater effect than compromising intentional components. Specifically, compromising intentional history was predicted to produce only a small effect.

The pattern of results for naming is different from that of causality and function. An intuitive result is that an object's name is not affected by the goals of an agent using it. An object's name does not depend on it being intentionally used. In contrast compromising intentional history or agent action both produce an effect, and of comparable magnitude (i.e., they are both different from baseline but not different from each other). An object's name does depend on it being intentionally created and correctly used. For naming—as in causality and function judgments—physical structure plays an important role. Compromising physical structure has an effect that is greater than that of intentional history or agent action. An object's name depends importantly on its appearance. And finally, intentional history is significantly more important for naming than for causality or function judgments.

Which theory (theories) predicts this pattern for naming? The effect of agent action on naming is predicted only by an affordances view. Excluding this result, the pattern seems much like what the intentional theory predicts for naming. Both history and physical structure are important. However the intentional theory predicts that this pattern should be also found for function ratings, which is not. Because the intentional theory is essentialist it assumes that naming reflects the understanding of an artifact's real nature. Intentional history's presumed centrality is based on its role in the comprehension of an artifact's essence. Consequently an object's name is thought to

reflect this conceptual understanding. The intentional theory cannot account for why function and naming ratings diverge given it assumes they should covary. Intentional history should be as important for function judgments as for naming judgments, and this is not the case.

The affordances view correctly predicts that agent action and physical structure will matter for naming. However it incorrectly predicts that agent goal will have an effect, and it does not predict the observed effect of intentional history. Furthermore, and similarly to the intentional theory, the affordances view predicts the same pattern for both naming and function ratings. As discussed above, this prediction does not hold. Overall, the affordances view does not do a good job at predicting naming results.

Although the HIPE theory does not predict the effects of physical structure or agent action on naming, it does predict the effect of intentional history. More importantly, it predicts that naming will follow a different pattern than function ratings. Because it assumes that intentional history's relevance in naming is derived from people's recognition of conventional naming practices, it predicts a decoupling of naming from conception, just as results show. Whereas conceptual understanding of function is closely linked to the causal structures evident in object use, naming is associated with social conventions for reference.

Nevertheless the HIPE theory did not predict that agent action and physical structure would also play a role in naming. This result can be interpreted in different ways. Recall that results for causality and function ratings show that both action and physical structure are central. Because subjects are reading scenarios that describe functions, it is possible that conceptual knowledge is leaking into naming. Subjects may

not be able to filter out their conceptual knowledge when naming. A different possibility is that these results are due to the importance of physical structure and action for object recognition. Subjects may be representing to themselves objects with inadequate physical structures or being used in incorrect ways and noticing that it is hard to recognize them. In this account action and physical structure play a role in naming because they are usually helpful in recognizing objects and not because of their role in conceptual structures.

In summary, Experiment 1's results show that for function, affordances override history and goals. Compromising physical structure or action affects the meaning of function regardless of whether the object was intentionally created and used or not. Conversely if an object was created or used for a purpose but does not have the requisite physical structure, or it is not used appropriately, function is considerably damaged. These results are contrary to the intentional theory's prediction (see Gelman & Bloom, 2000, p. 99) but can be handled by both the affordances view and HIPE.

Although action and physical structure are also relevant for naming, the latter is considerably more important than action. Subjects are less willing to assign the standard name to artifacts that have their physical structure compromised. Although compromising the actions of an agent also has detrimental effects in subjects' willingness to name artifacts, naming suffers less from this than from compromising physical structure. In contrast to functional and causal ratings, where it only showed a marginal effect, intentional history makes an important contribution to artifact naming. Its effect is as important as that of agent action. Accidentally created artifacts are not as likely to be given an artifact's standard name as intentionally created ones.

The two alternative accounts of these results do not receive support (i.e., incorrect use of the scale and practice effects). The majority of subjects appear to have used the rating scale correctly. They reported high confidence in their responses, and used intermediate ratings to indicate intermediate values in the scale and not simply that they were not sure of their response. When those subjects who used intermediate ratings to indicate being unsure were filtered out, the pattern of results for the sub-sample remained the same as for the complete sample.

Results are also unlikely to be explained by practice effects. If practice effects were relevant, subject's behavior would be different during initial critical trials as compared to final ones. The pattern towards the end of the critical trials would become increasingly like the one found for the complete design, showing that results are dependent on what subjects were able to learn from their exposure to the scenarios. On the contrary, causality and function ratings exhibited the same pattern on first and third block trials. Even the pattern of significance was almost identical. Naming ratings also behaved similarly. Data do suggest that subjects became more sensitive as they progressed through critical trials. Although not significant, the effect size for the difference in ratings between scenarios increased from the first to the third block of trials.

EXPERIMENT 2

Experiment 1 produced causality and function data that can be explained by both HIPE and the affordances view. Understanding function is heavily dependent on those aspects directly involved in artifact use (i.e., actions and physical structure). However, the understanding of function is also impaired when an artifact's history is unintentional. This effect is predicted by HIPE but not by the affordances view. Experiment 2 aimed at

further exploring the effect of intentional history on causality and function judgments. Of interest is the robustness of this effect and its interaction with other factors. If history continues to be important for causality and function judgments, this poses an increasing problem for the affordances view. Because naming is irrelevant to this issue, it was not included in the design, thereby making it more manageable.

Because scenarios for Experiment 1 were created such that only one HIPE component was compromised at a time, the question might arise of why not approach the problem by compromising all possible combinations of HIPE components. An important reason for not following this strategy is that there are 15 combinations of all 4 components (i.e., 15 different types of scenarios). This presents a problem because it entails either an unreasonable number of subjects, or an unreasonable number of scenarios that each subject must respond to.

However a limited combinatorial strategy is feasible. Better yet, compromising more than one component at a time offers an interesting way to test the role of intention in the conceptual structure of function. Though Experiment 2 follows the same general paradigm used previously, there are two important differences. First, physical structure and agent action are never compromised. The interest focuses on the contribution of intentional aspects (i.e., intentional history and agent's goal). Second, one of the scenarios compromises two components simultaneously. In addition to accidental creation, accidental use, and baseline scenarios, Experiment 2 utilizes a *fully accidental* scenario. In this scenario an artifact is described that is both used accidentally *and* created unintentionally. According to the affordances view, the fully accidental scenario should not receive lower function ratings than the accidental use one because history is

not part of the conceptual structure of function. In contrast, for HIPE both history and agent goal make independent causal contributions. Thus compromising both should produce an additive effect in functional understanding.

Predictions

Disjunctive model

Causal graph (6) assumes that all components can produce an outcome on their own. Thus, the prediction is that only when all components (history, goal, action, and physical structure) are missing will subjects show reductions in their causality ratings. As described for Experiment 1, function ratings should decline as increasingly larger combinations of components are compromised, decreasing the completeness of the functional network.

Conjunctive model

As discussed for the first experiment, causal graph (7) predicts that manipulating one component is enough to drive ratings down for all three measures. Consequently, the prediction for the second experiment is that higher order combinations will not lower subjects' causal or function ratings further. This is the opposite of a disjunctive model, for which there are additive effects in naming and function measures.

Affordances model

As described earlier in causal graph (9), an object's history plays no role from an affordances point of view. For this reason a scenario describing an object that is both created and used accidentally should not be more detrimental to causal and functional judgments than one describing an object that is accidentally used. The conjunction of

compromising history and agent goal should not have a greater effect than compromising only agent goal.

Intentional model

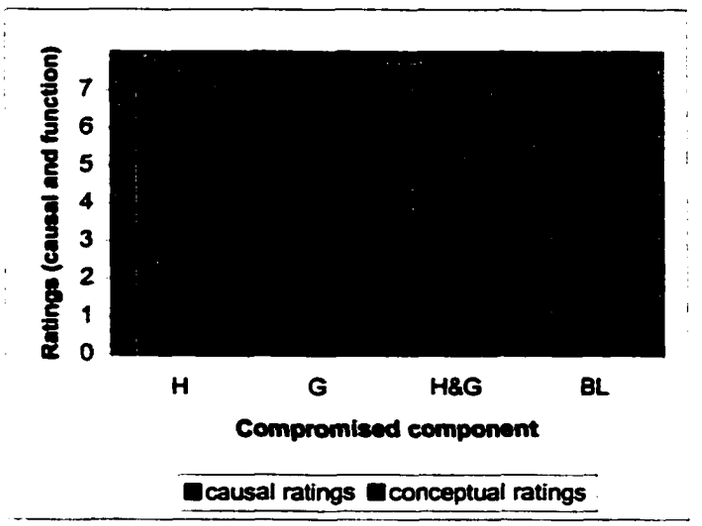
As causal graph (10) shows, the intentional theory assumes that history (H) causes agent goals, agent action, and physical structure. Consequently the theory predicts that only intentional history—and no higher order combinations—will affect causal ratings. Relative to function judgments, the theory's inferential process predicts they will be negatively affected if the object's physical structure does not support a causal account of its design. However no other component will enter into the inference process (i.e., if the agent's action or goal are not appropriate, it will not be considered as evidence that the function being described is not the designer's intended function). In summary, the theory predicts that both history (H) and physical structure (PS), and their combination will affect function ratings. The fully accidental scenario will not affect meaningfulness beyond the effect of accidental creation scenario.

HIPE model

To arrive at the HIPE theory's predictions for the different conditions (see Figure 13), it is necessary to review again the theory's assumptions. The theory assumes that knowing an artifact's function involves knowing everything in HIPE that is relevant to it. A corollary of this assumption is that conceptual understanding of an artifact's function accrues gradually. The more HIPE components present in a given situation, the greater the understanding of the artifact's function. By contraposition HIPE predicts that for someone who has close to complete conceptual understanding of an artifact, function

ratings should degrade gracefully as less and less of the concept is evidenced in a particular scenario.

Figure 13. HIPE theory predictions for causality and function ratings in Experiment 2 (Note: H = history, G = agent goal, H&G = history and goal, BL = baseline).



However, because HIPE components vary in their degree of centrality (i.e., those that are sufficient are more central than those that are not), the effect of manipulating different components should not be equal. The conceptual effect of manipulating a sufficient causal component should be greater than the effect of manipulating one that is not. Still if conceptual understanding accrues as the HIPE theory assumes, it should be possible to achieve a cumulative degradation of conceptual understanding by manipulating several distal components (i.e., intentional history and goal).

The resulting predictions are that if agent action and physical structure are not compromised and all one- and two-component combinations of history (H) and goal (G) are tried out, function ratings should decrease depending on how many HIPE components

are manipulated by a particular scenario. Something different is predicted for causality ratings. Manipulating HIPE components that are not proximal to the outcome in the causal chain should have no effect on causality ratings. Both intentional history and agent goal are assumed to be screened-off from the functional outcome. Not only that, but HIPE also does not restrict history to intentional creation. This is another reason why compromising intentional history should not produce changes in causality ratings.

Method

Design and Subjects

Forty-two Emory University undergraduates (6 males and 36 females) participated for course credit. Subjects read 12 scenarios and performed either causality or function ratings. Each scenario described the creation and use of an object (mop, whistle, charcoal pencil).

This experiment followed a 2 x 4 mixed design. The factors were: rating (causality and function) and scenario (four types of scenarios described below). Scenario was a within subjects factor.

Materials

There were four types of scenarios and three objects, for a total of twelve different scenarios (see Appendix B). As in the first experiment, each scenario presented two characters, one involved in the object's creation and the other in its use. The objects were a mop, a whistle, and a charcoal pencil. The first type of scenario was a baseline that described an artifact being intentionally created and used. The other three types of scenarios presented situations in which critical causal components were compromised (i.e., either H, G, or both). Accidental creation and accidental use scenarios were the

same as in Experiment 1. Additionally, the fully accidental scenario described an object being unintentionally created and unintentionally used.

