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The specific contribution of object's origin on artifacts categorization

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Abstract Gelman and Bloom found that adults and children's object naming was sensitive to how an object was created (man-made or not), but they did not reveal on which specific level of conceptual system this effect was. Using a free-naming task and a force-choice task, two experiments were conducted to test a hypothesis that this effect was specifically on domain level ("artifact/non-artifact" distinction). In Experiment 1, participants were asked to name shortly-depicted objects, rate their confidence, and report their reasons for each naming response. Results showed that most of the naming responses in "man-made" condition were in artifact domain, and most in "natural" condition were in non-artifact domain, although in both conditions names were very divergent on basic level. In Experiment 2, another group of participants were asked to choose one from two names (one in artifact domain and the other in non-artifact domain) to match the same shortly-depicted objects presented in the first experiment. Results of Experiment 1 on domain level were replicated in Experiment 2. These convergent findings supported the hypothesis that the effect of object's origin is specifically on domain level of conceptual system of objects. Reasons explicitly reported for naming responses in Experiment 1 suggested that participants might automatically infer objects' functions in "man-made" condition but not in "natural" condition. Here the function-based hypothesis of artifacts classification is discussed.

Keywords: artifacts, categorization, origin, function, design.

After being perceived and thought about, some novel objects would be classified into categories such as "chair", "table", and "flowerpot" and so on. What cognitive processes work underlying these categorization judgments?

Artifact is a domain of real world object concepts[1], representing object categories created and used by people. In everyday life, people interact with many artifacts with a rich database of conceptual knowledge[2], on which people categorize novel objects[3,4].

In the past two decades, theoretical assumptions of conceptual structure of objects were shifted from "similarity-based" to "explanation-based" view[2,5−10]. According to the latter, conceptual representations of objects are founded on humans' intuitive theories[7] and general knowledge about the world[2]. These "theories" are domain-specific. For example, naïve biology (folk-biology) is the theory in biological domain, which provides organized understanding of causal relations between properties of biological concepts[11]. Birds have wings, from which we infer that birds can fly, nest in trees, and avoid predators in sky[11], etc.

In artifact domain, Bloom[12−14] hypothesized that representation of artifacts depends on human's ability of understanding other's mental state (theory of mind). Basing on perceived features of objects (e.g. shape, structure, and function), people infer creator's intended category and make classification judgments. According to Bloom, the understanding of creator's intended category provides top-down constraints for artifact categorization. Now Bloom's theory and some variants of it are called "design-based theory"[15].

Many papers reported evidence for this theory[16−27]. It is shown that young children have the ability to ignore perceptual similarity of objects and to perform name extension task and object categorization task on the basis of objects' functions. The authors explained their findings in such a way: young children's understanding of objects' function depends on their ability of inferring creator's intent. However, from our view, the so-called "creator's intent" were confounded with objects' functions, especially practical function, in most of these experiments. So we do not agree that these experiments can be regarded as positive evidence for design-based theories[28].

In our opinion, the key evidence to design-based theories was an experiment reported by Gelman and Bloom[18]. They asked adults and children to name the same novel objects in different conditions. Experimental results showed that different stories (presented in

natural language) of object's origin lead to different naming responses referring to the same objects, without presenting any information of objects' functions.

Participants in this experiment are adults and 3- and 5-year-old children. Appearances of the novel objects used in this experiment are with high similarity to typical members of some artifact categories but their materials are atypical (e.g. a hat-shaped object folded with newspaper; or a knife-shaped object cut from a big piece of plastic). Experimenters told two conditions of story of object origin when presenting the same objects to participants. In the so-called "intentional" condition, the story told that someone created this object carefully and made it look like the current appearance (e.g. "Susan folded newspapers carefully and made it like this"). In the contrast "accidental" condition, the stories told that some accidents changed this object and made it look like the current appearance (e.g. "Susan crossed the street with newspaper. Newspapers were dropped accidentally and pressed by a car"). Participants were asked to name the novel objects. Results showed that most responses in "intentional" condition are in artifact domain (e.g. "hat") while most responses in "accidental" condition are material names (e.g. newspaper). Patterns of naming responses in adults and young children are similar.

According to Gelman and Bloom[18], stories of object's origin are cues to creator's intent (Fig. 1). In "intentional" condition, children and adults named novel objects as artifacts because they inferred creator's intent depending on these stories (e.g. newspapers were folded as a hat because participants inferred that the creator intended to make a hat). In "accidental" condition, participants named these objects as materials because there is neither such a creator, nor creator's intent.

