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Author	今井, むつみ(Imai, Mutsumi) Saalback, Henrik
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24 Influence of a Classifier System and Universal Cognitive Constraints

Mutsumi Imai[1] *and Henrik Saalback*[2]

[1] Department of Environmental Information, Keio University
[2] Institute for Behavioral Sciences, Swiss Federal Institute of Technology, Zurich, Switzerland

1. Introduction

The classifier grammar system categorizes nouns into grammatical categories, just as the count-mass grammar system does. There are two major functions of classifiers. First, like quantifiers or measuring terms in languages with count-mass grammar, classifiers provide a unit of quantification, although unlike measure terms that are used only for quantifying mass nouns (e.g. a *glass of* water), classifiers are applied to all nouns when quantifying them, including clearly individuated objects such as cars, computers, animals and humans. Second, classifiers classify a noun inherently. In other words, they designate and specify semantic features inherent to the nominal referent and divide the set of nouns of the classifier language into disjunctive classes (Senft, 2000). Importantly, the system of classification by classifiers is complimentary to the system of classification by nouns. This may be a matter of course considering the fact that a major function of classifiers is to provide semantic information that nouns do not carry. As a consequence, the categories created by classifiers largely cross-cut the categories created by nouns. In particular, while the noun lexicon is structured hierarchically around taxonomic relations, classifier systems are usually organized around semantic features such as animacy, shape, function, size, rigidity, or social importance, and do not have hierarchical

structures as the noun lexicon does. For example, tiao, a common Chinese is classifier for long and flexible things, includes many things from different taxonomic categories--fish, dogs, rivers, roads, pants, and more—even crossing the animate-inanimate boundary.

An interesting question is whether the classifier system affects the speakers' concepts in any significant ways. The acquisition of classifiers has been said to be relatively slow, especially in production (e.g., Carpenter, 1991); however, Saalbach et al. (2004) demonstrated that comprehension of classifier semantics starts as early as four years in Chinese children. Furthermore, Imai and Gentner (1997) reported that the absence of a grammatical distinction between count and mass nouns in a classifier language (Japanese) results in different construals of an ambiguous entity as either an individuated object or non-individuated substance across Japanese and American preschoolers and adults. Given these previous results and the semantic nature of classifier categories (i.e., the fact that classifiers classify objects in a way that largely cross-cuts taxonomic categories and the fact that shape is universally an important semantic feature across different classifier languages), it is possible that classifier categories affect children's concepts in *some* ways.

But in what ways can we assess young children's categories and conceptual structures? Three kinds of relations, taxonomic relations, shape similarity, and thematic relations, have been described as major organizers of young children's concepts. However, different results have been reported and different conclusions have been drawn concerning the question of *which* of the three types of relation children rely on the most. Many factors must be responsible for the differences in children's behavior in different studies, including the stimuli and the children's ages, to some extent. However, the most prominent factor affecting children's classification behavior seems to be the nature of the task and the instructions used in the task. For example, it has been often noted that young preschoolers tend to categorize objects based on thematic relations (Smiley & Brown, 1979) but they do not do so in the context of label extension (e.g., Markman & Hutchinson, 1984).

Furthermore, although researchers agree that young children do not extend labels based on thematic relations, they disagree as to whether children rely on non-perceptual taxonomic relation or on shape similarity

as the basis of label extension. When a taxonomic item that also resembles the originally labeled object is pitted against thematic items, children reliably select the taxonomic item (e.g., Markman & Hutchinson, 1984). However, when taxonomic similarity and shape similarity are separated and pitted against each other, preschool children tend to extend labels on the basis of shape similarity rather than taxonomic similarity (e.g., Baldwin, 1992; Imai, Gentner, & Uchida, 1994).

Categorization is not the only way to reveal the nature of human concepts. One basic function of categories is to promote inferences that enlarge the scope of knowledge and allow predictions about novel items. Importantly, many studies have demonstrated that young children rely on non-perceptual taxonomic relations more heavily than on perceptual similarity in generalizing non-perceptual properties to other objects when taxonomic relations and shape similarity are pitted against each other (e.g., Gelman & Markman, 1986).