Each subject received all 12 possible scenarios (3 objects x 4 scenario types). To control for order effects, three different sequences were constructed. Each sequence contained three blocks of 4 scenarios, with each block containing one instance of each type of scenario (i.e., one baseline, one accidental creation, one accidental use, and one fully accidental scenario). Once the first sequence was constructed, two other arrangements were obtained by counterbalancing the order of blocks. In each sequence of 12, there were no back to back scenarios that described the same object or the same type of scenario.

After reading each scenario subjects were asked to provide ratings on a single dependent measure (i.e., either causality or function) and to rate how confident of their responses they were. Rating was a between subjects variable, and was done in the same type of 7-point scale as in Experiment 1.

Procedure

Subjects were tested in groups of up to five at a time. Instructions were presented in printing but were also read out loud by the experimenter. After receiving instructions, subjects were required to perform three practice trials unrelated to function. These were identical to those used in the first experiment. They involved two characters, one of which was described as doing something that could potentially upset his partner, and subjects were asked to answer a question about the partner's subsequent emotional state. Subjects were encouraged to discuss their practice ratings as a way to promote correct scale use.

When practice trials were finished, subjects began to work individually. During this period they had to rate four buffer and twelve critical trials. Buffer trials acquainted subjects with the general structure of critical scenarios, and gave them the opportunity to use the full range of the scale. These trials involved two objects different from those used in critical trials (gardening fork and clothes hanger). After four buffers, subjects received 12 critical trials.

When subjects finished the critical trials, they were asked to describe their understanding of the experiment. They were asked to attempt to formulate the experiment's hypothesis, and to state any relations they observed among the scenarios.

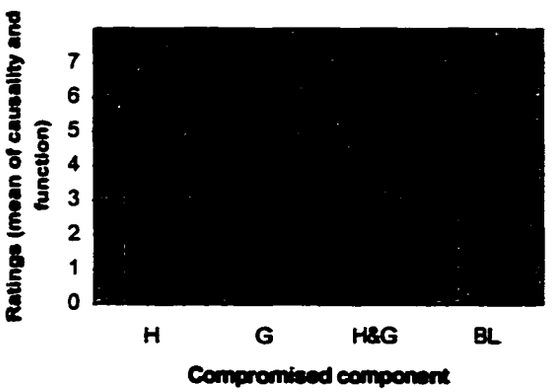
Results

Each subject contributed 4 data points to this analysis. Ratings were averaged across objects to obtain a single value for each type of scenario. These data were submitted to a 4 (scenario) x 2 (rating) ANOVA, with rating as between- and scenario as within-subjects factor. The overall analysis produced a main effect of scenario ($F(3, 120) = 28.71$, $MSe = .49$, $p < .001$, $R^2 = .42$, power = 1), no effect of rating ($F(1, 40) = .41$, $MSe = .79$, $p < .527$, $R^2 = .01$, power = .1), and no interaction ($F(3, 120) = 1.84$, $MSe = .49$, $p < .143$, $R^2 = .04$, power = .47). Just as in Experiment 1, causality and function ratings exhibited the same pattern. Given the null effect of rating and because it did not show an interaction with scenarios, results from both ratings were combined into a single measure (see Figure 14).

Five planned comparisons were carried out for the effect of scenarios. Baseline was compared to all other scenarios, and the fully accidental scenario was compared to accidental creation and accidental use. Relative to baseline, all other scenarios were rated

significantly lower (for accidental creation, $F(1, 40) = 11.72$, $MSe = .79$, $p < .001$; for accidental use, $F(1, 40) = 24.32$, $MSe = .84$, $p < .001$; for fully accidental, $F(1, 40) = 54.84$, $MSe = 1.48$, $p < .001$). Additionally, the fully accidental scenario was rated significantly lower than both accidental creation and accidental use (respectively, $F(1, 40) = 39.61$, $MSe = .9$, $p < .001$; $F(1, 40) = 20.94$, $MSe = .96$, $p < .001$).

Figure 14. Average of causality and function ratings in Experiment 2 (H = history, G = agent goal, H&G = history and goal, BL = baseline. Error bars are standard errors).



The grouped data pattern was also present in a majority of subjects. For each subject, two comparisons were made. The fully accidental scenario ratings were expected to be lower than both the accidental creation scenario, and the accidental use scenario. Out of 42 subjects, 24 (57%) exhibited this pattern.

As in Experiment 1, possible practice effects were a concern. Twenty-one subjects (50%) showed evidence of having learned the experiment's logic. They either were close to discovering the hypothesis, i.e., they thought that unintentional events should be considered less likely than intentional ones (7 subjects), or they showed

evidence of understanding the scenario structure, i.e., they mentioned the distinction between unintentional and intentional creation and use (14 subjects). However, when mean ratings were computed for the sample with the exclusion of these 21 subjects, the general pattern of results seen in Figure 14 remained (see Table 4). (Note that, as was done for Experiment 1, all results involving subsamples are presented in tabular form, as a way to distinguish them from analyses for the intact sample, for which figures are used).

Table 4. Mean ratings for subjects who did not discover Experiment 2's logic (standard errors in parenthesis).

	Compromised component			
	H	G	H&G	BL
Mean Rating	5.10 (.17)	5.16 (.24)	4.33 (.18)	5.90 (.20)

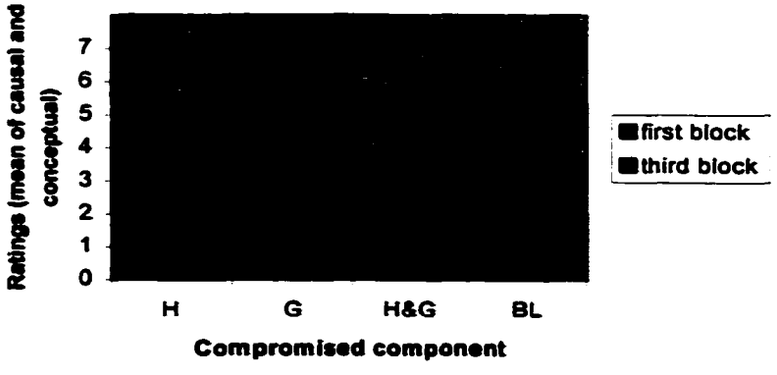
Note: H = history, G = agent goal, H&G = history and agent goal, BL = baseline.

In light of the number of subjects who discovered the experiment's logic, comparing the pattern of results from the first and third blocks of trials became particularly relevant. An analysis of both blocks suggested that practice effects did not account for results. Both blocks showed the same general pattern (see Figure 15). The same five planned comparisons carried out for the total design were performed for each block. In the first block, all other scenarios were rated lower than baseline. However only the fully accidental scenario achieved significance (for accidental creation, $F(1, 41)$

= .4, $MSe = 4.81, p < .53$; for accidental use, $F(1, 41) = 1.55$, $MSe = 4.98, p < .22$; for fully accidental scenario, $F(1, 41) = 13.7$, $MSe = 3.36, p < .001$). The fully accidental scenario was rated lower than both accidental use and accidental creation, but only the comparison against accidental creation was significant (for accidental creation, $F(1, 41) = 9.07$, $MSe = 3.22, p < .004$; for accidental use, $F(1, 41) = 4.03$, $MSe = 4, p < .051$).

The same 5 comparisons for the third block produced the following results. When contrasted to baseline, all other scenarios were rated significantly lower than baseline (for accidental creation, $F(1, 41) = 5.87$, $MSe = 1.62, p < .02$; for accidental use, $F(1, 41) = 24.78$, $MSe = 2.4, p < .001$; for fully accidental scenario, $F(1, 41) = 36.99$, $MSe = 3.06, p < .001$). The fully accidental scenario was rated significantly lower than accidental use and accidental creation, although the comparison was significant only for the latter (for accidental use, $F(1, 41) = 1.93$, $MSe = 4.45, p < .172$; for accidental creation, $F(1, 41) = 15.24$, $MSe = 3.75, p < .001$).

Figure 15. Pattern of results from first and third blocks of Experiment 2 (H = history, G = agent goal, H&G = history and goal, BL = baseline. Error bars are standard errors).



Subjects appear to have interpreted the scale correctly. Their confidence ratings were high (mean = 5.87, *SD* = .63). As in Experiment 1, subjects' causal or function ratings were recomputed by taking their absolute difference to each individual's mean rating. A correlation was computed between this measure and subjects' confidence ratings. Only four subjects (9.5%) produced a significant correlation ($\alpha = .05$, $df = 11$) suggesting an erroneous interpretation of the scale. When these 4 subjects were excluded and means recomputed, the overall pattern of ratings remained (see Table 5).

Table 5. Mean ratings for subjects who used the scale correctly in Experiment 2 (standard errors in parenthesis).

	Compromised component			
	H	G	H&G	BL
Mean Rating	5.61 (.15)	5.42 (.17)	4.72 (.19)	6.08 (.16)

Note: H = history, G = agent goal, H&G = history and agent goal, BL = baseline.

Discussion

As the disjunctive causes model predicts, function ratings decrease as the number of compromised components increases (i.e., a scenario with two compromised components shows lower ratings than those with one compromised component). However this model is insufficient because it cannot account simultaneously for other results from both the first and second experiments.

Theories that embrace either affordances or history—but not both—as determinants of function are also not able to account for these results. The affordances view model is obviously incorrect because it predicts compromising history will have no effect. It also erroneously predicts that compromising history in conjunction with goals (i.e., the fully accidental scenario) should not have a greater effect than compromising only goals. The intentional theory provides the reverse predictions. Under the conditions of Experiment 2 (i.e., physical structure is never compromised), the intentional theory predicts that only history will be causally and conceptually relevant. Compromising history and goals in conjunction should not increase the effect. However, the data do not support this prediction. As HIPE predicts, both history and affordances need to be considered to understand function.

A striking result is that causal and function ratings mirror each other with even greater clarity than in Experiment 1. Again, just as in Experiment 1, the pattern follows HIPE's predictions for function but not for causal ratings. As discussed earlier, this can be taken to mean that subjects are not able to fully screen-off distal causes. Proximal causes are not considered to be sufficient. Alternatively it can be interpreted as evidence that HIPE's causal model (causal graph 11) needs reformulation. Subjects may infer that the intentions of creators and agents are causally relevant because they are more likely to produce successful outcomes. It is not clear at this point which of these alternative explanations is correct.

Just as in Experiment 1, practice effects were a concern. Presumably because most scenarios in this experiment involved events happening unintentionally, at least 50% of the sample became aware of this distinction. This stands in contrast to the 23.6%

who learned aspects of Experiment 1's structure. The difference may lie in that Experiment 1 contained a greater variety of scenarios, more than half not involving unintentional events. Consequently it was easier for subjects to discern Experiment 2's structure. However this appears not to have unduly influenced results. The same pattern remained stable across different blocks of trials. Regarding the problem of scale use, as in the first experiment, subjects used the scale correctly.

Considering both experiments, history has been shown to be a conceptual component of function. Its role, however, is reduced relative to the importance of physical structure and agent action. These results are in sharp contrast to published studies where history has appeared essential to function (Gelman & Bloom, 2000; Matan & Carey, 2001). HIPE offers two ways of reconciling these conflicting results.

The first is that in both abovementioned studies subjects were asked to perform naming tasks. Experiment 1 shows that naming is precisely where history shows its strongest effect. Gelman and Bloom (2000) do note that the importance of history may partly come from people's knowledge of how language works. Their strongest claim however is that history plays a central conceptual role. It informs about artifacts' essences, i.e., about their deep nature. If this were the case, subjects' function ratings should not exhibit the pattern found in Experiment 1. They should not think a scenario describing the use of an accidentally created artifact provides a good illustration of function. Experiment 1 shows the contrary, supporting the conclusion that history's effect in previous studies may be largely due to the nature of naming and not to its conceptual nature.