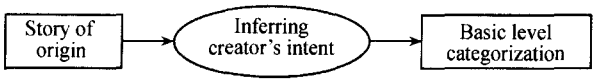

Fig. 1. According to Gelman and Bloom[18], story of object's origin influenced basic level categorization by making participants infer creator's intent.

Since this experiment presented no information about objects' function, the influence of story of objects' origin on object categorization was not confounded with object's function explicitly. However, we found two points that were unclear in the authors' explanation above.

The first point is that no evidence was shown demonstrating on which specific level of conceptual system stories of objects origin influenced categorization judgments. In Gelman and Bloom's view[18], classification judgments were on basic level. But the conceptual system of objects is a complex knowledge system with a hierarchical structure. Both domain level and basic level classification in conceptual system would influence output of naming responses on basic level. Gelman and Bloom did not tell us which one of these two possibilities is true.

Findings in cognitive developmental psychology provided cues to this question. According to Mandler and McDonough[29−32], development of infants and young children's conceptual system is in an "abstract first and concrete second" order. Global categories (e.g. animals and vehicles) emerged before basic level categories[33]. These findings suggested that categorization on domain level and basic level could be dissociated in conceptual system and some abstract rules can influence domain level categorization directly, without any processes relative to basic level classification. In this way of thinking, effect of stories of object's origin could be specifically on domain level ("artifact/non-artifact" distinction) but not on basic level.

The second point is no evidence was shown telling whether participants really inferred creator's intent or not in Gelman and Bloom's experiment. The only independent variable manipulated in this experiment is the type of stories of object's origin, but not creator's intent. It is always an assumption without any direct evidence that "reading story in a certain condition made participants infer creator's intent".

Furthermore, two factors were probably confounded in this experiment. In the "accidental" stories, neither a creator nor creator's intent was presented; while in the "intentional" story, both a creator and the creator's intent were explicitly shown. It was possible that solely on the difference of presenting a creator or not in the stories that participants could categorize the objects into artifact domain or non-artifact domain, without considering anything of the creator's intent.

Basing on the analysis above, we proposed two hypotheses to explain Gelman and Bloom's results in a different way from the design-based view. First, perceptual similarity of objects activated representation and names of artifact categories on basic level. Second, stories in the two conditions interact in different ways with the activated representation and names. In intentional condition, a story would not inhibit the representation and name of an artifact category but an acciden-

tal story would. Together with perceptual input, different conditions of stories of object's origin directly influenced the domain level judgments at the beginning of the process, and then influenced the basic level classification in an indirect way (Fig. 2). In short, we hypothesized that the effect of stories of object's origin on categorization is specifically on domain level of conceptual system. Basing on this hypothesis, no complex steps of reasoning about creators' intent were needed in the processes of artifact classification.

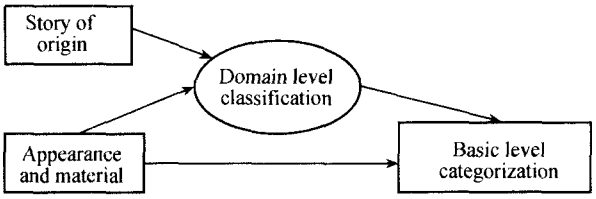

Fig. 2. Story of object's origin specifically influenced domain level categorization.

We had two predictions, consequently. (1) On domain level, different types of stories of object's origin would lead participants to name stimuli as artifacts or non-artifacts and such a result should be the same in both a free-naming task and in a force-choice task. (2) On basic level, participants' responses would have different distributions in these two different tasks. There would be a divergent distribution for categorization responses on basic level in the free-naming task but a convergent distribution for that in a force-choice task.

A free-naming task and a force-choice task, which are variants of Gelman and Bloom's task[18], were used in our study. In order to decrease impact of perceptual similarity with typical members of possible target artifact categories and maximize contribution of stories of object's origin on domain level categorization judgments, shortly depicted but not real objects were used as stimuli. We manipulated stories of object's origin and asked participants to make every classification judgment with confidence rating. In one experiment, participants were asked to report reasons for naming responses. These self-report data could help to reveal whether stories of object's origin automatically activated object's some properties that were not presented in the short depictions.

