Why do People Prefer Historically Intended Functions?

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Abstract

When presented with a hammer that is being used as a paperweight, most people judge that its proper function is to pound nails in place rather than to hold down pieces of paper. The bias to assign proper function based on historically intended function rather than on manifest or current function, can be explained as a memory effect (we have learned that hammers are used to pound nails), as abduction—a form of causal reasoning (a hammer's structure is not explained by the function of being a paperweight), or as a form of intentional/social reasoning (whoever was responsible for creating the hammer, decides what its function is). The experiments reported here rule out memory and abduction as sufficient explanations.

Keywords: Concepts; Function; Intentions.

Most objects that surround us were created to fulfill a function. In order to efficiently operate in their environment, an important task that humans face is to acquire the *proper functions* of these objects. Some functions (e.g., that a glass is used to contain liquids) appear to be rapidly acquired in the course of development (e.g., Aguiar & Baillargeon, 1998; Caron, Caron, & Antell, 1988). Most functions, however, need more extensive learning (e.g., that a hammer is used to pound nails in place). How are these more complex proper functions assigned to objects?

At a broad level, two answers have been proposed for this question. One is that proper functions are assigned based on direct experience (e.g., Madole & Oakes, 2004). Hammers have the proper function of pounding nails in place, either because we have seen people perform this function, or because we have done it ourselves (the *manifest view* of function). A contrasting answer is that proper functions are assigned based on knowledge of the *historically intended functions* (HIF). In this view, hammers have the proper function of pounding nails in place, not because our direct experience with them, but because we have been told or have somehow inferred that this is what they were made for (the *historical view* of function).

In the manifest view, people perceive an event where typically an agent acts intentionally with or on an object, which in turn behaves to cause the desired outcome. This event is somehow represented (e.g., by scripts, Schank & Abelson, 1977; by simulations, Barsalou, 1999; by causal models, Pearl, 2000) and used to reason about function (see Chaigneau, Barsalou & Sloman, 2004). In contrast, the historical view has generally been framed in the context of intentions. People assign proper function according to the perceived but most of the time inferred intention of the designer.

Evidence for the historical view comes mainly from the following observation. Imagine you have a hammer, and that you are using it as a paperweight. What is this object's proper function? Most people judge that its proper function is to pound nails in place, and that it is only currently being used to hold down sheets of paper. The HIF is seen as preeminent over the manifest function. This bias of assigning objects their historically intended function (from now on, the HIF bias), as opposed to their manifest or current function, was first described by Lance Rips (1989), and has since then been shown in different paradigms both with children and adults (e.g., Defeyter & German, 2003; Gelman & Bloom, 2000; Jaswal, 2006; Matan & Carey, 2001). Why do people tend to believe that the HIF is the proper function? As will be explained below, both the manifest and the historical views can account for this bias.

Memory

The manifest view gives a deflationary explanation for the HIF bias: manifest functions become entrenched in memory. Experience has taught people that the hammer in our example has *pounding nails*, and not *holding down paper* as its associated function. Most studies on the HIF bias have not ruled out this explanation, partly because they have used common everyday objects as materials (but see Defeyter & German, 2003). By using novel objects, we were able to test the entrenchment explanation in Experiment 1.

Causal Updating

This account is also consistent with the manifest view. If provided with a causal model that relates the HIF (i.e., the cause) to an object's physical structure (i.e., the effect), people can use it to reason. When people need to predict what an object will do, they use this model to infer that the object is physically fit to perform its HIF better than other possible alternative functions (Chaigneau et al., 2004; cf., Dennett, 1987). The hammer in our recurrent example has the function of pounding nails in place, because—as it was designed to pound—that is what it should be predicted to do best. In this view, the HIF bias occurs because when a historical function is known it leads us to infer that the object performs its HIF better than an alternative function (i.e., reasoning from cause to effect).