The second reason is that the aforementioned studies systematically leave out potentially important sources of information about function. Matan and Carey (2001) informed subjects about an object's history and use but left physical structure deliberately ambiguous. Gelman and Bloom (2000) informed subjects about an object's history and physical structure but not about its actual use. Because subjects rely strongly on actions and physical structure to understand function, the incompleteness of these descriptions may be a strong incentive to infer them from available information. By resorting to relational systems underlying function, subjects may infer an object being created to fulfill a certain role will have a physical structure that is appropriate for that and not other function (hence Matan and Carey's results). Similarly, subjects may infer that an accidentally created artifact does not afford the actions that an intentionally created one does (hence Gelman and Bloom's results). Noticeably, under these reinterpretations performance is based on physical structure and agent action (i.e., actual use) and only appears to be based on history because of the descriptions' incompleteness. The incompleteness hypothesis will be tested in Experiment 4.

EXPERIMENT 3

A critical evaluator may argue that Experiments 1 and 2 are not a fair test of intentional history. Results from these two experiments may be due to the narrative structure of the scenarios received by subjects. The general narrative structure of the scenarios always opened with history and followed with the actual use of the object. When compared to intentional history, other components may have increased their effect due to their recency. This may have obscured the purported relevance of intentional history.

As a way of addressing this potential problem, half the subjects in Experiment 3 received scenarios where the temporal sequence was reversed. These subjects first read about the actual use of the object, and later learned about its creation. If recency can account for previous experiments' results, intentional history should become more important than physical structure when the temporal sequence is reversed. Otherwise the results should replicate those of Experiment 1.

As in Experiment 2, the focus here is on history's effect on function judgments. Because of this, naming and causal ratings were not used, thus reducing the size of the design. In particular, of interest is the comparison between the centrality of physical structure, and the relative unimportance of intentional history. Because of this, agent action was not compromised in any of the scenarios.

Method

Design and Subjects

Fifty-four Emory University undergraduates (12 males and 42 females) participated for course credit. Subjects read 12 scenarios and performed function ratings (only function ratings were used). As in previous experiments, each scenario described the creation and use of an object (mop, whistle, charcoal pencil).

This experiment followed a 2 x 4 mixed design. The factors were narrative structure (history first, use first) and scenario (accidental creation, accidental use, inadequate object, baseline). Scenario was a within subjects factor. The inadequate action scenario used in Experiment 1 was not necessary here because the main concern was to test if intentional history was being hindered due to the narrative structure of the scenarios.

Materials

There were four types of scenarios and three objects, for a total of twelve different scenarios (see Appendix C). Just as before, the objects were a mop, a whistle, and a charcoal pencil. The first type of scenario was a baseline that described an artifact being intentionally created and used. The three other types of scenarios presented situations in which one critical causal component was compromised (i.e., intentional history, agent goal, or physical structure). After reading each scenario subjects were asked to provide a function rating and to rate how confident of their response they were.

One set of materials presented the functional event in its typical narrative structure: history, physical structure, agent goal, and agent action. The other set of materials reversed the structure by putting history last: agent goal, physical structure, agent action, and history.

Each subject received all 12 possible scenarios (3 objects x 4 scenario types) in blocks of 4 scenarios. Three different sequences were created by producing first a basic three-block sequence and later counterbalancing these blocks. In all these sequences, no two objects and no two scenario-types were repeated back to back.

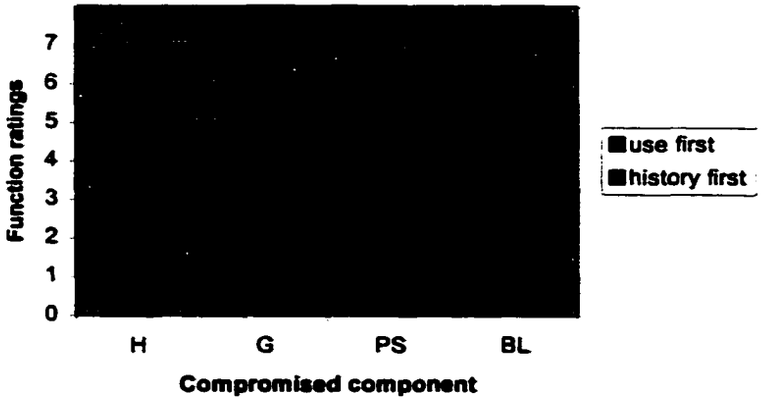
Procedure

The procedure was similar to the first two experiments (see procedure section of Experiments 1 and 2 for more details). After receiving instructions, subjects were asked to go through three practice trials that were unrelated to function. When these were finished, subjects had to rate four buffer and twelve critical trials. Upon finishing reading and rating all 12 scenarios, subjects were asked to describe their understanding of the experiment.

Results

Ratings for each type of scenario were averaged across all three objects (see Figure 16). These data were submitted to a 4 (scenario) x 2 (narrative structure) ANOVA, with narrative structure as a between subjects factor. Because of sphericity violations, degrees of freedom for the within part of the design were adjusted by Huynh-Feldt's epsilon (.677). For clarity of presentation, however, degrees of freedom are presented here without adjustment. The overall analysis revealed no main effect of narrative structure ($F(1, 52) = .27$, $MSe = 2.47$, $p < .606$, $R^2 = .005$, power = .08), a main effect of scenario ($F(3, 156) = 42.78$, $MSe = 1.62$, $p < .001$, $R^2 = .451$, power = 1), and an interaction of narrative structure and scenario ($F(3, 156) = 1.62$, $MSe = 4.32$, $p < .022$, $R^2 = .07$, power = .7).

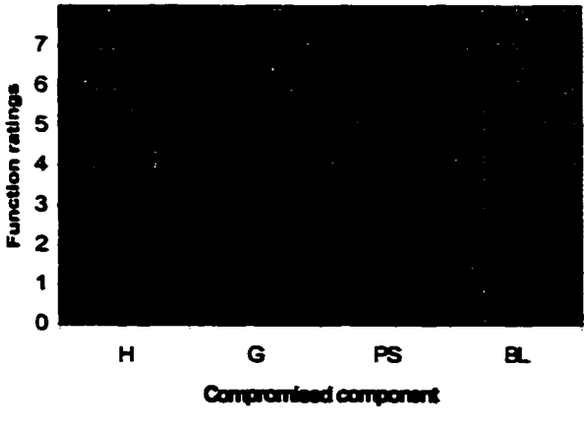
Figure 16. Mean function ratings for two different narrative structures in Experiment 3 (H = history, G = agent goal, PS = physical structure, BL = baseline. Error bars are standard errors).



To identify the source of the interaction, narrative structures (i.e., history first and use first) were compared at each level of scenario. Only accidental use produced a

significant difference between the two narrative structures ($F(1, 52) = 6.26$, $MSe = .92$, $p < .016$). A compromised agent goal had less influence on subjects' judgments when it occurred at the beginning of the narrative. In contrast accidental creation did not produce a significant effect. Intentional history was not significantly more influential when more recent in the narrative structure ($F(1, 52) = 2.43$, $MSe = 1.49$, $p < .125$). Analogously, physical structure was not significantly less influential when history was more recent in the narrative ($F(1, 52) = 1.5$, $MSe = 2.42$, $p < .226$). Baseline scenarios behaved similarly independent of any effect of recency ($F(1, 52) = .644$, $MSe = .92$, $p < .426$).

Figure 17. Mean function ratings with narrative structure as a controlled variable in Experiment 3 (H = history, G = agent goal, PS = physical structure, BL = baseline. Error bars are standard errors).



When planned comparisons were performed with narrative structure as a controlled variable, results closely replicated those of Experiment 1 (see Figure 17). All critical scenarios received lower ratings compared to baseline (for accidental creation $F(1, 53) = 17.83$, $MSe = 1.13$, $p < .001$; for accidental use $F(1, 53) = 9.94$, $MSe = 1.07$, $p < .003$; for inadequate object $F(1, 53) = 79.79$, $MSe = 3.1$, $p < .001$). Inadequate object

was rated significantly lower than accidental use ($F(1, 53) = 44.13$, $MSe = 3.19$, $p < .001$). Inadequate object was also rated significantly lower than accidental creation ($F(1, 53) = 35.61$, $MSe = 3.55$, $p < .001$).

A majority of subjects showed the same pattern evident in the grouped data. For 30 subjects (56%), the average of accidental creation and accidental use was lower than baseline, and the fully accidental scenario was lower than the average of accidental creation and accidental use.

Discussion

Concerns that the effects reported in the first two experiments may be due to narrative structure are not supported. Although function judgments were slightly affected by recency, these effects could not account for the relative importance of different functional components. Importantly, when narrative structure was controlled, different components of scenarios retained their relative influence on function. While physical structure showed the greatest contribution to the understanding of function, intentional aspects of scenarios (history and agent goal) showed a lesser effect.

EXPERIMENT 4

It may be useful here to briefly summarize the main findings up to this point. Contrary to the predictions of the intentional theory, history plays only a small role in function. Learning that an object was accidentally created does not greatly diminish the conceptual understanding of function. In contrast function is importantly debilitated when subjects learn that an object does not possess the necessary physical structure, or that an agent does not perform the actions necessary for the successful use of the object.

Understanding function and reasoning causally about it are both more affected by physical structure and agent action than by intentional history.

For naming, in contrast, intentional history plays a more important role. The hypothesis that subjects are sensitive to social conventions in naming receives support. An artifact receives a name from its creator. As a result, if there is no creator, naming suffers (i.e., as in accidental creation). It is not the case however that intentional history is the only consideration when reasoning about names. Just as for causal and function judgments, physical structure is more important when naming than intentional history.

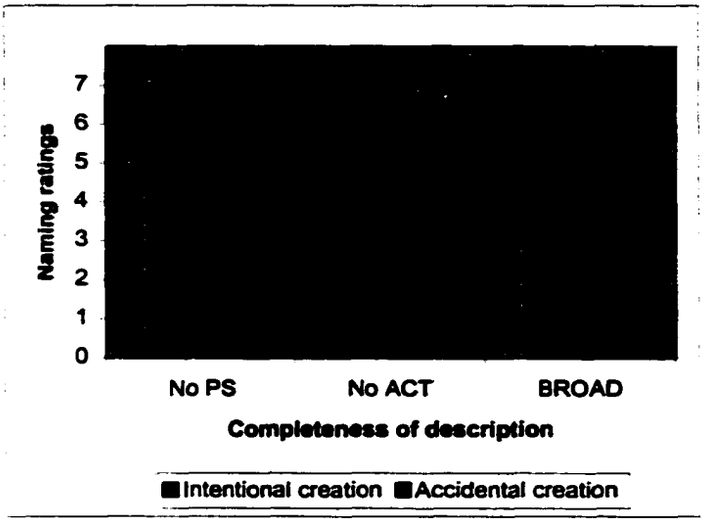
These results are in open contradiction to recent studies which seem to show that intentional history is more central than physical structure (Gelman & Bloom, 2000; Matan & Carey, 2001). HIPE's assumption that relational systems underlie function can explain these divergent results. In both abovementioned studies, important parts of what HIPE regards as functional information were omitted. In Gelman and Bloom (2000), subjects saw an object and received either an accidental or an intentional history for it. Agent action was not provided. For example, subjects were shown a paper hat and told that it was either accidentally or intentionally created. The hat's function, though, was not demonstrated. In Matan and Carey (2001) subjects received scenarios where a creator made an object which was latter used for a different role by an opportunistic agent. The object's physical structure, though, was left deliberately ambiguous. For example, an object whose structure was left largely unspecified, was described as created to be a teapot but used as a watering can. In both cases, history appears to have been the most informative component. However, this could be because other aspects of function were omitted and maybe had to be inferred.

Under these conditions, subjects may draw on their background knowledge to infer the value of missing or ambiguous information. The result may be that the contribution of intentional history may have seemed greater than it really is. When subjects fill-in missing information, they resort to default values (cf. Ahn, Kim, Lassaline, & Dennis, 2000). When agent actions are missing, subjects may infer that an accidentally created object does not afford the necessary actions to produce functional outcomes (hence Gelman & Bloom's 2000 results.) When physical structure is missing, subjects may infer that it should be consistent with the object's history (hence Matan & Carey's 2001 results).