1 Experiment 1: A free-naming task

1.1 Participants

77 undergraduates (35 males and 42 females), ages from 18—23 (20.6 in average), in Zhejiang Sci-Tech University and Hangzhou Vocational Tech College were recruited.

1.2 Materials and design

Six objects' appearances and materials were shortly depicted. Two versions of stories of origin were prepared for each object, describing how someone created the object in "man-made" condition and how this object was formed in natural force in "naturally-formed" condition (Fig. 3 and Appendix I at the website of Science in China Press (http://www.SciChina.com)).

Suppose an object like this.....
A round, big turtle shell with vertebral column protruding.
A certain kind of turtles has hard shell which protrudes gradually as the turtle grows up. The object was formed in this way.
Please answer questions below"
(1) What is it?
(2) How much confident are you in your answer? please tickle on 1—9:
1——2——3——4——5——6——7——8——9
Extremely low Middle Extremely high
(3) Please write down your reasons.

Suppose an object like this.....
A round, big turtle shell with vertebral column protruding
Someone polish turtle shells and make it vertebral column protruding. So this object was like what you read.
Please answer questions below:
(1) What is it?
(2) How much confident are you in your answer? please tickle on 1—9:
1——2——3——4——5——6——7——8——9
Extremely low Middle Extremely high
(3) Please write down your reasons.

Fig. 3. Two examples pages of booklet in Experiment 1.

A between-group design was used. In each condition, the 6 items were presented in random order for each participant. There were 3 questions for each item: a free naming question, a confidence rating question, and a reason reporting question (Fig. 3).

1.3 Procedure

The experiment was conducted in a quiet classroom. Materials were presented in a booklet with 7 pages (1 cover page and 6 testing pages). Instructions on the cover page explained that the goal of this experiment was to investigate how people understand objects, not to test personality or intelligence. Everyone was asked to answer questions on their own judgments. Experiment lasted for 15—20 min.

1.4 Results and discussions

All responses from 77 participants, 6 items each, 462 responses in total, were collected. The responses were classified into 3 kinds: valid (valid naming and reasons),

half-valid (valid naming but not reasons), and invalid (invalid naming or miss). There were 189 valid, 210 half-valid, and 63 invalid responses (19 missing and 44 invalid). See Appendix II at the website of Science in China Press (http://www.SciChina.com) for coding rules for naming and Appendix III at the website of Science in China Press (http://www.SciChina.com) for rules for reasons.

We calculated the number of each kind of response for each participant. Five participants provide 4 or 5 invalid responses each. Their data were deleted. Therefore, there were 72 valid participants (38 in man-made condition and 34 in naturally-formed condition) with 432 responses in total which included 186 valid responses (43.1%), 205 half-valid responses (47.5%) and 41 invalid responses (9.5 %).

(i) Domain level categorization judgment. Valid naming responses were coded into 3 types: artifact domain, natural kinds, and combined responses (see Appendix II for details of coding rules). Consistency of the two coders, Cohen's Kappa=0.96. We calculated frequencies of the 3 types of naming for each participant (from 0 to 6). Table 1 shows the means of frequencies of 4 kinds of responses in 2 conditions of stories of object's origin. From the responses in artifact domain in man-made condition, 12 names were selected for references to Experiment 2 (Appendix I at the website of Science in China Press (http://www.SciChina.com)).

A 2 (types of stories: man-made and naturally formed)×3 (types of naming responses: artifacts, natural kinds, and combined) repeated measures analysis of variance (ANOVA) on frequency revealed a significant main effect of types of naming and a significant interaction of naming and stories, $F(1.6,114.6)=17.68$, $P<0.001$; $F(1.6,114.6)=26.65$, $P<0.001$, respectively. No significant effect of stories was found, $F(1,70)=1.66$, $P>0.20$. These results showed that (1) most naming responses in man-made condition were in artifact domain and most responses in natural-formed condition were in natural kind domain; and (2) total frequencies of responses were equal in two experimental conditions.

We calculated the differences in frequency of names in artifact domain and natural kind for each participant. The value of the difference refers to the advantage of artifact names over natural kind names in each participant's responses[18]. It ranges from –6 to +6, which means that all responses were names in natural kind or artifact domain, respectively.

