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## The Developmental Trajectory of Categorizing Events by Verbs

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### I. Introduction

In learning meanings of verbs, children have to solve so called the “packaging problem.” ; They have to detect what semantic features are critical for the meaning of a given verb among features such as “manner,” “path,” “result” “change of states,” etc. For example, to acquire the adult-like meaning of “cut”, children must find out what kinds of features are included in the meaning of “cut” (e.g., the change of the state of the objects by the use of the particular instruments) and how these features of “cut” are different from that of other neighboring verbs such as “break” and “tear” (e.g., change of states of the object caused by the action with a particular manner). This process is very challenging for children. Some research demonstrated that semantic features children extract are often different from the features in the adults’ verb meanings. Furthermore, it has been suggested that children have a bias toward particular semantic features over others in incorporating semantic features in verbs in the context of novel verb learning (Maguire, Hennon, Hirsh-Pasek, Golinkoff, Slutzky & Sootsman, 2002; Imai, Haryu, & Okada, 2005; Imai, Haryu, Hirsh-Pasek, Li, Okada, Golinkoff & Shigematsu, 2008).

In this study, we investigated what features children tend to incorporate and utilize in differentially applying different verbs belonging to the same

action domain. For this purpose, we examined how Chinese children and adults apply various verbs referring to carrying actions. There are more than 20 words in this semantic domain in Chinese, each of which is distinguished from others by the manner in which an object is being carried (see Table 1 for example). For example, carrying an object on one's head is denoted by “顶” (ding3), while carrying/holding an object on one's shoulder is “扛 (kang2)”. Carrying an object with two arms is denoted by “抱 (bao4)”, but if the object is held with one arm on the side of the body, the action is called “夹 (jia1)”. There are several verbs referring to carrying actions, depending largely on the shape of the hand and arm when holding. To learn the meaning of these verbs appropriately, children need to delineate boundaries among neighboring verbs. Then in what degree does the pattern of children's use of verbs converge with that of adults? And how does it develop with age? Furthermore, what features do children attend to distinguish different events by verbs and how are these features different from that of adults'? To cope with these issues, we adopted some multiple-variable analyses.

## II. Experiment

### 1. Method

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#### 1.1. Participants and Stimuli.

A total of 78 native Mandarin speaking children and adults participated. Production data was collected from 16 3-year olds, 20 5-year olds, 21 7-year olds, 21 undergraduates, 15 mothers of 2-years-old children and 15 mothers of 5-years-old children.

For stimuli, a set of 13 videos showing carrying actions were prepared. We first selected 13 representative verbs in the domain that Chinese speakers use in everyday situations when referring carrying/holding activities. The description of each verb is given in Table 1. Each event was video-taped with a female agent carrying a familiar and typical object for the carrying action denoted by the verb. The object involved in the carrying events for the same verb was identical.

Table 1. Stimuli Verbs

Verb	Action	object
抱 (Bao4)	Carrying an object in both arms	Stuffed animal
背 (Bei4)	Carrying an object on the back	Rucksack
顶 (Ding3)	Carrying an object on the top of head	Wooden bowl
端 (Duan1)	Carrying an object by hand, keeping the object horizontally	Glass bowl with water
夹 (Jia1)	Carrying an object under one arm	Square bag
举 (Ju3)	Carrying an object by lifting the object over the head	Square box
扛 (Kang2)	Carrying an object on the shoulder	Pipe
挎 (Kua4)	Carrying an object, hanging it on the shoulder	Tote bag
☒ (Lin1)	Carrying an object, dangling it with on hand	Plastic bag
拿 (Na2)	Carrying an object with one hand	Plastic bottle
捧 (peng3)	Carrying an object cautiously in both hands	Banquet
提 (Ti2)	Carrying an object dangling it around the arm	Hand bag
托 (Tuo1)	Carrying an object in the palm(s)	Tray

## 1.2. Procedure.

The videos were presented on a computer screen in random order. In production task, a sentence “She is X-ing the thing (“Ta [she] shenme [what] zhe [-ing] yi [a/one] dongxi [thing]?”) was presented with each video, and the participants were asked what X would be. Undergraduates read the sentence appeared on the screen by themselves and were required to type the verb into a window at the right side of the video. For 3-years to 7-years-old children, the stimuli sentences were presented orally by the experimenter. Mothers participated in the experiment with their children, and were shown the videos and asked to describe the action to the child.