Experiment 4 tests this explanation. The prediction is that when subjects encounter incomplete information about function, they fill-in the missing information by drawing on their knowledge of relational systems underlying function. When the contrast between accidental and intentional creation is present, subjects will use it to infer missing functional components. This will produce an unusually large effect of intentional history because subjects will infer missing information that is consistent with existing constraints (see Figure 18). If creation was accidental, they will infer either an insufficient physical structure, or an insufficient agent action. However, when subjects receive close to complete information, the effect of intentional history will become small because it is not necessary to infer anything. Thus, an interaction is predicted between the description's completeness and the size of the intentionality effect. Incomplete descriptions will produce a larger intentionality effect than more complete ones. In order to test this hypothesis in as similar conditions as possible to the problematic studies, naming ratings

were used. Because the first three experiments showed that intentional history plays a small role in function and causality ratings, these ratings were not used here.

Figure 18. Predictions for Experiment 4 (No ACT = missing action, No PS = missing structure, BROAD = broad description).



Method

Design and Subjects

Thirty-six Emory University undergraduates (10 males and 26 females) participated for course credit or pay. Subjects read 6 scenarios and rated name appropriateness (only naming ratings were used).

This experiment followed a 2 x 3 mixed design. The factors were intentionality (intentional creation, accidental creation) and completeness (missing structure, missing action, broad). Intentionality was a within- and completeness a between-subjects factor. In contrast to previous experiments, baseline (i.e., where all components are intact) does not figure here as a condition. The only baseline scenario is the intentional creation

scenario in the broad definition condition. Subjects in the broad condition were the only group to read about an object being created and used, including a description of its physical structure (as in Experiments 1 and 2). The missing action group read about an object being created, including a description of its physical structure. There was no description of its use (as in Gelman & Bloom, 2000). The missing structure group learned about an object's creation and its posterior use. They did not receive a description of its physical structure (as in Matan & Carey, 2001).

Materials

There were two types of scenarios and three objects, for a total of six different scenarios (see Appendix D). The objects were a mop, a whistle, and a comb. "Charcoal pencil", which was used in previous experiments, was substituted by "comb" because a charcoal pencil was difficult to describe in a way that avoided giving away a crucial aspect of its physical structure (i.e., that it is made of charcoal). Completely omitting this information was a necessity in the missing structure condition.

A basic sequence of six scenarios was constructed which presented all three objects once as intentionally and once as accidentally created. Objects did not occur back to back in the sequence, and scenarios alternated between accidental and intentional creation. Six sequences of scenarios were derived by counterbalancing.

Procedure

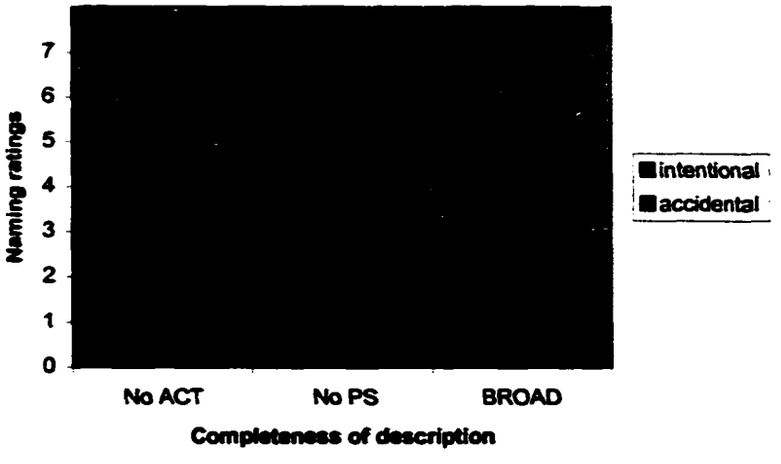
As in previous experiments, subjects read the instructions, ran through 3 practice trials, four buffer trials, and then received the critical trials (six in this case). After each scenario, subjects were asked to provide a naming rating and also to rate how confident

they were of their response. Finally, they answered the same debriefing questions as in the first three experiments.

Results

Each subject contributed two scores to the analysis. One score was the average of all three intentional scenarios, and the other the average of all accidental scenarios (see Figure 19). Data were submitted to a 2 (intentionality) x 3 (completeness) mixed ANOVA. Both main effects were significant. There was a main effect of completeness ($F(2, 33) = 3.92$, $MSe = 1.62$, $p < .03$, $R^2 = .19$, power = .67) and a main effect of intentionality, where intentional creation scenarios received higher naming ratings ($F(1, 33) = 41.3$, $MSe = .91$, $p < .001$, $R^2 = .56$, power = 1). More importantly, there was an intentionality by completeness interaction ($F(2, 33) = 3.48$, $MSe = .91$, $p < .042$, $R^2 = .17$, power = .61).

Figure 19. Mean naming ratings in Experiment 4 (No ACT = missing action, No PS = missing structure, BROAD = broad description. Error bars are standard errors).



To examine the interaction, the difference between intentional and accidental ratings across all three completeness conditions was analyzed. On all three completeness conditions, intentional creation scenarios were rated higher than accidental creation ones. However this difference was significant only for incomplete scenarios, i.e., missing action and missing structure (respectively, $F(1, 11) =$, $MSe = .96$, $p < .001$, $R^2 = .64$, power = .98; $F(1, 11) = 19.39$, $MSe = 1.17$, $p < .001$, $R^2 = .64$, power = .98). The difference between intentional and accidental scenarios was not significant in the broad description condition ($F(1, 11) = 3.77$, $MSe = .59$, $p < .078$, $R^2 = .26$, power = .43). Additionally, the size of these differences (i.e., intentional minus accidental) was comparable for both incomplete conditions ($F(1, 33) = .09$, $MSe = 1.82$, $p < .764$), but significantly greater for missing action as compared to broad description ($F(1, 33) = 4.49$, $MSe = 1.82$, $p < .042$) and for missing structure also as compared to broad description ($F(1, 33) = 3.48$, $MSe = 1.82$, $p < .021$).

As in previous experiments, if subjects used the scale correctly, their confidence ratings should be high. Subjects' confidence ratings produced a mean of 5.88 ($SD = .72$). Subjects showed no significant difference in their confidence ratings across completeness conditions ($F(2,33) = 2.58$, $MSe = .47$, $p < .091$). As in other experiments, a significant number of subjects learned something about the structure of the experiment (23 subjects or 63.9%). In this experiment, however, subjects awareness of the scenarios' structure should have worked against the hypothesis. Explicitly discriminating between intentional and accidental scenarios presumably should have amplified that contrast, thus blurring the predicted interaction. Because of this, it was not necessary to perform separate analyses with those subjects who did not become aware of the experiment's structure.

Furthermore, the number of subjects who understood the hypothesis was stable across completeness conditions, making it highly unlikely that this factor could explain the results (8 subjects in the missing action, 8 in the missing structure, and 7 in the broad description condition; χ^2 (2, $N = 36$) = .241, $p < .887$).

Discussion

Clearly intentional history will be important when it is the main source of information. Having ambiguous information about an object's affordances motivates subjects to draw inferences about affordances in ways consistent with situational constraints. When history is the main source of information, subjects use it to guide their inferences. This explanation reconciles the apparent contradiction between Experiments 1 and 2, and previous published studies. The relevance of intentional history is maximized in the unusual situation of having incomplete information about affordances. When subjects have close to complete information, intentional history plays only a small role.

An alternative explanation for these results can be ruled out. The outcome of this experiment cannot be explained as a result of subjects' understanding the structure of stimuli. As a matter of fact, there is no difference across completeness conditions in the number of subjects who gave evidence of noticing the intentional/accidental contrast. Furthermore, even if all subjects had noticed the contrast it would have worked against obtaining the predicted pattern of results, not in favor. It would have tended to increase the difference between intentional and accidental scenarios, thus obscuring the predicted interaction.

One cannot argue based on these data that intentional history's relevance for naming completely disappears when subjects have close to complete information about affordances. The fact that there was not a significant difference in the broad description condition could be due to the relatively low power of this contrast. The contribution of intentional history to naming was significant in Experiment 1, where power was more adequate. However current results make this a plausible alternative.

GENERAL DISCUSSION

This dissertation began by asking what is function's nature and what is its contribution to concepts. A review of the relevant psychological literature indicated that function is a relational system. Rather than being a single unanalyzable attribute of objects, function is best characterized as knowledge of the relational structure linking multiple aspects of object use. When people are aware of this relational system they can make sense of function. Only then does it show its full impact in concepts.

This analysis suggested the importance of characterizing this relational system, in other words, the importance of defining the possible components of function and their relations. An examination of different views on function pointed to several elements that jointly help to define it. Although more components can enter into function, a minimal account includes the following components: (1) an object's creation history, (2) an agent's goal when using the object, (3) the object's physical structure, (4) the agent's action.

Three main theories were discussed that differ in their causal arrangement of these basic components: The affordances view, the historical view, and the HIPE theory of function. The first of these regards function as the actual use an artifact is put to. In

accordance, the conceptual structure of function closely mirrors actual use episodes. An agent's goal causes her to act in a certain way, which together with the object's physical structure, causes a certain outcome to take place. In contrast, the intentional theory assumes function is tied to the circumstances of the artifact's creation. An object's function depends on the role for which it was created. Intentional history causes an object's physical structure and its actual use. The last of the theories—HIPE—allows for different causal structures depending on the conceptualizer's intentional perspective. However the theory holds that affordances have a primary role when reasoning about functional events, with history typically not playing a central role.

Four experiments contrasted these theories' predictions in causal, function, and naming tasks. Results challenge the intentional theory on several grounds. First, function is not overly debilitated by accidental creation. In contrast, the data show that information about an object's affordances are central, both in causal and functional reasoning. Second, intentional history is more relevant for naming than for reasoning causally or conceptually about function. If intentional history were essential, its effect should show on both naming and function judgments (perhaps even more in the latter). Results support instead the hypothesis that intentional history's role in naming is due to people reasoning about naming practices, as HIPE predicts. Third and last, when intentional history has appeared central, it has been because affordances were not controlled. When the amount of ambiguous information about affordances is reduced, the effect of intentional history on naming decreases substantially.

What is then the nature of the relational system that underlies function? These four experiments support the following description. The actual use of artifacts furnishes

the conceptual understanding of their function, with knowledge about an object's physical structure and the actions an agent can perform with it both being central. Contrastingly, in naming, an object's intentional history plays a role alongside action and physical structure. Subjects appear to reason that artifacts are generally named by their creators and that users causally follow that practice. The effect of intentional history in naming appears related to the communicational value of names, not to the conceptual structure of function.

Though these results are broadly consistent with HIPE, there are several points that remain problematic for this research program. Two methodological problems will be addressed first, leaving the more theoretical concerns for later. A first practical concern is that using narrative scenarios may be a limited approach. Their verbal nature offers some advantages (e.g., it is easy to combine them in different ways), but also some disadvantages (e.g., investigating these issues with verbal narratives may imply loosing ecological validity). A plausible alternative is to use concrete objects whose functions can be directly demonstrated. This has the advantage of allowing a straight manipulation of function's different components (e.g., physical structure), rather than having to describe them verbally. In fact, this is the approach we took fruitfully in Chaigneau, Barsalou, and Zamani (in preparation). However, using real objects makes it more difficult to inform subjects about their history, unless this is done verbally. The point is that no single type of study can solve these complex problems. Rather, as in many other areas, different methodologies will probably be necessary to converge on robust conclusions.

A second methodological issue concerns why subjects did not give higher ratings to baseline scenarios. Although baseline scenarios were typically considered by subjects to be the best available description of an object's function, they were generally not given the highest possible ratings (i.e., seven points). Should this be considered a failure of the HIPE theory, given that baseline scenarios did not produce maximal ratings although they did contain most of what the theory considers relevant for understanding function? Probably not. In order for baseline scenarios to produce ceiling ratings, all subjects should have given them seven points. Although some subjects did give this score at least to some baseline scenarios, this was not the general case. This may be a reflection of at least two contributing factors. First, there are idiosyncratic conceptual differences, which produce intersubject variability. It is very likely that different subjects have slightly different concepts. This may be especially true of complex concepts, such as function. Furthermore, the verbal nature of the scenarios makes it highly unlikely that they will capture all nuances in every subject's concept of function. This is a consequence of the necessary level of abstraction in the description that each scenario furnishes. Second, as all four experiments show, subjects are sensitive to seemingly small deviations from canonical descriptions of function. Once these two elements—individual differences and the effect of deviations—are taken into account, it is easy to see why baseline scenarios did not generate higher ratings. There are individual differences in people's concepts, and any standard description will inevitably fail to capture all these differences. Another factor that may explain why subjects did not rate baseline scenarios higher, is that the descriptions they received included only a minimal number of HIPE components. Presumably, if richer descriptions were furnished, it would result in higher ratings.