To make the story even more complicated, preschool children's classification behavior may vary even within the same (non-lexical) categorization task when different instructions are used (e.g., "Which goes best with the [target]?" vs. "Can you find another one?", Waxman & Namy, 1997).

Given the large difference in the results across different studies using different tasks and instructions, it has been suggested that the conceptual preference exhibited by children in a given task may reflect task-specific processes rather than stable preferences that characterize cognition at a particular developmental level (Waxman and Namy, 1997).

If different types of behavior across different tasks indeed reflect children's flexible and task-specific cognitive processes, the influence of classifier categories on children's cognitive structure must be tested in multiple tasks rather than in a single task. It is in fact very important to ask whether the influence of classifier categories, if there is any, is found across a range of tasks or only in particular tasks or contexts. This in turn will reveal how pervasive the influence of classifier categories is, and how it interacts with tasks-specific cognitive processes. In fact, our previous studies with Chinese and German adults revealed an effect of classifier categories in similarity judgment of two objects in which participants were to determine the criteria for similarity on their own (Saalbach and Imai,

2005). The language-specific classifier effect was also found in a property reasoning task, in which the target property was not specified. ("Suppose Object A has an important property X. Judge how likely Object B also has this property.") However, the language-specific effect disappeared in a property inference task in which the participants were given a specific property ("*carry the same bacteria*") and asked to judge the likelihood with which this property would be shared across the two objects.

2. Present research

To examine (1) whether classifier categories affect young children's cognitive activities such as category making and inductive reasoning, and if the answer to the first question is yes, (2) whether and how this effect interacts with the nature of the task context, we tested Chinese and German-speakers in three age groups (3-year-olds, 5-year-olds, adults) on a match-to-the standard generalization paradigm in three different contexts: no-word classification (Study 1), label extension (Study 2) and property inference (Study 3). In all three contexts, a child was shown a picture of the standard object (e.g., banana), and was asked to choose the one item out of the three choice items: a taxonomic item (grape), a shape item (feather) and a thematic item (monkey). In Study 1, the participants were asked to select the item that best matches the standard object. In Study 2, the participants were asked to extend a novel label that was given to the standard. In Study 3, a novel non-perceptual property about the standard object was taught, and the participants were asked to select the item that would be most likely to have the same property.

If there is an influence of classifier categories, we may predict that Chinese speakers, especially children, pay more attention to shape similarity than German speakers, given that shape is a prominent semantic feature in classifier categories. Among the three tasks, the no-word classification task seems to place weakest constraints on the kind of knowledge that should be accessed, leaving children to determine the basis for the "best match" freely on their own. We may thus expect the largest crosslinguistic difference in this context. On the other hand, given the previous results that preschool children tend to extend novel labels on the basis of shape, it is interesting to see whether Chinese children show an

even stronger shape bias than German children in this context. It is also interesting to see whether the system of classifier categories, which cross-cut taxonomic categories, influences Chinese children's inductive reasoning. If this is the case, we may expect that Chinese children project properties onto taxonomic relations to a smaller degree than German children.

3. Experiment 1: No-word classification

3.1. Method

Participants. A total of 87 native Mandarin-speaking and native German-speaking pre-school children and adults participated in this study. In the Chinese sample, there were 16 3-year-olds, 16 5-year-olds, and 15 adults from Beijing. In the German sample, there were 15 3-year-olds, 15 5-year-olds, and 10 adults from Berlin. The range and mean age of children in each age group were comparable across the two language groups in this as well as other experiments reported in this paper.

Materials. Twelve item sets of four color drawings of familiar objects were prepared. Each set consisted of a standard item, a taxonomic item, a shape item and a thematic item. Of the twelve, four sets represented animal categories, four represented plants, and four represented artifacts (see table 1).