Abduction or Inference to the Best Explanation

This is also a causal account, but consistent with the historical view. The HIF bias occurs because people spontaneously build a causal model where history is the cause and manifest function the effect, and reason backwards—from the effect to the cause—to assign proper function (Bloom, 1996, 1998, 2000). When people perceive a manifest function, they do not take it for granted. Instead, they perform an inference to the best explanation, looking for its central cause. People reason backward in their causal model to corroborate if a designer could have intentionally created an object with that particular manifest function in mind. They use their knowledge of design to reason about the most likely intention of the designer when creating a particular object. Consequently, people perceive that intention to be the object's proper function. In this view, the hammer in our example has the function of pounding nails in place, because that HIF explains it having a *heavy head with a flat striking surface* and a *long handle*, better than does the putative HIF of holding down sheets of paper. The abduction theory predicts that a well-formed and causally efficient manifest function, is evidence of a historically intended function (e.g., pounding nails for a hammer), but that a not well-formed and causally inefficient manifest function is evidence contrary to that particular function being the object's historically intended function (e.g., being a paperweight cannot be a hammer's HIF, because that account leaves unexplained many of the hammer's physical features). We test the abduction account in Experiment 2.

Pure Intention Theory

In this account, consistent with the historical view, a designer's genuine intention that an object belongs to a certain category, imbues that object with the category's essence (Bloom, 1996). Think of an urinal being put in a museum and categorized as a work of art. Importantly, in this theory, being causally relevant in the creation of the object is not a factor that explains the HIF bias. The urinal is not created by the artist, but simply placed in a museum. In this view an object's function is what the designer intended it to be (e.g., a hammer's function is to pound nails in place because that is what it was intended to do).

Moral Responsibility Theory

In this theory (consistent with the historical view, and presented here for the first time as explanation for the bias), designer's intentions are also relevant, but only insofar as they reflect responsibility. The HIF bias occurs because of a reasoning akin to moral responsibility judgments (e.g., Knobe, 2003; Mele, 2003). Note that responsibility is a complex construct and does not require intention nor direct causality (see Spellman, 1997). For example, expectations about typical behaviors can influence responsibility judgments (e.g., a parent who does not rescue his or her child from drowning may be deemed responsible). In this view, a HIF is judged to be the proper function because people reason that if the designer is responsible for the creation of an object, then that intended function should be honored.

In the experiments reported here, we tested entrenchment and abduction against intention and responsibility theories by presenting our participants with scenarios where an object was described physically (verbally and pictorially), along with its design history, and its subsequent use for a different but possible alternative function (see Figure 1 for an example). After learning about each object, participants had to answer questions about the object's function (i.e., is its function the historically intended or the alternative function?, Experiments 1 and 2), or about its causal efficacy (i.e., is the object efficient when performing each function?, Experiment 2).

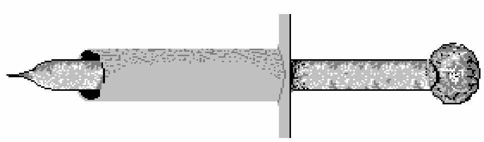
Experiment 1

We had two goals in this experiment. First, we wished to show that the HIF bias could be observed with our paradigm and materials. Second, we wanted to test the entrenchment explanation. This is the least theoretically interesting account, and we wanted to show that the phenomenon occurs even when there is little room for entrenchment. Most prior experiments that report the bias, have used common everyday objects. In contrast, we created novel objects for which participants presumably had little prior knowledge (i.e., the object did not have an associated function). If entrenchment were the only factor responsible for the HIF bias, participants should not prefer historically intended functions over alternative functions when judging novel objects. If participants did exhibit the HIF bias with our novel objects, then entrenchment is an insufficient explanation.

Method

Design and Participants We used a 2 x 3 fully within participants design. The two factors were *function* (two functions, X and Y, could be described as the historically intended function or the alternative function) and *object* (objects A, B and C, see Figure 1 for an example). Which function (X or Y) was historical and which was alternative, scenario structure (whether historical or alternative function was described first in the scenario), and rating order (historical first or alternative first) were completely crossed, to produce 8 basic versions of the materials. Object order was counterbalanced and crossed with the 8 basic versions, to produce 24 final versions. Participants were 48 University of Tarapaca undergraduate students, 18 males and 30 females, who participated for course credit.