The differences were 2.55 and –1.12 under the man-made and naturally-formed conditions, respectively. A *t*-test on frequencies revealed a significant effect of types of stories of object's origin, $t(70)=5.80$, $P<0.001$, which confirmed our hypothesis that domain level categorization is influenced by stories of object's origin.

Furthermore, domain level analysis on these results showed asymmetrical distribution in responses in the two conditions. The absolute value of the difference in man-made condition is larger than that in naturally-formed condition, suggesting that two conditions of stories of object's origin interacted differently with objects' appearances and materials. This detailed pattern is consistent with our second hypothesis. Short depictions of objects activated representations of object concepts, and different stories interacted with them in different ways. It is possible that participants' general preference on classification judgment to the depictions also contribute to these results. We tested these two possibilities in Experiment 2.

(ii) Confidence ratings for categorization judgments. Table 2 shows the means of confidence rating for 3 types of naming responses. No main effect or interac-

Table 1 Means of frequencies of 4 kinds of responses in 2 conditions of stories of object's origin[a)]

Conditions of stories	Types of (valid) naming responses			N/A
	artifacts	natural kinds	combined	
Man-made	3.29 (0.25)	0.74 (0.22)	1.29 (0.16)	0.68 (0.13)
Naturally-formed	1.85 (0.26)	2.97 (0.23)	0.74 (0.17)	0.44 (0.14)

a) With SE in parentheses.

Table 2 Means of confidence rating for 3 types of naming responses[a)]

Conditions of stories	Types of naming responses		
	artifacts	natural kinds	combined
Man-made	5.47 (0.38)	6.20 (0.46)	5.26 (0.63)
Naturally-formed	5.41 (0.49)	5.59 (0.62)	5.80 (0.58)

a) With SE in parentheses.

tion was found in a 2 (types of stories: man-made and naturally-formed)×3 (types of naming responses: artifacts, natural kinds, and combined) repeated measures analysis on confidence rating, suggesting that participants have equal confidence in the three types of naming responses in the two conditions.

Since confidence ratings range from 1 to 9, all these results are on the middle level (around 6). There are two possible explanations to this result. (1) Stories of object's origin influenced basic level response indirectly, as our hypotheses predicted. (2) Objects were not presented visually but in words. Consequently, the sizes of candidate object sets were increased. Depending on so little information, it is easy to understand that participants had low confidence to do specific basic level classification judgments.

(iii) Distribution of basic level categorization responses. We computed types and tokens of all responses on basic level. "Type" refers to number of non-repeated basic level category names. Token just refers to number of valid responses.

We defined a variable named "divergency of naming" (*S*) referring to quotient of type divided by token (*S*=Type/Token). The value of *S* ranges from 1/token (extremely convergent because type is 1) to 1 (extremely divergent because type is equal to token). Results showed that *S* (man-made)=0.71 (143/202) and *S* (naturally-formed)=0.74 (139/189), suggesting that responses on basic level are as divergent as our hypotheses predicted.

(iv) Reasons reported for naming responses. 59 participants (31 for man-made condition and 28 for naturally formed condition) reported 186 valid responses in total. We analyzed four kinds of reasons in every participant's report: shape (*P*), material (*M*), history (*H*) and function (F). Each valid response included 1—4 reasons (Appendix III at the website of Science in China Press (http://www.SciChina.com)). Consistencies of two coders for the 4 kinds of reason are Kappa(*P*) = 0.93, Kappa(*M*)=0.95, Kappa(*H*)=0.88, and Kappa(*F*) = 0.84, respectively. Table 3 shows the frequencies of the 4 kinds of reasons for 3 types of naming in two conditions of stories.

Table 4 shows the means of differences in frequencies of the 4 kinds of reasons for two domains of naming in 2 conditions of stories. In man-made condition, frequencies of shape and function reported are higher for naming responses in artifact domain than that in non-artifact domain, but in naturally-formed condition no such domain difference was found for any reasons. Four 2 (types of stories: man-made and naturally formed)×2 (types of naming responses: artifacts and natural kinds) repeated measures analysis of variance (ANOVA) on frequencies of the 4 kinds of reasons confirmed above observation. Significant interactions were found only on shape and function, $F(1,57)= 5.06$, $P=0.028<0.05$, and $F(1,57) = 14.88$, $P<0.001$, respectively.