## 2. Analyses and Results

### 2.1. Matrix preparation

For further quantitative analyses, we first created matrices for each age group (3 to 7-years-old children and 3 adults’ groups). In each production

matrix, we tallied the numbers of verbs which had been produced by the participants of each age group for each video. There were 13 rows which represented 13 videos and columns which represented to generated verbs in each. Originally, each matrix had 13 columns of the 13 verbs we prepared for the stimuli in advance, and a new column was added when the participant produced a verb other than the 13 verbs.

## **2.2. Analysis1: How many verb types did children and adults produced across 13 carrying actions?**

In order to see the degree of convergence between children's pattern of verb use and that of adults (undergraduates), the production matrices from each age group was compared to the adult group. We followed the correlation analysis proposed by Ameel, Malt & Storms, (2008) which allows us to examine what degree the pattern of using word are different between children & adults. First, we calculated correlations for all pairs of the videos within each age group. Next, using the first-order correlation matrices, we further calculated the correlation between each child's group and adults' group. This second-order correlation should indicate that the degree of similarity between the children's verb use and that of adults. Figure1 shows the correlation among the age groups. The correlation between 3-year-olds and adults was as low as .17. The convergence with the adult pattern increases linearly from 3 to 7years (5-years-old: .043, 7-years-old: .58). However, even 7-year olds are not quite adult-like in the use of the verbs in the domain, much lower than .84, which is the average of correlations calculated from 3 adults groups (undergraduates, mothers of 2-years-old, and mothers of 5-years-old). This result shows that it takes long time for children to use these words in the same way adults do.

Why is children's production pattern so different from that of adults? One possibility is that care-takers use verbs very differently when talking to their child than when talking to an adult. Perhaps they intuitively know that using so many different verbs are cognitively too demanding for young children, and hence use only a small number of verbs so broadly. This possibility, however, was not supported in current analyses. In correlation analyses, mothers did not overuse particular verbs when talking to their child: use of the verbs by the mothers of 2-year-olds and mothers of 5-

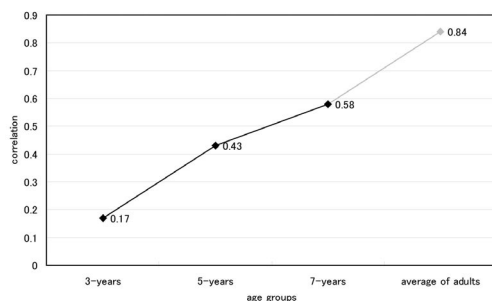


Figure 1. Correlation between Children and Adults

year-old was no different from the undergraduates ( $r = .81, .83$ , respectively). Then what kinds of underlying factor affected children's pattern of verb use which was very different from adults? To investigate these problems, we conducted next analyses.

### 2.3. Analysis2: What features do children attend to to distinguish different events?

We conducted a kind of Multi-Dimensional-Scaling model incorporating differences of naming patterns across the 4 age groups (INDSCAL:INDividual SCALing). INDSCAL provides results in two steps. First, it extracted the dimensions underlying their verb production which were common to all age groups (common space). In the second step, it identified weights each group placed on to the dimensions when naming an event (individual space).