Procedure. The participants in both language groups were individually tested by a trained native speaker of Chinese or German in a quiet room in their preschool or in a university laboratory. Both children and adults were shown each set of the pictures, one set at a time, and were asked to select the object that "best matches" the standard object. The instruction was given in the participants' language by a native speaker.

3.2. Results and Discussion

The mean percentage of the shape, taxonomic, and thematic response is given in Table 2.

The distribution of the three responses looked different as a function of Age and Language. Chinese children, both 3- and 5-year-olds, made the

Table 1. Materials of Experiment 1-3

Set	Standard	Taxonomic	Shape	Thematic
	Animal			
1	Snake	Turtle	Jump.rope	Glass cage
2	Eel	Guppy	Belt	Water tank
3	Salamander	Frog	Scarf	Pond
4	Beaver	Cat	Tie	Logs
	Plant			
5	Banana	Grape	Feather	Monkey
6	Apple	Cucumber	Ball	Knife
7	Carrot	Tomato	Match	Rabbit
8	Onion	Peppers	Candle	Flying pan
	Artifact			
9	Hat	Turban	Tent	Head
10	CD	Tape	Pizza	Stereo
11	Necklace	Ring	Ribbon	Neck
12	Comb	Bruch	Knife	hair

Table 2. Mean frequency, Standard Deviation, and Percentages of Choices in each task, language, and age.

	Chinese			German		
	Taxonomic	Shape	Thematic	Taxonomic	Shape	Thematic
Exp1						
3-Year	31.8%	52.6%*	16.2%*	42.8%	25.6%	33.3%
5-Year	15.6%*	47.4%	37.0%	19.4%*	17.8%	62.8%*
Adults	26.7%	25.0%	48.3%	43.4%	5.0%*	51.7%*
Exp2						
3-Year	28.2%	63.4%*	8.3%*	27.8%	57.8%*	14.4%*
5-Year	27.9%	61.3%*	10.8%*	32.2%	56.7%*	11.1%*
Adults	57.5%*	30.8%	11.7%*	78.0%*	16.7%*	5.3%*
Exp3						
3-Year	41.7%	37.5%	20.8%+	41.7%	34.4%	23.9%
5-Year	64.1%*	27.6%	8.3%*	65.0%*	18.3%*	18.9%*
Adults	79.2%*	14.2%+	6.7%	90.8%*	8.3%*	0.8%*

Note. T-tests have been conducted to test whether the rate of a particular choice is significant different from chance level.

* Denotes significantly different from chance level, $p<.05$ (based on Bonferroni adjusted probabilities).

+ Denotes marginally different from chance level, $p<.1$ (based on Bonferroni adjusted probabilities).

shape response most frequently. German 3-year-olds showed no particular preference across the three items. In contrast, German 5-year-olds showed clear preference for thematic relations (62.8%) in this no-word classification. Interestingly, both Chinese and German adults also made the thematic response most frequently (41.7 % and 51.8%, respectively).

In each Age/Language group, we classified the participants into four categories according to the response dominance (table 3).

The participant was considered a Shape Dominant individual when s/he made Shape response 7 times or more. The Taxonomic and Thematic Dominant individuals were determined likewise. The participants who did not make a particular response type 7 times or more were classified as a No Dominance individual. The distribution of individuals across the four

Table 3. Frequencies of Response Dominance Type in each task, language, and age.

		N	TAX	SHAPE	THEME	NON
Exp1						
3-Y.	CH	16	1	6	2	7
	GER	15	4	0	2	9
5-Y.	CH	16	2	8	4	2
	GER	15	1	2	9	3
Adult	CH	15	2	3	8	2
	GER	10	2	0	4	4
Exp2						
3-Y.	CH	18	1	11	0	6
	GER	15	0	8	0	7
5-Y.	CH	17	3	9	0	5
	GER	15	2	9	0	4
Adult	CH	10	5	2	1	2
	GER	11	10	0	0	1
Exp3						
3-Y.	CH	16	5	5	2	4
	GER	15	4	2	1	8
5-Y.	CH	16	12	2	0	2
	GER	15	11	2	0	2
Adult	CH	10	8	1	0	1
	GER	10	11	0	0	0