<u>Physical Description</u>: In an ancient culture, there was an inventor who worked with an assistant. One of his or her inventions was a wooden stake that had been sharpened on one of its tips and rounded on the other. The stake was partially covered by a metallic tube with a sharp edge (as shown in the drawing below).



<u>Function X</u>: The inventor used the object to decorate the body. People in that culture liked to decorate their bodies during different rituals. The inventor dipped the sharp point into ink, and holding the tube firmly, repeatedly hit the rounded side with his or her hand. As he or she did this, the sharp point pierced the skin, introducing the ink into the skin, and creating a tattoo.

<u>Function Y</u>: The assistant used the object to eat a type of fruit. In that culture, there was a type of fruit of bitter and hard husk, but having a sweet and soft center. The assistant pressed the tip of the stake to the husk, and then pushed the tube all the way through the fruit. As he or she did this, he or she was able to extract the fruit's center and eat it, leaving the husk aside.

Figure 1: Example of novel objects used in the experiments. Participants did not receive the underlined headings, which are presented here only for reference.

Materials and Procedures Participants read scenarios describing three novel objects. Each scenario contained a graphical depiction of the object, its physical description, and two equally afforded functions: one being the historically intended, and the other an alternative function to which the object had been put to use (see Figure 1). After learning about an object, participants had to rate both possible functions (Do you think the function of this object is X?, where X was once the historically intended function, and once the alternative function). Ratings were done on a 7 point scale, where 1 meant "no", 7 "yes", and 4 "to some extent". Materials were presented in a booklet, and the experimenter read the instructions out loud to the participants. It took them an average of 10 minutes to complete the experiment.

Materials were designed and selected in a preliminary experiment. We created seven novel objects, with physical descriptions and drawings, and each affording two different functions. An independent sample (n = 20) judged the causal efficacy of the two different functions. For this experiment we selected three objects whose two possible functions were judged to be about equally efficient. This was done to reduce variability in judgments, but which of both functions was historical and which alternative was completely counterbalanced across conditions in the current experiment.

Results and Discussion Data were submitted to a 2 (function: historically intended, alternative function) by 3 (object: A, B, C) fully within participants ANOVA. As predicted, we found a main effect of function favoring the historically intended over the alternative function ($F(1, 47) = 6.88$, $MSe = 8.27$, $p < .05$, $R^2 = .13$, power = .73). Participants were biased into believing that the objects' functions were the historically intended and not the alternative functions. We found no effect of object and no interaction (respectively, $F(2, 94) = 1.96$, $MSe = 2.36$, $p < .25$, $R^2 = .04$, power = .40; $F(2, 94) = 1.89$, $MSe = 4.17$, $p < .25$, $R^2 = .04$, power = .38). As shown in Figure 2, all three objects showed the same pattern of results.

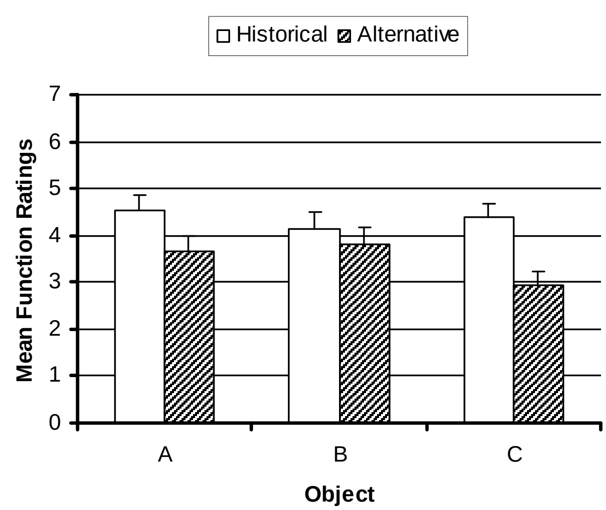


Figure 2: In Experiment 1, mean function ratings for historical and alternative functions. Error bars are standard errors.