Considering that stories of object's origin were presented in stimuli but objects' function was not, it is surprising that domain difference emerged on function but not on origin. Together with domain difference in ob-

Table 3 Frequencies of the 4 kinds of reasons for 3 types of naming in two conditions of stories[a)]

Conditions of stories	3 types of naming	4 kinds of reasons for naming			
		shape	material	origin	function
Man-made	artifacts	36 (57)	22 (57)	25 (57)	16 (57)
	natural kinds	6 (14)	7 (14)	7 (14)	0 (14)
	combined	13 (24)	18 (24)	15 (24)	3 (24)
Naturally-formed	artifacts	25 (32)	15 (32)	11 (32)	0 (32)
	natural kinds	32 (50)	19 (50)	24 (50)	4 (50)
	combined	5 (9)	7 (9)	5 (9)	0 (9)

a) With total frequency of the reason for one type of naming in parentheses.

Table 4 Means of difference of frequency of the 4 kinds of reasons for two domains of naming in 2 conditions of stories[a)]

Conditions of stories	Two domains of naming	4 kinds of reasons for naming			
		shape	material	origin	function
Man-made	artifacts	0.60 (0.08)	0.24 (0.06)	0.28 (0.06)	0.15 (0.03)
	natural kinds	0.16 (0.07)	0.16 (0.05)	0.16 (0.06)	0.00 (0.01)
Naturally- formed	artifacts	0.50 (0.09)	0.23 (0.06)	0.19 (0.07)	0.00 (0.03)
	natural kinds	0.45 (0.07)	0.17 (0.06)	0.22 (0.06)	0.03 (0.01)
Value of *F* for interaction		5.06*	0.03	1.69	14.88***

a) With SE in parentheses. b) *, $P=0.05$; ***, $P=0.001$.

jects' shape, the above results suggested that stories of object's origin activated objects' functions automatically, which interacted with object's appearance and material on domain level classification judgments.

2 Experiment 2: A force-choice task

In Experiment 2, we used a force-choice task instead of the free-naming task in Experiment 1. Since basic level categorization judgments were changed by force but domain level judgments were not, our hypothesis that effect of stories of object's origin is specifically on domain level categorization could be tested by comparing patterns of the two experiments results. Also, since 2 detailed hypotheses on processes in basic level categorization were drawn from the asymmetric distribution of naming responses in Experiment 1, we tested them by setting a controlled condition showing no story of object's origin.

2.1 Participants

96 college students (48 males and 48 females), ages from 18 to 23 (19.9 in average), in Zhejiang Sci-Tech University were recruited.

2.2 Materials and design

There were 2 items in practice phase and 4 for formal test phase. Materials are the same as those in Experiment 1, except (1) the free-naming question was changed into name force-choice one, and (2) Question 3 was eliminated. The candidates for the force-choice question including one artifact category and one natural kind were selected from results of Experiment 1.

Participants were randomly assigned in equal numbers to three conditions (man-made story, naturally-formed story, and a control condition without any story of objects' origin). Positions of the two categories were balanced between participants and their genders.

2.3 Procedure

E-Prime 1.1 was used to present stimuli and collect responses. The 2 items in practice phase were presented in random order, and the 4 items in formal test phase were presented in random order, too. There were 5 pages for each trial. On the first page, "Please read materials carefully and answer questions" and "Please press the space bar" were presented. On the second page, depictions of object's appearance and stories of object's origin were shown. On the third page, "Please answer question according to words you read" and "Question 1. What is it?" were presented with the two candidate names for a forced choice. Next, "Question 2. What about your confidence for your choice? Please press 1—9 on your keyboard to show it" and a 9-point scaling was presented on the fourth page. On the fifth page, "OK, please press the space bar to continue" was presented. After all trials finished, "Experiment finished. Thank you very much!" was presented on the last page. The whole experiment lasted for 5—10 min.

2.4 Results and discussion

Table 5 shows the means of frequencies, differences, and confidence ratings for responses in the two domains under the three conditions. The differences range from –4 to +4.

Neither significant main effect of position nor significant interaction between stories and positions was found in a 3 (stories of object's origin: man-made, control, and naturally-formed)×2 (positions: left and right) repeated measures analysis of variance (ANOVA) on frequencies of artifact candidate names. Therefore, we did not consider Position as a factor in the following analysis.