Though these methodological concerns are relevant, two theoretical issues are of greater significance. They relate to HIPE's failure to predict two important phenomena. First, the role of physical structure and action in naming, and second, the close relation of causal and functional judgments. For naming, HIPE predicted the effect of intentional history, but failed to predict the role of structure and action. The two latter components played an important role in subjects' naming judgments. For causal judgments, HIPE predicted that they would diverge from function judgments. Whereas all conceptual components should be important for function judgments, only the causally sufficient ones should be relevant for causal judgments. In particular, subjects should not have given lower causal ratings to scenarios that compromised intentional components (i.e., intentional history and goal). Contrary to these predictions, subjects' causal ratings seemed to indicate that they viewed intentions as playing a causal role.

These theoretical issues suggest the need for further empirical tests, which should provide additional support for HIPE in some areas, and also indicate how the theory should be modified to better account for function. The fact that both affordances and history play a role in naming, creates two interesting questions:

1. The HIPE theory explains the effect of intentional history on naming as a result of subjects' understanding of how language is used. The names of artifacts in particular are causally transmitted from creator to user. It would be desirable to have additional evidence to support the hypothesis that subjects have and rely on this knowledge when reasoning about artifact names. A new prediction that follows from HIPE is that when the causal link between creator and user is broken, an artifact's long-term

history (including its original role and invention) should cease to have an effect on naming.

2. The HIPE theory did not predict that affordances (i.e., agent action and object physical structure) would play a role in naming. A relevant question is in what capacity are action and physical structure exerting their influence. One alternative is that they relate to naming in their conceptual capacity. In this view, for example, a mop is called "mop" because it functions as one. A slightly different alternative is that functionally relevant conceptual components tend to leak into naming. In this view, because structure and action are conceptually relevant, people feel compelled to include them in their naming judgments. A third alternative is that structure and action play a role in naming because of the importance of physical structure—and of action to a lesser degree perhaps—for recognition. In this view, for example, a mop is called a "mop" because it looks like one. These alternatives should be empirically tested.

Regarding the second theoretical issue, the first two experiments show that functional judgments closely follow causal ones. The question here is why, even when subjects are explicitly told that an object fulfills the required affordances, does compromising intentionality have consequences for causal judgments. Two alternative explanations—considered in detail in the discussions of both initial experiments—are that subjects are either unable to filter out conceptual content from their causal judgments, or are able to construct a causal account where intentionality is causally relevant. Deciding between these alternatives is possible by carrying out an experiment where affordances are described in as much detail as possible, while the nature of objects' history is

presented as either intentional or accidental. If unambiguous affordances eliminate intentionality effects, the correct alternative is the second one. Intentionality per se would not be important, relying instead on the precise and controlled nature of outcomes that causally follow intentional actions.

Finally, it is worth noting that the present experiments provide support for an embodied view of conceptualization in general, and for perceptual symbol systems theory in particular (Barsalou, 1999, in press). Data showing the conceptual importance of physical structure and agent action are precisely what those theories would predict. The conceptualization of an object's function involves the same aspects that are implicated in people's interaction with that object. Importantly, not only does HIPE allow an integration with these broader views of conceptualization, but—as evident throughout this dissertation—it offers rich, productive, and deep ways of formulating questions about the conceptual structure of function.

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APPENDIX A: Materials for Experiment 1

This appendix contains one set of materials, including instructions, three practice trials, four buffer trials, fifteen critical trials, and three debriefing questions. As described in methods, subjects received either causality, function, or naming questions. The current set of materials though shows only the function question (an example of the causality question can be found in appendix B; an example of the naming question can be found in appendix D).

Critical scenarios are structured similarly throughout all four experiments. Each describes an artifact's history, its physical structure, the goal of an agent who uses it, and his or her actions. Though subjects received scenarios as an unbroken narrative, in the following example of a baseline scenario, each component has been isolated. Thus, this example can be used as a template to analyze other scenarios.

History: "One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later."

Physical structure: "The object consisted of bundle of thick cloth attached to a 4 foot long stick."

Goal: "Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that Jane had made and thought that it would be good for wiping up a water spill on the kitchen floor."

Action: "He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill."

Subjects received one of four possible sequences of all fifteen critical trials. The construction of these sequences is described in methods. The current set does not correspond though to any of those sequences. To facilitate readers' understanding critical trials are organized by object, with scenarios always in the following order: baseline, accidental creation, accidental use, inadequate action, inadequate object.

Instructions

In this study we are studying the knowledge that people have of daily life activities. On the next pages you will find several short stories or scenarios, describing events in the daily lives of two characters. Each scenario is different from the others. Read each one carefully. As you read them, imagine to yourself what is happening.

After each scenario, you will have to answer two questions. If you find it necessary, you can read the story again in order to answer the questions. However, once you have answered them, continue with the next scenario without re-reading any previous

ones. After answering the questions, put the corresponding page in the tray provided for you under the desk. Also, do not look ahead to other scenarios in the booklet.

Read the scenarios one at a time, in exactly the same order in which they appear in this booklet. Each scenario provides all the information that you need to answer the questions. This is not a test of your intellectual ability. Instead, we are simply trying to assess what people generally know about everyday activities. You will have enough time to read each scenario carefully.

In each scenario, there are two characters. The names of the two characters in all the scenarios are Jane and John. Jane has a young child, called John, who is constantly running around the house and trying new things.

Please use a 7 point rating scale in order to answer the first question that follows a scenario. A one (1) always means "not at all", a four (4) means "somewhat", and a seven (7) means "very well." Respond by circling the number that best reflects your answer. Immediately below, you can find an example of the rating scale.

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

After you respond to the first question, you will be asked to rate how confident you are about the response you gave. If you are not confident, use a one (1), if you are somewhat confident use a four (4), and use a seven (7) if you are very confident of your response. Respond by circling the number that best reflects your answer. Immediately below, you can find an example of this rating scale.

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

In summary, for each scenario you will have to do the same things. You will find a scenario that you will read. Immediately after reading the scenario, you will respond to a question by using a rating scale. Finally, you will rate your confidence on the response you gave.

Here are three examples that will help you to get used to this procedure.

First example:

"Jane was reading a book that she was very interested in, and remembered she had to make a phone call. While she made the phone call, she left her book on the table.

While Jane was on the phone, John looked for something to do. He saw the book that Jane was reading, picked it up, and browsed through it."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Here is a second scenario:

"On a certain occasion Jane was feeling stressed, extremely tired, and grouchy. To get her mind off her worries, she decided to watch some TV.

While Jane was watching TV, John started to complain that he was hungry. Reluctantly, Jane had to get up and fix him something to eat."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Here is a third scenario:

"One day, Jane was getting ready to go out. She had decided to wear a nice outfit that she had recently bought. She left the outfit over her bed, and took a shower.

While Jane was taking a shower, John came into the room carrying a permanent marker he found elsewhere. He decided to climb onto the bed, and in doing so he stained Jane's outfit."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

The three examples you just read are about emotions. In contrast, the scenarios that you will read and rate next are not about emotions. However, they have the same structure. In each page you will find a scenario and two questions that you will answer by using the rating scale.

You can put this page in the tray and read the first scenario now.

One day Jane wanted to loosen the soil in her garden pots, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in the garden so she could use it later. The object had three prongs and a handle.

Later that day, John was looking for something to loosen the soil in the garden. He saw the object that Jane had made and thought that it would be good for loosening the soil in the garden. He grabbed the object by the handle and repeatedly pushed the prongs into the garden soil.

Question:

How well does this scenario illustrate the function of a gardening fork?

not at all	somewhat	very well
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of the scrap pieces looked like a spherical piece of metal with a handle attached to it.

Later that day, John was looking for something play with. He saw the object that Jane had made and thought that it would be good for playing with. He grabbed the object from the spherical part, and repeatedly waved it above his head.

Question:

How well does this scenario illustrate the function of a gardening fork?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to hang her clothes, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in her room so she could use it later. The object was a long wire shaped like the outline of a person's shoulders, and with a hook on the top.

Later that day, John was looking for something to hang his clothes on. He saw the object that Jane had made and thought that it would be good for hanging his clothes on. He grabbed the object and fit it inside his T shirt so that the hook came out through the neck.

Question:

How well does this scenario illustrate the function of a hanger?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of the scrap pieces looked like a wire twisted in different ways.

Later that day, John was looking for something play with. He saw the object that Jane had made and thought that it would be good for playing with. He grabbed the object from both sides, and repeatedly squeezed it with his hands.

Question:

How well does this scenario illustrate the function of a hanger?

not at all	somewhat	very well
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that Jane had made and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane was cleaning the attic. She picked up a bunch of useless things and put them all inside a big cardboard box. Because the box was overflowing, she used a long stick to shove things down. As she did this, something became attached to the stick. Then, Jane carried the box downstairs. She didn't notice that as she did this, the stick and the thing that was attached to it fell together, as a single object to the floor. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that had fallen on the floor and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was in the kitchen looking for something to eat. He was distracted as he looked for something, and inadvertently grabbed the object that Jane had left in the kitchen. He grabbed the object with the bundle of thick cloth pointing downward and, without noticing it, pressed it against a water spill.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that Jane had made and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object with the bundle of thick cloth pointing upward instead of downward, and pressed the bare wood end against the water spill.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. The object consisted of bundle of plastic bags attached to a 4 foot long stick.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that Jane had made and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object with the bundle of plastic bags pointing downward, and pressed it against the water spill.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to draw lines on a white sheet of paper, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned.

Later that day, John was looking for something to draw lines on a white sheet of paper. He saw the object that Jane had made and thought that it would be good for drawing lines on a white sheet of paper. He grabbed the object and pressed its tip against a white sheet of paper while moving his hand in different directions.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane noticed that the fireplace needed to be cleaned. She piled up the ashes, half-burned logs and sticks, and carefully transferred everything into an ash bucket. She didn't notice that as she did this, one object fell on the floor. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned.

Later that day, John was looking for something to draw lines on a white sheet of paper. He saw the object that had fallen on the floor and thought that it would be good for drawing lines on a white sheet of paper. He grabbed the object and pressed its tip against a white sheet of paper while moving his hand in different directions.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to draw lines on a white sheet of paper, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned.

Later that day, John was sitting at the table while eating his lunch. He was distracted as he munched, and inadvertently grabbed the object that Jane had left on the table. He grabbed the object and, without noticing it, pressed its tip against a white sheet of paper while moving his hand in different directions.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1-------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1-------2--------3--------4--------5--------6--------7		

One day Jane wanted to draw lines on a white sheet of paper, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned.

Later that day, John was looking for something to draw lines on a white sheet of paper. He saw the object that Jane had made and thought that it would be good for drawing lines on a white sheet of paper. He grabbed the object, and waived it in front of the white piece of paper, without ever touching it.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to draw lines on a white sheet of paper, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object consisted of a slender wooden stick, approximately 3 inches in length, that had been polished with sandpaper.

Later that day, John was looking for something to draw lines on a white sheet of paper. He saw the object that Jane had made and thought that it would be good for drawing lines on a white sheet of paper. He grabbed the object and pressed its tip against a white sheet of paper while moving his hand in different directions.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object was a conical sea shell that now had its tip broken.