Because subjects rated three consecutive scenarios, learning was a concern. If subjects learned something about the design, any bias they showed should increase from the first to the last scenario. To test for learning effects, we computed for each individual and each scenario the difference between historical and alternative function ratings (historical minus alternative). Positive delta values (i.e., higher rating for historical than alternative function) reflected the HIF bias. Zero and negative delta values reflected no HIF bias. When we submitted delta values to a repeated measures ANOVA, first, second and third position scenarios did not differ in the size of the bias they produced ($F < 1$). In fact, the first object showed a nominally greater bias than the second and third objects.

Another concern was raised by an anonymous reviewer who pointed out that ratings hovered around the center of the scale (see Figure 2). Presumably, a pure historical view would have subjects rating historical functions with a 7 and alternative functions with a 1, thus predicting that ratings for the historical function should be significantly greater than 4 and ratings for the alternative function significantly lower than 4. As Figure 2 shows, this is not generally the case. We think this pattern of results is due to task demands. Subjects rated two functions for a each object, which may have induced them to balance their ratings. Had we used a design where subjects rated only one function (i.e., either historical or alternative), it is likely their ratings would have been more extreme.

To reduce these concerns and to provide further evidence for the bias, we averaged delta values across scenarios for each subject, and compared the number of subjects with a positive average delta (i.e., subjects who showed the bias) versus the number of subjects with zero or negative average delta (i.e., subjects who showed a pattern inconsistent with the bias). Taken as a group, our sample was biased. Over 60% of our subjects had positive average deltas, about 10% showed no preference, and about 30% behaved contrary to our predictions (χ^2 (2, N = 48) = 18.38, $p < .001$).

In all, we were able to produce the HIF bias with our paradigm and materials. Most important, Experiment 1 showed that the effect is not simply due to the entrenchment of historical functions in memory. It is possible that entrenchment happens with common everyday objects, but our data shows this is not the sole factor accounting for the phenomenon. Finally, the effect showed for all three objects, and appears not to be due to learning. The bias showed from the first trial, and did not depend on participants learning something about the task.

Experiment 2

Abduction predicts that a well-formed and causally efficient manifest function, is evidence of a historically intended function, but that a not well-formed and causally inefficient manifest function is evidence contrary to that particular function being the object's historically intended function. In Experiment 2 we tested this account by using objects that performed one function more efficiently than the other. Presumably, designers would not create an object to perform its function poorly. Consequently, if participants reason causally about manifest functions to make inferences about history, they should conclude that an inefficient function is unlikely to be a true historical function. There were two levels of the *efficiency* factor. Each participant learned about two objects, one that performed its historical function efficiently (but its alternative function poorly), and one that performed its historical function poorly (but its alternative function efficiently).

Method

Design and Participants We used a mixed 2 x 2 x 2 design, with *rating* (functional, causal) as the between participants factor, and *function* (historically intended, alternative) and e*fficiency* (efficient historical function, inefficient historical function) as within participants factors. All participants learned about one object which performed its historical function with efficiency, and about another object that performed its historical function without efficiency. Participants rated both, the historical and the alternative functions, and were randomly assigned to perform either functional or causal ratings. Abduction predicts that, for functional ratings, function and efficiency will interact. Only an efficient, but not an inefficient, historical function should produce the bias. Intentional and responsibility theories predict that, for functional ratings there will be a main effect of function (historical > alternative) independently of efficiency.

Sixteen versions of the materials were constructed by crossing scenario structure (whether historical or alternative function was described first in the scenario), object order (D-E or E-D, see below), which object was assigned to each level of the efficiency factor, and rating order (historical first or alternative first).

Participants were 128 (64 for each rating type) University of Talca and University of Tarapaca undergraduates (48 males, 80 females), who volunteered to participate.