A one-way 3-level (stories of object's origin: man-made, controlled, and naturally-formed) analysis of variance (ANOVA) was performed on the differences in the choice frequencies for candidate names in artifact domain and natural kind domain. Results showed that main effect of stories of object's origin was significant, F (2,93)= 10.24, P<0.001, demonstrating

Table 5 Means of frequency, difference, and confidence rating for responses in artifact domain and natural domain under the three conditions[a)]

Dependent variables	Stories of object's origin	Types of responses		
		artifact domain	natural kinds domain	artifact-natural kinds
Frequency	man-made	3.19 (0.16)	0.81 (0.16)	2.38 (0.33)
	controlled	2.31 (0.19)	1.69 (0.19)	0.63 (0.38)
	naturally-formed	1.94 (0.24)	2.06 (0.24)	–0.13 (0.48)
Confidence	man-made	6.78 (0.48)	6.58 (0.37)	—
	controlled	7.22 (0.23)	7.19 (0.28)	—
	naturally-formed	5.62 (0.62)	7.16 (0.26)	—

a) With SE in parentheses.

that changing basic level categorization judgments by force did not change domain level categorization at all. In other words, on domain level, result in Experiment 1 was repeated, suggesting that effect of objects' origin on object categorization is specifically on domain level but not on basic level. Our hypothesis was confirmed by these results.

Furthermore, a similar asymmetric pattern to that in Experiment 1 was revealed. Although the values of the differences in the choice frequencies for candidate names in artifact domain and natural kind domain in the three conditions decrease one-by-one, Games-Howell test showed that difference was significant between man-made condition and the controlled condition but not between the controlled condition and the naturally-formed condition, $P<0.01$ and $P>0.4$, respectively. Also, under controlled condition, the value of difference in frequencies for artifact and natural kinds (0.63) was larger than 0. These two results suggested not only different stories of object's origin interacted with objects' appearance on domain level classification in different way but also the depictions themselves made participants prefer the can- didate names in artifact domain.

Table 6 shows the percentage of the selection for the six items under each condition. Trends in the results among three conditions for the six items are similar and consistent with our hypothesis.

No significant main effect nor interaction was found in an analysis of variance (ANOVA) of 3 (stories of origin: man-made, control, and naturally-formed)×2 (type of responses: artifacts and natural kinds) repeated measures on confidence rating, suggesting that confidence is equal for the two types of responses in the three conditions.

3 General discussion

Using variants of Gelman and Bloom's task[18], we investigated how stories of object's origin influenced domain level and basic level categorization in two experiments. Results showed that when basic level categorization judgments were changed by force, the effect of objects' origin on domain level were not changed, suggesting that the effect of stories of object's origin on object categorization is specifically on domain level ("artifact/non-artifact" distinction).

3.1 Methodological discussion on "Specificity"

There are some benefits to understand specific relations among independent and dependent variables. The first one is that a specific result may reveal true causal relations. A true causal relation tells us not only what kind of relations variables have but also what kinds of relations they do not have. Specific causal relations sometimes reveal how some certain components of an independent variable (or a new IV) influence some certain components of a dependent variable (or a new DV). Possible confounding factors or components can be excluded in specific causal relations. Second, in a study with many factors, once a specific relation between an IV and a DV is identified, the effect of the IV could be peeled off. Based on this, researchers may infer whether there is another possible factor and what the effect of that IV could be. Third, a whole picture of mechanisms underlying processes for some cognitive tasks could be gradually drawn out by taking all specific effects of possible factors piece by piece.

Specificity has two faces. One is on IV's component and the other is on IV's effect. For the former, the common method is to set contrast(s) to experimental condition(s). In this way, confounding factors will be excluded from a list of possible causes. For example, a placebo group should be a contrast to the drug group to find out whether the drug has effect on certain diseases. For the latter, researchers use similar tasks with similar stimuli but ask participants to react in different ways. Effects not caused by the certain IV could be excluded. Researchers can find out what effect the IV made.