Later that day, John was looking for something to call his dog with. He saw the object that Jane had made and thought that it would be good for calling his dog. He grabbed the object, put its tip in his mouth, and blew.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to clean up her desk. She reviewed different documents and objects that were on her desk, and began to put all unwanted items in a cardboard box. Because she wasn't careful when throwing objects into the box, the tip of one of the objects she discarded broke. The object was a conical sea shell that now had its tip broken.

Later that day, John was looking for something to call his dog with (who was out in the garden and was trained to answer to a high pitch sound). He saw the object that Jane had left in the box and thought that it would be good for calling his dog. He grabbed the object, put its tip between his lips, and blew.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object was a conical sea shell that now had its tip broken.

Later that day, John was searching on the table for something to play with. He was distracted as he looked for something, and inadvertently grabbed the sea shell. He tried to look into it, and then put its tip to his mouth and blew through it.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object was a conical sea shell that now had its tip broken.

Later that day, John was looking for something to call his dog with. He saw the object that Jane had made and thought that it would be good for calling his dog. He grabbed the object, put his mouth near the wider opening, and whispered his dog's name.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object was a conical sea shell that now had its tip broken and replaced with a solid piece of plastic resin that completely blocked the opening.

Later that day, John was looking for something to call his dog with. He saw the object that Jane had made and thought that it would be good for calling his dog. He grabbed the object, put its tip in his mouth, and blew.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

We would like to know what do you think this experiment is about. Please respond to the following questions:

1. **What do you believe the hypothesis of the experiment is?**

2. **During the experiment, did anything occur to you about how the different scenarios were related to each other?**

3. **If you answered yes to question 2, describe how you thought the scenarios were related?**

APPENDIX B: Materials for Experiment 2

This appendix contains one set of materials, including instructions, three practice trials, four buffer trials, and twelve critical trials. Debriefing questions are not shown and can be found in appendix A. As described in methods, subjects received either causality or function questions. The current set of materials though shows only the causality question (an example of the function question can be found in appendix A).

Subjects received one of three possible sequences of all twelve critical trials. The construction of these sequences is described in methods. The current set does not correspond though to any of those sequences. To facilitate readers' understanding critical trials are organized by object, with scenarios always in the following order: baseline, accidental creation, accidental use, fully accidental.

Instructions

In this study we are studying the knowledge that people have of daily life activities. On the next pages you will find several short stories or scenarios, describing events in the daily lives of two characters. Each scenario is different from the others. Read each one carefully. As you read them, imagine to yourself what is happening.

After each scenario, you will have to answer two questions. If you find it necessary, you can read the story again in order to answer the questions. However, once you have answered them, continue with the next scenario without re-reading any previous ones. After answering the questions, put the corresponding page in the tray provided for you under the desk. Also, do not look ahead to other scenarios in the booklet.

Read the scenarios one at a time, in exactly the same order in which they appear in this booklet. Each scenario provides all the information that you need to answer the questions. This is not a test of your intellectual ability. Instead, we are simply trying to assess what people generally know about everyday activities. You will have enough time to read each scenario carefully.

In each scenario, there are two characters. The names of the two characters in all the scenarios are Jane and John. Jane has a young child, called John, who is constantly running around the house and trying new things.

Please use a 7 point rating scale in order to answer the first question that follows a scenario. A one (1) always means "not at all", a four (4) means "somewhat", and a seven (7) means "very." Respond by circling the number that best reflects your answer. Immediately below, you can find an example of the rating scale.

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

After you respond to the first question, you will be asked to rate how confident you are about the response you gave. If you are not confident, use a one (1), if you are somewhat confident use a four (4), and use a seven (7) if you are very confident of your response. Respond by circling the number that best reflects your answer. Immediately below, you can find an example of this rating scale.

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

In summary, for each scenario you will have to do the same things. You will find a scenario that you will read. Immediately after reading the scenario, you will respond to a question by using a rating scale. Finally, you will rate your confidence on the response you gave.

Here are three examples that will help you to get used to this procedure.

First example:

"Jane was reading a book that she was very interested in, and remembered she had to make a phone call. While she made the phone call, she left her book on the table.

While Jane was on the phone, John looked for something to do. He saw the book that Jane was reading, picked it up, and browsed through it."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

Here is a second scenario:

"On a certain occasion Jane was feeling stressed, extremely tired, and grouchy. To get her mind off her worries, she decided to watch some TV.

While Jane was watching TV, John started to complain that he was hungry. Reluctantly, Jane had to get up and fix him something to eat."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Here is a third scenario:

"One day, Jane was getting ready to go out. She had decided to wear a nice outfit that she had recently bought. She left the outfit over her bed, and took a shower.

While Jane was taking a shower, John came into the room carrying a permanent marker he found elsewhere. He decided to climb onto the bed, and in doing so he stained Jane's outfit."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1-------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1-------2---------3---------4---------5---------6---------7		

The three examples you just read are about emotions. In contrast, the scenarios that you will read and rate next are not about emotions. However, they have the same structure. In each page you will find a scenario and two questions that you will answer by using the rating scale.

You can put this page in the tray and read the first scenario now.

One day Jane wanted to loosen the soil in her garden pots, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in the garden so she could use it later. The object had three prongs and a handle.

Later that day, John was looking for something to loosen the soil in the garden. He saw the object that Jane had made and thought that it would be good for loosening the soil in the garden. He grabbed the object by the handle and repeatedly pushed the prongs into the garden soil.

Question:

How likely would it be that, as a result of the events described above, John loosened the garden soil?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of the scrap pieces looked like a spherical piece of metal with a handle attached to it.

Later that day, John was looking for something play with. He saw the object that Jane had made and thought that it would be good for playing with. He grabbed the object from the spherical part, and repeatedly waved it above his head.

Question:

How likely would it be that, as a result of the events described above, John loosened the garden soil?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to hang her clothes, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in her room so she could use it later. The object was a long wire shaped like the outline of a person's shoulders, and with a hook on the top.

Later that day, John was looking for something to hang his clothes on. He saw the object that Jane had made and thought that it would be good for hanging his clothes on. He grabbed the object and fit it inside his T shirt so that the hook came out through the neck.

Question:

How likely would it be that, as a result of the events described above, John hanged his T shirt?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of the scrap pieces looked like a wire twisted in different ways.

Later that day, John was looking for something play with. He saw the object that Jane had made and thought that it would be good for playing with. He grabbed the object from both sides, and repeatedly squeezed it with his hands.

Question:

How likely would it be that, as a result of the events described above, John hanged his T shirt?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that Jane had made and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill.

Question:

How likely would it be that, as a result of the events described above, John wiped up the water spill?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane was cleaning the attic. She picked up a bunch of useless things and put them all inside a big cardboard box. Because the box was overflowing, she used a long stick to shove things down. As she did this, something became attached to the stick. Then, Jane carried the box downstairs. She didn't notice that as she did this, the stick and the thing that was attached to it fell together, as a single object to the floor. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that had fallen on the floor and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill.

Question:

How likely would it be that, as a result of the events described above, John wiped up the water spill?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was in the kitchen looking for something to eat. He was distracted as he looked for something, and inadvertently grabbed the object that Jane had left in the kitchen. He grabbed the object with the bundle of thick cloth pointing downward and, without noticing it, pressed it against a water spill.

Question:

How likely would it be that, as a result of the events described above, John wiped up the water spill?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane was cleaning the attic. She picked up a bunch of useless things and put them all inside a big cardboard box. Because the box was overflowing, she used a long stick to shove things down. As she did this, something became attached to the stick. Then, Jane carried the box downstairs. She didn't notice that as she did this, the stick and the thing that was attached to it fell together, as a single object on the kitchen floor. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was in the kitchen looking for something to eat. He was distracted as he looked for something and inadvertently grabbed the object that had fallen on the kitchen floor. He grabbed the object with the bundle of thick cloth pointing downward and, without noticing it, pressed it against a water spill.

Question:

How likely would it be that, as a result of the events described above, John wiped up the water spill?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to draw lines on a white sheet of paper, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned.

Later that day, John was looking for something to draw lines on a white sheet of paper. He saw the object that Jane had made and thought that it would be good for drawing lines on a white sheet of paper. He grabbed the object and pressed its tip against a white sheet of paper while moving his hand in different directions.

Question:

How likely would it be that, as a result of the events described above, John drew lines on the white piece of paper?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane noticed that the fireplace needed to be cleaned. She piled up the ashes, half-burned logs and sticks, and carefully transferred everything into an ash bucket. She didn't notice that as she did this, one object fell on the floor. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned.

Later that day, John was looking for something to draw lines on a white sheet of paper. He saw the object that had fallen on the floor and thought that it would be good for drawing lines on a white sheet of paper. He grabbed the object and pressed its tip against a white sheet of paper while moving his hand in different directions.

Question:

How likely would it be that, as a result of the events described above, John drew lines on the white piece of paper?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to draw lines on a white sheet of paper, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned.

Later that day, John was sitting at the table while eating his lunch. He was distracted as he munched, and inadvertently grabbed the object that Jane had left on the table. He grabbed the object and, without noticing it, pressed its tip against a white sheet of paper while moving his hand in different directions.

Question:

How likely would it be that, as a result of the events described above, John drew lines on the white piece of paper?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane noticed that the fireplace needed to be cleaned. She piled up the ashes, half-burned logs and sticks, and carefully transferred everything into an ash bucket. She didn't notice that as she did this, one object fell on the floor. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned.

Later that day, John was sitting on the floor while eating a sandwich. He was distracted as he munched, and inadvertently grabbed the object that had fallen on the floor. He grabbed the object and, without noticing it, pressed its tip against a white sheet of paper while moving his hand in different directions.

Question:

How likely would it be that, as a result of the events described above, John drew lines on the white piece of paper?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object was a conical sea shell that now had its tip broken off.

Later that day, John was looking for something to call his dog with. He saw the object that Jane had made and thought that it would be good for calling his dog. He grabbed the object, put its tip in his mouth, and blew.

Question:

How likely would it be that, as a result of the events described above, John called his dog?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to clean up her desk. She reviewed different documents and objects that were on her desk, and began to put all unwanted items in a cardboard box. Because she wasn't careful when throwing objects into the box, the tip of one of the objects she discarded broke. The object was a conical sea shell that now had its tip broken off.

Later that day, John was looking for something to call his dog with (who was out in the garden and was trained to answer to a high pitch sound). He saw the object that Jane had left in the box and thought that it would be good for calling his dog. He grabbed the object, put its tip between his lips, and blew.

Question:

How likely would it be that, as a result of the events described above, John called his dog?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object was a conical sea shell that now had its tip broken off.

Later that day, John was searching on the table for something to play with. He was distracted as he looked for something, and inadvertently grabbed the sea shell. He tried to look into it, and then put its tip to his mouth and blew through it.

Question:

How likely would it be that, as a result of the events described above, John called his dog?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to clean up her desk. She reviewed different documents and objects that were on her desk, and began to put all unwanted items in a cardboard box. Because she wasn't careful when throwing objects into the box, the tip of one of the objects she discarded broke. The object was a conical sea shell that now had its tip broken off.

Later that day, their dog—who was trained to answer to a high pitch sound—was out in the garden. Meanwhile, John was searching on the desk for something to play with. He was distracted as he looked for something, and inadvertently grabbed the sea shell. He tried to look into it, and then put its tip to his mouth and blew through it.

Question:

How likely would it be that, as a result of the events described above, John called his dog?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

APPENDIX C: Materials for Experiment 3

This appendix contains one set of materials, including instructions, three practice trials, four buffer trials, and twelve critical trials. Debriefing questions are not presented and can be found in appendix A. As described in methods, subjects read either scenarios where the artifact's history was narrated first, or scenarios where the artifact's use was narrated first. Because the history-first scenarios are already found in appendix A, only use-first scenarios are presented here. Only the function question was used.

Subjects received one of three possible sequences of all twelve critical trials. The construction of these sequences is described in methods. The current set does not correspond though to any of those sequences. To facilitate readers' understanding critical trials are organized by object, with scenarios always in the following order: baseline, accidental creation, accidental use, inadequate object.