dominance categories was submitted to an asymmetric loglinear model with the Response Dominance as the dependent variable and Age and Language as independent variables. In the first model, we only contrasted 3-year-olds and 5-year-olds for easier interpretation of the Age effect. A saturation model revealed that the Age X Language interaction did not make any significant contribution to the model fit. We thus deleted the interaction and employed the main effect model. Age and Language both made a significant contribution to the model, χ^2 (3) = 10.49 and χ^2 (3) = 8.33, respectively, both ps < .05. The pattern of the parameter estimates suggests that the main effect of Age mainly came from a decrease of Shape Dominance and an increase of Thematic Dominance with age, and the effect of Language came from the higher proportion of the Shape Dominance individuals in the Chinese group than in the German group. A parallel log-linear model was carried out, to contrast the 5-year-olds and adults. In neither the saturated model nor the main effect model, was there any significant effect of Age or Language, both *ps*>.05.

To summarize, the children's no-word classification behavior was consistent with the hypothesis that classifier categories affect Chinese-speaking children's categorization; however, this effect was not observed in adults. Somewhat surprisingly, different from the generally shared assumption that adults exclusively organize their concepts around taxonomic relations, both Chinese and German adults made the thematic response in a higher proportion than the taxonomic response. However, this is consistent with a recent proposal that thematic relations are an important and integral part of conceptual structure even in educated adults along with taxonomic relations (e.g., Lin & Murphy, 2001; Wisniewski & Bassok, 1999).

4. Experiment 2: Label Extension

4.1. Method

Participants. A total of 85 Chinese and German preschool children and adults participated in this study. In the Chinese sample, there were 18 3-year-olds, 17 5-year-olds, and 10 undergraduates. They were all from Beijing, and were native speakers of Mandarin-Chinese. In the German

sample, there were 15 3-year-olds, 15 5-year-olds, and 10 undergraduates. They were living in Berlin and were native speakers of German.

Materials and Procedure. The stimulus materials and the procedures were the same as those in Experiment 1 except for the instructions. Preschoolers were told that they were helping a puppet who was learning new words in Puppet language. For each set, the experimenter assigned a novel label to the standard and asked the child to extend it to one of the choice alternatives. Adults were told to assume that the novel labels were words in a foreign language they do not know.

4.2. Results and Discussion

In contrast to no-word classification, the pattern revealed in the label extension task looks surprisingly similar across the two language groups, although there was a large difference between children and adults. Chinese and German children, both 3- and 5-year-olds, selected the shape alternatives most frequently, and more often than what would be expected by chance. Different from children, the adult speakers of Chinese and German both extended labels on the basis of taxonomic relations.

As in Experiment 1, we classified the participants into four categories of Shape Dominant, Taxonomic Dominant, Thematic Dominant, and No Dominance individuals (Table 3) and conducted two 2 (Language) X 2 (Age) X 4 (Response Dominance) asymmetric log-linear models with the Response dominance as the dependent variable, one contrasting three-and 5-year-olds, and the other contrasting children (3-year-olds and 5-year-olds aggregated) and adults. The first model revealed no main effects for Age, Language, or the interaction effect, all $ps > .5$. The second model contrasting children and adults revealed a highly significant main effect for age, $\chi^2 (3) = 23.13$, $p < .01$, reflecting a strong shape-to-taxonomic shift from children to adults. Different from Experiment 1, the effect of Language was not significant $p > .5$. No Age X Language interaction was detected.