Materials and Procedures For this experiment we selected two additional objects from our preliminary experiment. For these additional objects (labeled D and E), participants in the preliminary experiment had agreed that one of their possible functions was afforded significantly better than the other. Thus, we were able to create scenarios where the HIF was inefficient relative to the alternative function or vice versa. Participants went through a procedure similar to that of Experiment 1. Half our subjects rated function (do you think the function of this object is X?, where X was once the historically intended function and once the alternative function) and half rated causality (is the object efficient when performing X?, where X was once the historically intended function and once the alternative function). It took subjects an average of 8 minutes to complete the task.

Results and Discussion Data were submitted to a mixed 2 x 2 x 2 ANOVA (see Figure 3). This analysis revealed no main effect of efficiency (F < 1), and only a marginal effect of function and rating (respectively, $F(1, 126) = 3.28$, $MSe = 3.91$, $p < .07$, $R^2 = .03$, power = .44; $F(1, 126) = 3.07$, $MSe = 2.69$, $p < .08$, $R^2 = .02$, power = .41). However, function interacted with rating ($F(1, 126) = 7.81$, $MSe = 3.91$, $p < .01$, $R^2 = .06$, power = .79) and there was a three-way interaction between function, efficiency and rating ($F(1, 126) = 7.91$, $MSe = 4.91$, $p < .01$, $R^2 = .06$, power = .80).

A

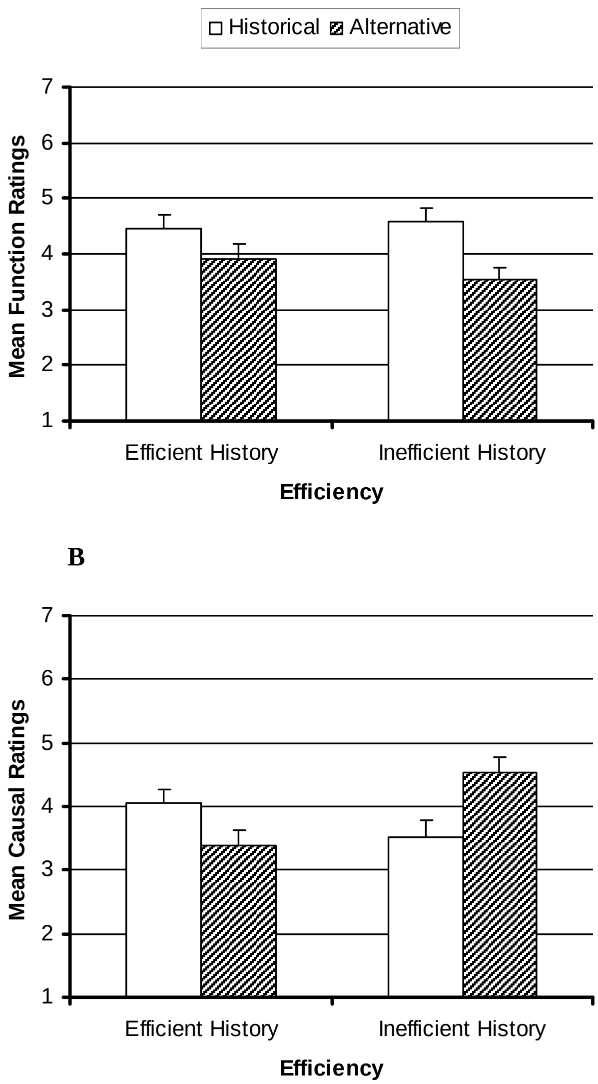


Figure 3: In Experiment 3, Panel A: mean function ratings for historical and alternative functions when historical functions were efficiently or inefficiently performed. Panel B: mean causal ratings for historical and alternative functions when historical functions were efficiently or inefficiently performed. Error bars are standard errors.