Instructions

In this study we are studying the knowledge that people have of daily life activities. On the next pages you will find several short stories or scenarios, describing events in the daily lives of two characters. Each scenario is different from the others. Read each one carefully. As you read them, imagine to yourself what is happening.

After each scenario, you will have to answer two questions. If you find it necessary, you can read the story again in order to answer the questions. However, once you have answered them, continue with the next scenario without re-reading any previous ones. After answering the questions, put the corresponding page in the tray provided for you under the desk. Also, do not look ahead to other scenarios in the booklet.

Read the scenarios one at a time, in exactly the same order in which they appear in this booklet. Each scenario provides all the information that you need to answer the questions. This is not a test of your intellectual ability. Instead, we are simply trying to assess what people generally know about everyday activities. You will have enough time to read each scenario carefully.

In each scenario, there are two characters. The names of the two characters in all the scenarios are Jane and John. Jane has a young child, called John, who is constantly running around the house and trying new things.

Please use a 7 point rating scale in order to answer the first question that follows a scenario. A one (1) always means "not at all", a four (4) means "somewhat", and a seven (7) means "very well." Respond by circling the number that best reflects your answer. Immediately below, you can find an example of the rating scale.

not at all	somewhat	very well
1-------2--------3--------4--------5--------6--------7		

After you respond to the first question, you will be asked to rate how confident you are about the response you gave. If you are not confident, use a one (1), if you are somewhat confident use a four (4), and use a seven (7) if you are very confident of your response. Respond by circling the number that best reflects your answer. Immediately below, you can find an example of this rating scale.

not at all	somewhat	very confident
1-------2--------3--------4--------5--------6--------7		

In summary, for each scenario you will have to do the same things. You will find a scenario that you will read. Immediately after reading the scenario, you will respond to a question by using a rating scale. Finally, you will rate your confidence on the response you gave.

Here are three examples that will help you to get used to this procedure.

First example:

"John was looking for something to do while Jane was on the phone. He saw a book that Jane had been reading, picked it up, and browsed through it.

Jane had been reading that book because she was very interested in it. She left it on the table while she got up to make the phone call."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Here is a second scenario:

"John started to complain that he was hungry while Jane was watching TV. Reluctantly, Jane got up and fixed him something to eat.

On that particular evening, Jane was feeling stressed, extremely tired, and grouchy. She had decided to watch some TV to get her mind off her worries."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Here is a third scenario:

"While Jane was taking a shower, John came into her room carrying a permanent marker he found elsewhere. He decided to climb onto the bed, and in doing so he stained an outfit that Jane had left there.

Jane was taking a shower because she was getting ready to go out. She had decided to wear that nice outfit she had recently bought, so she left it on her bed while she took a shower."

Question:

How well does this scenario illustrate a situation where Jane is going to be mad at John?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

The three examples you just read are about emotions. In contrast, the scenarios that you will read and rate next are not about emotions. However, they have the same structure. In each page you will find a scenario and two questions that you will answer by using the rating scale.

You can put this page in the tray and read the first scenario now.

One day John was looking for something to loosen the soil in the garden. He saw an object that Jane had left around and thought that it would be good for loosening the soil in the garden. The object had three prongs and a handle. He grabbed the object by the handle and repeatedly pushed the prongs into the garden soil.

Earlier that day Jane had wanted to loosen the soil in her garden pots, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in the garden so she could use it later. This is the object John found later.

Question:

How well does this scenario illustrate the function of a gardening fork?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day John was looking for something play with. He saw an object that Jane had left and thought that it would be good for playing with. The object was a spherical piece of metal with a handle attached to it. He grabbed the object from the spherical part, and repeatedly waved it above his head.

Earlier that day Jane was working in her metal shop, and decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of these scrap pieces was what John found later.

Question:

How well does this scenario illustrate the function of a gardening fork?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day John was looking for something to hang his clothes on. He saw an object that Jane had left around and thought that it would be good for hanging his clothes on. The object was a long wire shaped like the outline of a person's shoulders, and with a hook on the top. He grabbed the object and fit it inside his T shirt so that the hook came out through the neck.

Earlier that day Jane had wanted to hang her clothes, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in her room so she could use it later. This is the object John found later.

Question:

How well does this scenario illustrate the function of a hanger?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day John was looking for something play with. He saw an object that Jane had left and thought that it would be good for playing with. The object was a wire twisted in different ways. He grabbed the object from both sides, and repeatedly squeezed it with his hands.

Earlier that day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of these scrap pieces was what John found later.

Question:

How well does this scenario illustrate the function of a hanger?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was looking for something to wipe up a water spill on the kitchen floor. He saw an object that Jane had left in the kitchen, and thought that it would be good for wiping up a water spill on the kitchen floor. The object consisted of a bundle of thick cloth attached to a 4 foot long stick. He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill.

Jane had made the object earlier that day, because she wanted to wipe up a water spill on the kitchen floor. Because she didn't have anything to wipe up a water spill with, she decided to make something herself. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was looking for something to wipe up a water spill on the kitchen floor. He saw an object that had dropped in the kitchen and thought that it would be good for wiping up a water spill on the kitchen floor. The object consisted of a bundle of thick cloth attached to a 4 foot long stick. He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill.

Jane had been cleaning the attic earlier that day. She picked up a bunch of useless things and put them all inside a big cardboard box. Because the box was overflowing, she used a long stick to shove things down. As she did this, something became attached to the stick. Then, Jane carried the box downstairs. She didn't notice that as she did this, the stick and the thing that was attached to it fell together, as a single object to the floor. This was the object John later found.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was in the kitchen looking for something to eat. He was distracted as he looked for something, and inadvertently grabbed an object that Jane had left in the kitchen. The object consisted of bundle of thick cloth attached to a 4 foot long stick. He grabbed the object with the bundle of thick cloth pointing downward and, without noticing it, pressed it against a water spill.

Jane had made the object earlier that day, because she wanted to wipe up a water spill on the kitchen floor. Because she didn't have anything to wipe up a water spill with, she decided to make something herself. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was looking for something to wipe up a water spill on the kitchen floor. He saw an object that Jane had left in the kitchen and thought that it would be good for wiping up a water spill on the kitchen floor. The object consisted of a bundle of plastic bags attached to a 4 foot long stick. He grabbed the object with the bundle of plastic bags pointing downward, and pressed it against the water spill.

Jane had made the object earlier that day, because she wanted to wipe up a water spill on the kitchen floor. Because she didn't have anything to wipe up a water spill with, she decided to make something herself. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a mop?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was looking for something to draw lines on a white sheet of paper. He saw an object that Jane had left on a table, and thought that it would be good for drawing lines on a white sheet of paper. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned. He grabbed the object and pressed its tip against a white sheet of paper while moving his hand in different directions.

Jane had made the object earlier that day, because she wanted to draw lines on a white sheet of paper. Because she didn't have anything to do it with, she decided to make something herself. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on the table so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was looking for something to draw lines on a white sheet of paper. He saw an object that had dropped on the floor, and thought that it would be good for drawing lines on a white sheet of paper. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned. He grabbed the object and pressed its tip against a white sheet of paper while moving his hand in different directions.

Jane had noticed that the fireplace needed to be cleaned earlier that day. She piled up the ashes, half-burned logs and sticks, and carefully transferred everything into an ash bucket. She didn't notice that as she did this, one object dropped on the floor. This was the object John later found.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was sitting at the table while eating his lunch. He was distracted as he munched, and inadvertently grabbed an object that Jane had left on the table. The object consisted of a slender wooden stick, approximately 3 inches in length, which had been lightly burned. He grabbed the object and, without noticing it, pressed its tip against a white sheet of paper while moving his hand in different directions.

Jane had made the object earlier that day, because she wanted to draw lines on a white sheet of paper. Because she didn't have anything to do it with, she decided to make something herself. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on the table so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day, John was looking for something to draw lines on a white sheet of paper. He saw an object that Jane had left on a table, and thought that it would be good for drawing lines on a white sheet of paper. The object consisted of a slender wooden stick, approximately 3 inches in length, that had been polished with sandpaper. He grabbed the object and pressed its tip against a white sheet of paper while moving his hand in different directions.

Jane had made the object earlier that day, because she wanted to draw lines on a white sheet of paper. Because she didn't have anything to do it with, she decided to make something herself. She looked around the house for things that would allow her to make an object for drawing lines on a white sheet of paper. She gathered all the materials and made it. When she finished, she left it on the table so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a charcoal pencil?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was looking for something to call his dog with (who was out in the garden and was trained to answer to a high pitch sound). He saw an object that Jane had left on a table, and thought that it would be good for calling his dog. The object was a conical sea shell that had its tip broken. He grabbed the object, put its tip in his mouth, and blew.

Jane had made the object earlier that day, because she wanted to call her dog. Because she didn't have anything to do it with, she decided to make something herself. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on the table so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day, John was looking for something to call his dog with (who was out in the garden and was trained to answer to a high pitch sound). He saw an object that Jane had left in a box and thought that it would be good for calling his dog. The object was a conical sea shell that had its tip broken. He grabbed the object, put its tip between his lips, and blew.

Jane had wanted to clean up her desk earlier that day. She reviewed different documents and objects that were on her desk, and began to put all unwanted items in a cardboard box. Because she wasn't careful when throwing objects into the box, the tip of one of the objects she discarded broke. This was the object John later found.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day, John was searching on a table for something to play with. He was distracted as he looked for something, and inadvertently grabbed an object that Jane had left there. The object was a conical sea shell that had its tip broken. In the process of exploring the object, he put its tip to his mouth and blew.

Jane had made the object earlier that day, because she wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound). Because she didn't have anything to do it with, she decided to make something herself. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on the table so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day, John was looking for something to call his dog with (who was out in the garden and was trained to answer to a high pitch sound). He saw an object that Jane had left on a table, and thought it would be good for calling his dog. The object was a conical sea shell that had its tip broken and replaced with a solid piece of plastic resin that completely blocked the opening. He grabbed the object, put its tip between his lips, and blew.

Jane had made the object earlier that day, because she wanted to call her dog. Because she didn't have anything to do it with, she decided to make something herself. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on the table so she could use it later. This was the object John later found.

Question:

How well does this scenario illustrate the function of a whistle?

not at all	somewhat	very well
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

APPENDIX D: Materials for Experiment 4

This appendix contains three sets of materials, including instructions, three practice trials, four buffer trials, and six critical trials. Debriefing questions are not presented and can be found in appendix A. The first set of materials corresponds to the broad description condition, and to avoid repetition is the only one that shows instructions and practice trials, which are identical in all three conditions. The second and third sets correspond to the missing structure and missing action conditions, respectively. Only the naming question was used in this experiment.

As described in methods, subjects received one of six counterbalanced orders of critical trials. For ease of understanding the current sets show critical trials organized by intentionality of creation, with objects in the following order: mop, comb, whistle.

Broad description condition

Instructions

In this experiment we are studying the knowledge that people have of daily life activities. On the next pages you will find three short stories or scenarios describing a series of events. In each page you will find a separate scenario.

After each scenario, you will have to answer two questions. If you find it necessary, you can read the story again in order to answer the questions. However, once you have answered them, continue with the next scenario without re-reading any previous ones. After answering the questions, put the corresponding page in the tray provided for you under your desk. Also, do not look ahead to other scenarios in the booklet.

Read the scenarios one at a time, in exactly the same order in which they appear in this booklet. Each scenario provides all the information that you need to answer the questions. This is not a test of your intellectual ability. Instead, we are simply trying to assess what people generally know about everyday activities. You will have enough time to read each scenario carefully.

Please use a 7 point rating scale in order to answer the first question that follows a scenario. A one (1) always means "not at all", a four (4) means "somewhat", and a seven (7) means "very." Respond by circling the number that best reflects your answer. Immediately below, you can find an example of the rating scale.