To summarize the results, first, we replicated previous results found in English-speaking children with two new languages, Chinese and German: (1) children show different categorization behavior across the context of label extension and no-word classification; (2) children extend a label on

the basis of shape similarity rather than taxonomic relations when the two are pitted against each other; (3) reliance on shape in label extension shifts to reliance on taxonomic relations with development. Second, different from Experiment 1, there was no cross-linguistic difference between Chinese and German speaking children, as children dominantly extended labels on the basis of shape similarity. This suggests that the nature of the task (i.e., what type of information and/or knowledge is most relevant for the inference) constrains people's categorization behavior and that the influence of classifier categories we observed in the no-word classification context is washed away by the task-specific constraints. We further pursue this possibility in Experiment 3, in which we examine which of the three relations (Shape, Taxonomic, Thematic) Chinese and German-speaking children and adults rely on in generalizing a novel, non-perceptual property to other objects.

5. Experiment 3: Property Generalization

5.1. Method

Participants. In the Chinese sample, there were 16 3-year-olds, 16 5-year-olds, and 10 undergraduates, all of whom were native speakers of Mandarin-Chinese and living in Beijing. In the German sample, there were 15 3-year-olds, 15 5-year-olds, and 10 undergraduates. They were living in Berlin, and their native language was German.

Materials and Procedure. The same material was used as in the previous experiments. In each set, the experimenter taught a novel internal property about the standard object and asked the children to select the item that also had this property (e.g., "Look! This one has IDOFORM inside. Can you tell which one of them also has IDOFORM inside?"). In testing adults, we used a blank property, saying that "This object has an important property X inside. Which of these do you think is more likely to have this property inside?"

5.2. Results and Discussion

As in the label extension task, the response pattern is very similar across

the two cultures (see Table 3). However, different from the label-extension case, a dominance of shape response was not observed even among the 3-year-olds, although 3-year-olds did not select the taxonomic item at above chance level; the 5-year-olds and adults strongly projected novel properties based on taxonomic relations. Each participant was again classified into one of the four response dominance categories, and asymmetric log-linear models were fitted on the 2 (Language) X 2 (Age) X 4 (Response Dominance) contingency table. The first model contrasting 3-year-olds and 5-year-olds revealed a main effect for age, χ^2 (3) = 9.34, $p < .01$. There was no main effect for Language, nor was there an interaction effect, both *ps* > .5. The pattern of parameter estimates suggests that the difference between the two age groups mainly came from the distribution of the Taxonomic dominant individuals. The second model contrasting 5-year-olds and adults revealed no effect of Age. No effect for Language nor interaction between Language X Age was detected, *ps*>.5.

As in the label extension case, the cross-linguistic similarity between Chinese and German speakers was striking in all age groups here. This converged with the results of Experiment 2 to suggest that the nature of the task strongly constraints people's inferences and the resulting behavior, independent of the language they speak, and a language-specific effect such as our classifier effect disappears in the face of the strong task-specific constraints.

Both Chinese and German 5-year-olds and adults predominantly generalized a novel property on the basis of taxonomic category membership. This finding confirms a widely accepted notion that young children, just like adults, assume that taxonomic categories carry high inductive potential, while perceptual similarity does not (e.g., Gelman and Markman, 1986). In addition, the results of this study suggest that speakers of a classifier language do not consider classifier categories as carrying high inductive potential. The results are also important in establishing that that label extension and property induction do not reflect exactly the same type of knowledge or cognitive processes. We will discuss this difference between label extension and property induction in more detail in the General Discussion.

6. General Discussion

In this research, we found a complex interaction between the effect of classifiers and task-specific constraints on category formation and inductive reasoning in young children. First, we found that Chinese preschoolers used shape similarity as a basis for no-word categorization at a higher rate than German preschoolers, which supports the idea that classifier categories may affect young children's categories beyond the context in which classifiers are invoked. Second, however, this cross-linguistic difference was not observed in the label extension or property inference tasks. In the former case, not only Chinese but also German-speaking children predominantly extended novel labels on the basis of shape similarity, replicating the results with English-speaking children in previous similar studies (e.g., Baldwin, 1992; Imai et al., 1994). In the latter case, children did not rely on shape in generalizing a novel property to other objects. In fact, both Chinese and German 5-year-olds generalized the properties on the basis of taxonomic relations to the same degree as adults did. It is important to note that, in our task, the children were not taught that the taxonomic item shared the label with the standard object, unlike the well-known property induction studies in the literature (e.g., Gelman & Markman, 1986). In other words, the children in our study not only determined what relation was likely to carry the highest inductive potential, but also recruited the relevant taxonomic knowledge on their own.