To follow the three-way interaction, we analyzed functional and causal ratings separately. For ratings about function, we found no main effect of efficiency ($F < 1$), an effect of function (historical > alternative, $F(1, 63) = 8.54$, $MSe = 4.85$, $p < .01$, $R^2 = .12$, power = .82), and no efficiency by function interaction ($F < 1$). The lack of interaction shows that participants had a preference for the historical function, irrespective of how efficiently it was performed (see Figure 3, Panel A), as predicted by intention and responsibility theories. Separate comparisons for each level of efficiency, showed that when the historically intended function was efficient, the HIF bias was in the predicted direction although not significant ($F(1, 63) = 1.58$, $MSe = 6.06$, $p < .25$, $R^2 = .02$, power = .24). Importantly, when the historically intended function was inefficient, the HIF bias was significant in the predicted direction ($F(1, 63) = 6.54$, $MSe = 5.52$, $p < .05$, $R^2 = .09$, power = .71).

When we analyzed ratings about causality, a different pattern of results emerged. We found no main effect of efficiency ($F(1, 63) = 2.49$, $MSe = 2.77$, $p < .25$, $R^2 = .04$, power = .34), no effect of function ($F < 1$), but a function by efficiency interaction ($F(1, 63) = 14.73$, $MSe = 3.09$, $p < .001$, $R^2 = .19$, power = .97). Participants perceived that one object performed its historical function efficiently, while the other performed its historical function inefficiently, reflecting that participants perceived objects' causality as we intended (see Figure 3, Panel B).

The three way interaction between function, efficiency and rating, tells us that participants perceived differences in causal efficiency of historical and alternative functions, but did not use these differences when deciding which function to assign to an object. This pattern of results is what intention and responsibility theories predicted, but not what the abduction theory predicted. If this last theory were correct, we should have found no HIF bias when objects performed their historically intended function poorly. In contrast, we found the bias remained irrespective of efficiency. To ensure that the whole pattern remained when each object was considered separately, we computed separate means for participants that learned about an efficient object D and an inefficient object E, and for participants that learned about an inefficient object D and an efficient object E. On both cases, means reflected a similar overall pattern (this is a pattern of means and not of statistical significance).

General Discussion

The HIF bias does not require the entrenchment of functions in memory nor reasoning by abduction. We are not denying that entrenchment does happen with everyday objects. After many repeated encounters with instances of the category, one can hardly think that adults will question what a hammer's function is. However, participants showed the bias even when little room for entrenchment was left, which shows some other process is at work.

A similar argument can be made about inference to the best explanation. Abduction is likely to occur in situations where the need for deliberate reasoning exists (e.g., problem solving), or when the task makes explanations of this kind salient. Our point here is that participants did not spontaneously engage in the kind of causal analysis necessary to assign function abductively. This was not because they could not appreciate the causal implications of the stimuli they received. To the contrary, participants noticed the differences in efficiency when explicitly asked to do so. But when asked to assign proper function, their reasoning appears to have corresponded to a different process. This strongly suggests that abduction does not play a role in everyday assignment of function.

Currently, we are conducting experiments in our laboratory to test the remaining theories. Prior research (Chaigneau et al., 2004) shows that causal updating operates when there is limited information about an objects' affordances, but that its influence diminishes as this information becomes increasingly available. This suggests that in normal interactions—at least with relatively simple objects—where much information about affordances becomes rapidly available through perception and action, causal updating plays a limited role in linking history and manifest or current function.

Based on preliminary results, our preferred theory now is that proper function is assigned based on a reasoning similar to the attribution of responsibility. If a designer is causally and intentionally involved in the coming into being of a functional object, his or her assignment of function counts as the proper function, although causal reasoning may show the object can efficiently perform several different functions. We believe this kind of reasoning may not happen frequently in everyday situations, but that it may be very important in certain moments of development, both phylo- and onto-genetically. In the course of the evolution of our species, sharing consensual functions may have allowed modern humans to manage an increasing number of tools and create a complex culture (cf., Mithen, 1996; Searle, 1995). In the course of individual development, the capacity to rapidly affix a preferred function to an object may allow people to efficiently reason within their culture (cf., Defeyter & German, 2003).

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