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

After you respond to the first question, you will be asked to rate how confident you are about the response you gave. If you are not confident, use a one (1), if you are somewhat confident use a four (4), and use a seven (7) if you are very confident of your response. Respond by circling the number that best reflects your answer. Immediately below, you can find an example of this rating scale.

not at all	somewhat	very confident
1-------2--------3--------4--------5--------6--------7		

In summary, for each scenario you will have to do the same things. You will find a scenario that you will read. Immediately after reading the scenario, you will respond to a question by using a rating scale. Finally, you will rate your confidence on the response you gave.

Here are three examples that will help you to get used to this procedure.

First example:

"Jane was reading a book that she was very interested in, and remembered she had to make a phone call. While she made the phone call, she left her book on the table.

While Jane was on the phone, John looked for something to do. He saw the book that Jane was reading, picked it up, and browsed through it."

Question:

Is it appropriate to call this a frustrating situation?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Here is a second scenario:

"On a certain occasion Jane was feeling stressed, extremely tired, and grouchy. To get her mind off her worries, she decided to watch some TV.

While Jane was watching TV, John started to complain that he was hungry. Reluctantly, Jane had to get up and fix him something to eat."

Question:

Is it appropriate to call this a frustrating situation?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Here is a third scenario:

"One day, Jane was getting ready to go out. She had decided to wear a nice outfit that she had recently bought. She left the outfit over her bed, and took a shower.

While Jane was taking a shower, John came into the room carrying a permanent marker he found elsewhere. He decided to climb onto the bed, and in doing so he stained Jane's outfit."

Question:

Is it appropriate to call this a frustrating situation?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

The three examples you just read are about emotions. In contrast, the scenarios that you will read and rate next are not about emotions. However, they have the same structure. In each page you will find a scenario and two questions that you will answer by using the rating scale.

You can put this page in the tray and read the first scenario now.

One day Jane wanted to loosen the soil in her garden pots, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in the garden so she could use it later. The object had three prongs and a handle.

Later that day, John was looking for something to loosen the soil in the garden. He saw the object that Jane had made and thought that it would be good for loosening the soil in the garden. He grabbed the object by the handle and repeatedly pushed the prongs into the garden soil.

Question:

Is it appropriate to call this object a gardening fork?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of the scrap pieces looked like a spherical piece of metal with a handle attached to it.

Later that day, John was looking for something play with. He saw the object that Jane had made and thought that it would be good for playing with. He grabbed the object from the spherical part, and repeatedly waved it above his head.

Question:

Is it appropriate to call this object a gardening fork?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to hang her clothes, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in her room so she could use it later. The object was a long wire shaped like the outline of a person's shoulders, and with a hook on the top.

Later that day, John was looking for something to hang his clothes on. He saw the object that Jane had made and thought that it would be good for hanging his clothes on. He grabbed the object and fit it inside his T shirt so that the hook came out through the neck.

Question:

Is it appropriate to call this object a hanger?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of the scrap pieces looked like a wire twisted in different ways.

Later that day, John was looking for something play with. He saw the object that Jane had made and thought that it would be good for playing with. He grabbed the object from both sides, and repeatedly squeezed it with his hands.

Question:

Is it appropriate to call this object a hanger?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that Jane had made, and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill.

Question:

Is it appropriate to call this object a mop?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to comb her hair, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for combing her hair. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. It was a toothed object, of about 8 inches in length.

Later that day, John was looking for something to comb his hair with. He saw the object that Jane had made and thought that it would be good for combing his hair. He grabbed the object, and pulled it through his hair.

Question:

Is it appropriate to call this object a comb?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object was a conical sea shell that now had its tip broken off.

Later that day, John was looking for something to call his dog with. He saw the object that Jane had made, and thought that it would be good for calling his dog. He grabbed the object, put its tip in his mouth, and blew.

Question:

Is it appropriate to call this object a whistle?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane was cleaning the attic. She picked up a bunch of useless things and put them all inside a big cardboard box. Because the box was overflowing, she used a long stick to shove things down. As she did this, something became attached to the stick. Then, Jane carried the box downstairs. She didn't notice that as she did this, the stick and the thing that was attached to it fell together, as a single object to the floor. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that had fallen on the floor and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object with the bundle of thick cloth pointing downward, and pressed it against the water spill.

Question:

Is it appropriate to call this object a mop?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to do something with a bunch of plastic scrap she had. She wanted to put it somewhere so that she could inspect it later, but she didn't know where to put it. So, she decided to put it temporarily in the oven. Because she didn't notice that her oven was on, when she retrieved the scrap, some of it had melted. She left everything on a table, so that it would cool down. Part of the melted scrap had formed a toothed object, of about 8 inches in length.

Later that day, John was looking for something to comb his hair with. He saw the object that Jane had left on the table, and thought that it would be good for combing his hair. He grabbed the object, and pulled it through his hair.

Question:

Is it appropriate to call this object a comb?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to clean up her desk. She reviewed different documents and objects that were on her desk, and began to put all unwanted items in a cardboard box. Because she wasn't careful when throwing objects into the box, the tip of one of the objects she discarded broke. The object was a conical sea shell that now had its tip broken off.

Later that day, John was looking for something to call his dog with (who was out in the garden and was trained to answer to a high pitch sound). He saw the object that Jane had left in the box, and thought that it would be good for calling his dog. He grabbed the object, put its tip in his mouth, and blew.

Question:

Is it appropriate to call this object a whistle?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Missing action condition

Note: Instructions and practice trials are not shown here, and can be found with the materials for the broad description condition. Buffer trials continue below.

One day Jane wanted to loosen the soil in her garden pots, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in the garden so she could use it later. The object had three prongs and a handle.

Question:

Is it appropriate to call this object a gardening fork?

not at all	somewhat	very
1-------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1-------2---------3---------4---------5---------6---------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of the scrap pieces looked like a spherical piece of metal with a handle attached to it.

Question:

Is it appropriate to call this object a gardening fork?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to hang her clothes, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in her room so she could use it later. The object was a long wire shaped like the outline of a person's shoulders, and with a hook on the top.

Question:

Is it appropriate to call this object a hanger?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table. One of the scrap pieces looked like a wire twisted in different ways.

Question:

Is it appropriate to call this object a hanger?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Question:

Is it appropriate to call this object a mop?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to comb her hair, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for combing her hair. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. It was a toothed object, of about 8 inches in length.

Question:

Is it appropriate to call this object a comb?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later. The object was a conical sea shell that now had its tip broken off.

Question:

Is it appropriate to call this object a whistle?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane was cleaning the attic. She picked up a bunch of useless things and put them all inside a big cardboard box. Because the box was overflowing, she used a long stick to shove things down. As she did this, something became attached to the stick. Then, Jane carried the box downstairs. She didn't notice that as she did this, the stick and the thing that was attached to it fell together, as a single object to the floor. The object consisted of bundle of thick cloth attached to a 4 foot long stick.

Question:

Is it appropriate to call this object a mop?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to do something with a bunch of plastic scrap she had. She wanted to put it somewhere so that she could inspect it later, but she didn't know where to put it. So, she decided to put it temporarily in the oven. Because she didn't notice that her oven was on, when she retrieved the scrap, some of it had melted. She left everything on a table, so that it would cool down. Part of the melted scrap had formed a toothed object, of about 8 inches in length.

Question:

Is it appropriate to call this object a comb?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to clean up her desk. She reviewed different documents and objects that were on her desk, and began to put all unwanted items in a cardboard box. Because she wasn't careful when throwing objects into the box, the tip of one of the objects she discarded broke. The object was a conical sea shell that now had its tip broken off.

Question:

Is it appropriate to call this object a whistle?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

Missing structure condition

Note: Instructions and practice trials are not shown here, and can be found with the materials for the broad description condition. Buffer trials continue below.

One day Jane wanted to loosen the soil in her garden pots, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in the garden so she could use it later.

Later that day, John was looking for something to loosen the soil in the garden. He saw the object that Jane had made and thought that it would be good for loosening the soil in the garden. He grabbed the object and repeatedly pushed it into the garden soil.

Question:

Is it appropriate to call this object a gardening fork?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane was working in her metal shop, and she decided to make something. She gathered all the materials and started to work. As she worked, metal scraps were left to the side of her table.

Later that day, John was looking for something play with. He saw the object that Jane had made and thought that it would be good for playing with. He grabbed the object and repeatedly waved it above his head.

Question:

Is it appropriate to call this object a gardening fork?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to hang her clothes, but she didn't have anything to do it with. So she decided to make something. She gathered all the materials and made it. When she finished, she left it in her room so she could use it later.

Later that day, John was looking for something to hang his clothes on. He saw the object that Jane had made and thought that it would be good for hanging his clothes on. He grabbed the object and fit it inside his T shirt.

Question:

Is it appropriate to call this object a hanger?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane was working in her shop, and she decided to make something. She gathered all the materials and started to work. As she worked, scraps were left to the side of her table.

Later that day, John was looking for something play with. He saw the object that Jane had left and thought that it would be good for playing with. He grabbed the object and repeatedly squeezed it with his hands.

Question:

Is it appropriate to call this object a hanger?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to wipe up a water spill on the kitchen floor, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for wiping up a water spill on the kitchen floor. She gathered all the materials and made it. When she finished, she left it in the kitchen so she could use it later.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that Jane had made, and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object, and pressed it against the water spill.

Question:

Is it appropriate to call this object a mop?

not at all	somewhat	very
1--------2---------3---------4---------5---------6---------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2---------3---------4---------5---------6---------7		

One day Jane wanted to comb her hair, but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for combing her hair. She gathered all the materials and made it. When she finished, she left it in a table so she could use it later.

Later that day, John was looking for something to comb his hair with. He saw the object that Jane had made, and thought that it would be good for combing his hair. He grabbed the object, and pulled it through his hair.

Question:

Is it appropriate to call this object a comb?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to call her dog (who was out in the garden and was trained to answer to a high pitch sound), but she didn't have anything to do it with. So she decided to make something. She looked around the house for things that would allow her to make an object for calling her dog. She gathered all the materials and made it. When she finished, she left it on a table so she could use it later.

Later that day, John was looking for something to call his dog with. He saw the object that Jane had made, and thought that it would be good for calling his dog. He grabbed the object, put it to his mouth, and blew.

Question:

Is it appropriate to call this object a whistle?

not at all	somewhat	very
1-------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1-------2--------3--------4--------5--------6--------7		

One day Jane was cleaning the attic. She picked up a bunch of useless things and put them all inside a big cardboard box. As she did this, some objects inside the box became attached. Then, Jane carried the box downstairs. She didn't notice that as she did this, the things that were attached fell together, as a single object to the floor.

Later that day, John was looking for something to wipe up a water spill on the kitchen floor. He saw the object that had fallen on the floor, and thought that it would be good for wiping up a water spill on the kitchen floor. He grabbed the object, and pressed it against the water spill.

Question:

Is it appropriate to call this object a mop?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to do something with a bunch of plastic scrap she had. She wanted to put it somewhere so that she could inspect it later, but she didn't know where to put it. So, she decided to put it temporarily in the oven. Because she didn't notice that her oven was on, when she retrieved the scrap, some of it had melted. She left everything on a table, so that it would cool down. Part of the melted scrap had formed an object.

Later that day, John was looking for something to comb his hair with. He saw the object that Jane had left on the table, and thought that it would be good for combing his hair. He grabbed the object, and pulled it through his hair.

Question:

Is it appropriate to call this object a comb?

not at all	somewhat	very
1--------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1--------2--------3--------4--------5--------6--------7		

One day Jane wanted to clean up her desk. She reviewed different documents and objects that were on her desk, and began to put all unwanted items in a cardboard box. Because she wasn't careful when throwing objects into the box, a part of one of the objects she discarded broke.

Later that day, John was looking for something to call his dog with (who was out in the garden and was trained to answer to a high pitch sound). He saw the object that Jane had left in the box, and thought that it would be good for calling his dog. He grabbed the object, put it to his mouth, and blew.

Question:

Is it appropriate to call this object a whistle?

not at all	somewhat	very
1-------2--------3--------4--------5--------6--------7		

How confident are you of your response?

not at all	somewhat	very confident
1-------2--------3--------4--------5--------6--------7		