The pattern of results suggests that the classifier system may indeed affect Chinese children's formation of categories, but the effect is limited to a context in which the type of information/knowledge to be processed for the task is left ambiguous. When the task constrains the kind of knowledge to be accessed, the language-specific effect of classifiers seems to disappear.

The fact that children relied on different relations across no-word classification, label extension, and inductive reasoning tasks suggests that children's behavior in categorization and inductive reasoning strongly depend on the task at hand rather than on a particular general conceptual preference, as suggested by Waxman and Namy (1997). In other words, even young children are aware of what kind of knowledge should be

recruited for a given task and are able to flexibly shift the basis for category formation and inference in accord with task-specific constraints. The difference across the label extension task and the property generalization task is particularly noteworthy and requires explanation. It is important to make clear that the reliance on shape in label extension demonstrated in this research does not mean that children cannot consider non-perceptual information in label extension or can never extend novel labels on the basis of taxonomic relations under any circumstances (e.g., Liu et al., 2001). However, young children constantly encounter new words, and often need to extend newly heard words even when they do not have much knowledge about the referent objects. In such cases, among the features that children have access to without rich domain knowledge, shape is the best predictor for taxonomic categories, in particular, for basic level categories (Imai et al., 1994). Given that children first learn basic-level object names, it is probable that children have extracted this pattern from their early word learning experience and apply it even when learning non-basic level words such as superordinate category names (Smith et al., 2002). Furthermore, object names are often extended to other same-shape objects of different kinds. For example, we may call a bunny-shaped chocolate "a bunny" even when it is really a piece of chocolate and not a rabbit. This kind of lexical convention may have enhanced the reliance on shape in label extension.

The situation may be quite different for property inference. First, occasions in which children must infer internal properties of objects do not probably occur as often as occasions in which they must infer the extension of a word. Hence, children may not have to have heuristics that can be instantly applied when not much knowledge about the object is available. Furthermore, not every property of a given object can be generalized to other objects, and even when a property is generalizable, the scope of generalization depends on the property (e.g., some properties are true for all animals, but other properties are true only for mammals). In other words, one needs a fair amount of the domain knowledge about the object and the property in question to be able to make a meaningful inference (c.f., Gelman et al., 1986; Imai, 1995). By three years of age, young children, regardless of the language they speak, may have noticed this, and have realized that making an inference about an unfamiliar (internal)

property instantly does not buy them much. Also, from early on, children seem to be aware that objects from different ontological classes (e.g., animals vs. non-animals) have very different internal as well as behavioral properties and are governed by different causal principles (e.g., Mandler & MacDonough, 1996). It is probable that at 3years of age (or earlier), children are aware of different principles underlying label extension and property inference, and are able to pay attention to different sources of information to adapt to the cognitive processes required by the two different cognitive activities.

Lastly, we did not find the classifier effect in any of the tasks in this research in adults. However, this may be because the forced-choice-match-to-sample paradigm was not sensitive enough for examining cognitive processes in adults, as Saalbach and Imai (2005) found a subtle but stable classifier effect in similarity judgment using rating scales.

To conclude, this research provides important implications for the field of language and thought as well as for the field of cognitive development. First, it suggests that the simple Whorifan-vs.-non-Whorifian dichotomy does not deepen our understanding of the nature of our concepts and categories very much, as the effect of language-specific categories may be seen in one type of cognitive activity, but not in others (see also Saalbach & Imai, 2005). What is important, then, is *how*, rather than *whether*, language-specific categories, be them grammatical or lexical, affect our concepts, categories, and cognitive processes, and how they interact with task-specific constraints as well as our universal cognitive dispositions. Second, this research demonstrates that children are extremely flexible and adaptive learners, and a single cognitive task cannot fully reveal the nature of children's cognitive structure.

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