Solutions in three-dimensions resulted in stress values of .14. The two kinds of output are displayed: Figure 1 shows a common space across the four age groups, and Figure 2 shows the weight plots for the four age groups on the common dimensions. Figure 1 shows the common space in which the location of each event point was calculated with the data from all four age groups. The location of Dimension1 seems to correspond to the "salience of hands". Events plotted in positive direction consist of carry-actions in which the object is carried by other body parts than hands (e.g., "ding" [head], "kua" [shoulder], and "bei" [back]), whereas in events

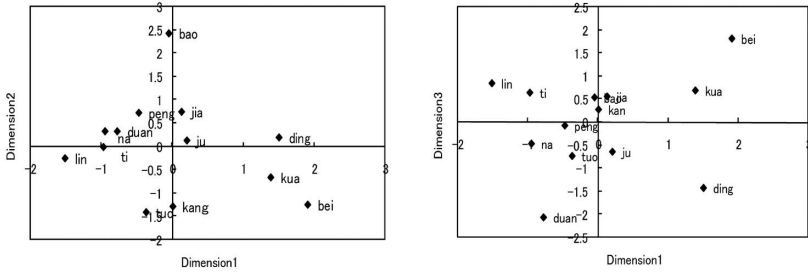


Figure 2. Common Space

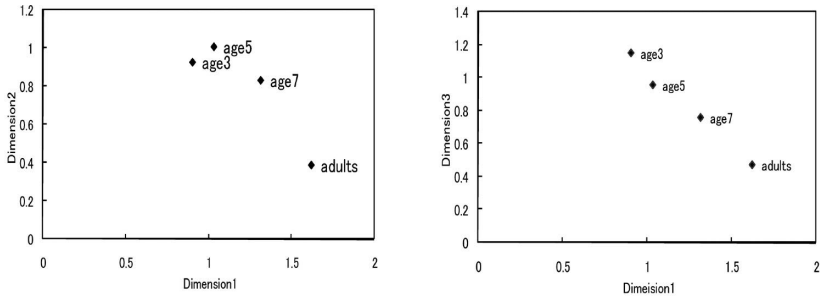


Figure 3. Individual Space

which are plotted in the negative directions, objects are carried with the hand (e.g., “lin”, “ti”, “na”). On the other hand, dimension 2 cannot adequately captured by a single feature as it distinguishes only “bao” [carrying something in both arms] from the other events. Given that the carried stuffed animal in the “bao” event stands out from the other carried objects for children, dimension 2 may be related to the “salience of the object”. Dimension3 is more interpretable than dimension2. It seems to correspond to “kind of objects”. Carried objects in the events plotted in positive direction of dimension3 are “bei” [rucksack], “lin”[plastic bag], “ti”[hadbag], “kua”[tote bag], “jia”[square bag], which are all kinds of “bag”. On the other hand, objects in negative direction are “duan” [glass bowl with water], “ding”[wooden bowl], which are kinds of “bowl”.

Figure 2 shows the plots of weights which each age group attached to the dimensions. As expected, there were large differences between children and adults in the weights they placed on each dimension. While Dimension

1 was more important for the adults than Dimension 2, adults attached more weight on dimension 1 (“salience of hands”) than on dimension 2 (“salience of object”), and 3- and 5-year olds showed the reverse pattern. Seven-year olds were in-between. The plots of D3 also show difference between children and adults. Children attached more weight on dimension3 (kinds of object) than adults.

### **III. Discussion**

In this study, we revealed that children’s pattern of verb use was quite different from that of adults (Analysis1) and that children attended to different features than adults when producing verbs to refer to actions belong to the same lexical domain (Analysis2). Furthermore, our result shows that young children evaluate the feature of objects (salience of the object and type of the object) in applying the verbs to videos much more than adults, while they evaluate feature of manner (salience of hands) less than adults. This result is consistent with Bowerman (2006), who argued that the process of verb learning by young children involves finding out object categories that could be arguments (either Agent or Patient) of the verb. Our study is unique in that we quantitatively and visually demonstrated the developmental trajectory from object-based category to manner-based category. To acquire adult-like meaning of verb, children have to delineate the relationships among neighboring verbs, discovering more abstract features in the action (e.g. manner of the action) and inhibiting their attention to the features of object in the action.

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