Rogers and his colleagues' experiment[34] is an example for identifying specificity in effect of independent variables. They tested the so-called "animal domain specific" brain area (lateral posterior fusiform gyri) with PET (Positron Emission Tomography) technique. The same stimuli were presented (pictures of animals

Table 6 The percentage of the selection for the six items under each condition

Stories of object's origin	Practice items		Items in Formal test			
	bamboo branches (%)	bines net (%)	earth block (%)	tree branch (%)	connected leaves (%)	turtle shell (%)
Man-made	69	66	88	63	75	94
Controlled	63	50	69	44	41	78
Naturally-formed	53	25	53	44	44	53

and artifacts) but semantic tasks in different levels (categorization tasks at middle level or a specific level) were used. They asked participants to report their categorization judgments at two different levels (e.g. one level is "Dog" or "Car"; the other is "Labrolado" or "BMW"). Results showed that (1) animal pictures activated lateral posterior fusiform gyri more than artifact pictures when participants were asked to categorize stimuli on middle level ("Dog" or "Car"). But (2) categorizing pictures on the specific level ("Labrolado" or "BMW") activated lateral posterior fusiform gyri more than categorizing them on middle level. Rogers *et al*.[34] concluded that it is not visual properties of stimuli but the processes of differentiating visual or semantic features that enhanced activation of lateral posterior fusiform gyri. According to this conclusion, the increment of activation in lateral posterior fusiform gyri in previous studies is not "animal" domain specific but a "processes" specific effect.

In Rogers *et al*.'s study[34], by presenting the same stimuli but asking participants to perform different tasks, experimenter excluded the possibility that certain effect was caused by some independent variable. Our idea and methods are similar to those in their experiment. In different tasks, results at domain level are the same, but at basic level the results are different, showing that the effect of our independent variable is specifically on domain level.

3.2 How stories of object's origin impact classification

What factors work in the processes of novel object categorization as "artifact" or some certain artifact category? We hypothesized a two-step answer to this question. (1) Object's origin's effect is specifically on domain level. (2) Objects' origin interacts with objects' appearances on basic level categorization. Our experimental results reported in this paper confirmed the first step in our hypotheses.

What about the second step, then? We have proposed a tentative answer in introduction. Objects' appearances activate representations and names of some certain artifact categories, but different stories interact with them on categorization judgments in different ways. Man- made stories do not inhibit such representations and names but naturally-formed stories do.

Some patterns in our results support above hypotheses. One is the asymmetry in frequencies of responses between the two conditions of stories of object's origin in domain level categorization. The other is the domain specificity in patterns of reasons reported for naming responses in the two conditions of stories. Based on these two results, we can draw a whole picture to the question.

The point to this question is that object's function might affect participants reasoning processes even if there was no functional information in stimuli. Appearances of objects' part(s) can activate objects' functions automatically. This point was proposed by *Affordance* theory first and then has been confirmed in cognitive neuroscience[35]. Also, based on their intuition, participants might expect that man-made objects have some certain functions, even if they cannot identify what function an object would have, while for non-man-made objects, they will not have such an expectation. In Experiment 1, reasons reported for naming responses are consistent with our analysis. In man-made condition, participants reported significantly more shape and function reasons for "artifact" responses than for "natural kind" responses. But in naturally-formed condition, there was no such difference. These patterns suggested that both objects' origin and appearances could activate objects' functional information. Basic level categorization could be affect indirectly by object's origin mediated by object's function.

Now we can re-explain Gelman and Bloom's experiment[18]. If functional information was automatically activated in their experiment, there would be some possible confounding factors in their experimental design. Basing on above two points, we explain Gelman and Bloom's experiment[18] as follows: object's function mediates object's origin and basic level categorization judgment. We call this proposal "utility-based hypothesis" for artifact categorization. Nevertheless, this hypothesis still needs more direct evidence because there are only correlations but not causal relations among self-reported reasons and categorization judgments in this experiment.

More evidence may be revealed in studies using techniques of brain imaging (fMRI or PET) and TMS. Some experiments showed that processing of objects' functions related information increased activation in left premotor cortex[36] and processing of other's mental state (TOM) increased activation in anterior paracingulate cortex, superior temporal sulciform, and temporal poles bilaterally[37]. According to these findings, in conditions of not presenting objects' functions, if design-based theory is correct, the stories of object's origin would increase activation in areas related with TOM, and disorder made by TMS in these area would

increase errors in artifact classification judgments. But if utility-based hypothesis is correct, the activation in areas related with objects' function (left premotor cortex) would be increased, and disorder made by TMS in this area would decrease accuracy in artifact categorization.

3.3 Summary

Experiments reported in this paper showed that the specific effect of stories of object's origin on object categorization is at domain level (i.e. "artifact/non-artifact" distinction). Basing on the results of categorization judgments and reasons reported for them, we pointed out the deficiency of the design-based theory and proposed a new hypothesis for artifact categorization.

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