

NOTE

**Object name learning and object perception: a deficit  
in late talkers\***

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(Received 31 July 2003. Revised 15 March 2004)

ABSTRACT

Two experiments examined the relation between early object name learning and the ability to represent objects by their abstract shapes. In Experiment 1, two-year-old children with productive vocabularies in the bottom 20th percentile – ‘late talkers’ – were compared with (1) same-age children with larger vocabularies, and (2) younger children matched for productive vocabulary, on their ability to recognize named common objects. Object categories were represented two ways: by lifelike, perceptually rich toys, and by grey caricatures of those objects’ abstract shapes. All 3 groups recognized lifelike objects equally well. Both typically-developing control groups were better than late talkers at recognizing shape caricatures of objects whose names they knew. In Experiment 2, late talkers and age-matched controls identified named objects represented by lifelike toys and by duplicates of those toys covered in grey textured paint. Age-matched controls knew more of the object names overall, but both they and the late talkers performed equally well on both kinds of test objects. Thus, late talkers had some difficulty in Experiment 1 recognizing objects from abstract shape cues, but no difficulty in Experiment 2 when the shape cues were realistic. The findings imply a relation between the growth of productive vocabulary and the emergence of the ability to represent object categories by abstract shape.

INTRODUCTION

Among the first achievements in language learning is learning the names for things. For most children, this process begins slowly at around 1;0 but becomes progressively faster, so that by the time the child is about 2;0 she

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produces on average more than 300 different object names (Fenson, Dale, Reznick, Bates, Hartung, Pethick & Reilly, 1993; Bloom, 2000). Of course, children differ in the rates at which they acquire object names (Mervis & Bertrand, 1995). Some children lag considerably behind their peers. Often called 'late talkers', many of these children show an interesting profile (Thal & Tobias, 1994; Gershkoff-Stowe, Thal, Smith & Namy, 1997; Leonard, 1998). They do not produce as many object names as their peers, but they appear to comprehend an equal number of words. This apparent discrepancy between the comprehension and production of object names suggests that these late-talking children have the same category knowledge as more typical language learners, but differ specifically in the processes relevant to saying object names (Rescorla & Schwartz, 1990; Rescorla, Roberts & Dahlsgaard, 1997). In the experiments that follow, we employ an object name comprehension task and ask whether in fact these children do 'know' these object categories in the same way as children with more object names in their productive vocabularies. The results have implications, not only for characterizing the late talkers, but also for understanding the more general issues of how language comprehension is related to production, and how increases in both are related to other cognitive developmental changes.

The starting points for this study are two recent findings – one (Jones, 2003) suggesting a previously unrecognized difference in how late-talking children deal with new object names; and the second (Smith, 2003) suggesting a link between object name learning and the perception of object shape. First, Jones (2003) reported a difference between late talkers and age-matched children in a kind of comprehension task – the widely used novel noun generalization task. In that task, children are presented with a novel object and a novel name, and asked what other instances have the same name. Note that this task does not test children's specific word knowledge, but rather measures their general expectations about how nouns map to object categories. Typically-developing children, by the time they are 2;0, show in this task that they expect nouns to refer to object categories that are well-organized by shape (Landau, Smith & Jones, 1988; Imai, Gentner & Uchida, 1994; Graham, Williams & Huber, 1999; Smith, 2003). However, late-talking two- to three-year-olds do not show a shape bias in extending novel object names (Jones, 2003). In the present study, we use a different comprehension task to ask whether this lack of a shape bias reflects weaknesses in late talkers' knowledge of the structure of the lexical categories they have already acquired.

The second recent finding to motivate this study is Smith's (2003) report that the perception of object shape changes dramatically between 1;6 and 2;0 – that is, at about the same time as children begin to show a shape bias in naming. Smith (2003) specifically examined children's ability to recognize

abstract representations of 3-dimensional object shape, the kinds of representations that theorists of adult object recognition believe underlie adults' rapid recognition of common things such as chairs, cups and cars (e.g. Biederman, 1987; Edelman & Duvdevani-Bar, 1997; Duvdevani-Bar & Edelman, 1999). She found that children who were more advanced in language learning readily recognized these abstract forms just as well as they did realistic ones, but that children who were less advanced in language learning did not. More specifically, recognition of abstract forms was strongly related to the number of object names in the children's productive vocabularies. Smith proposed that core processes in object recognition, the perception and representation of object shape, change as children learn and use increasing numbers of object names.

Do late talkers recognize common objects given only an abstract representation of shape? The fact that these children often comprehend common nouns as well as their age mates suggests that they have the same category knowledge, and if they have the same category knowledge, then they should be as good as their peers at recognizing common object categories from abstract representations of shape. However, we might find that late-talkers lag behind in their perception of object shape as well as in their productive vocabulary growth. If this result were to obtain, it would suggest that the same comprehension of common nouns by late-talking and typically-developing children does not necessarily reflect the same knowledge about categories. It would also raise new questions about the relations among comprehension, production, and developing category knowledge.

## EXPERIMENT 1

In Experiment 1, we compare late-talking children with two groups of typically-developing children: one composed of like-aged children with larger productive vocabularies; and one composed of younger children with comparable productive vocabulary sizes. We present all of the children with richly detailed objects that are typical instances of their categories, and also with 3-dimensional abstract caricatures of those objects' shapes. Examples of both kinds of stimulus objects are shown in Figure 1. This method of representing the abstract shape characteristic of a class of objects was suggested by Biederman's description of 'geons', which he proposes as the primitives of shape perception (1987; see also Hummel & Biederman, 1992). As can be seen in Figure 1 the shape caricatures provide only rather abstract shape cues to indicate the category to which the object belongs. Biederman has shown that adults are well able to recognize common categories from these representations, and Smith (2003) has shown that with advancing lexical knowledge, typically-developing children acquire the ability to recognize category instances from this kind of representation. Is

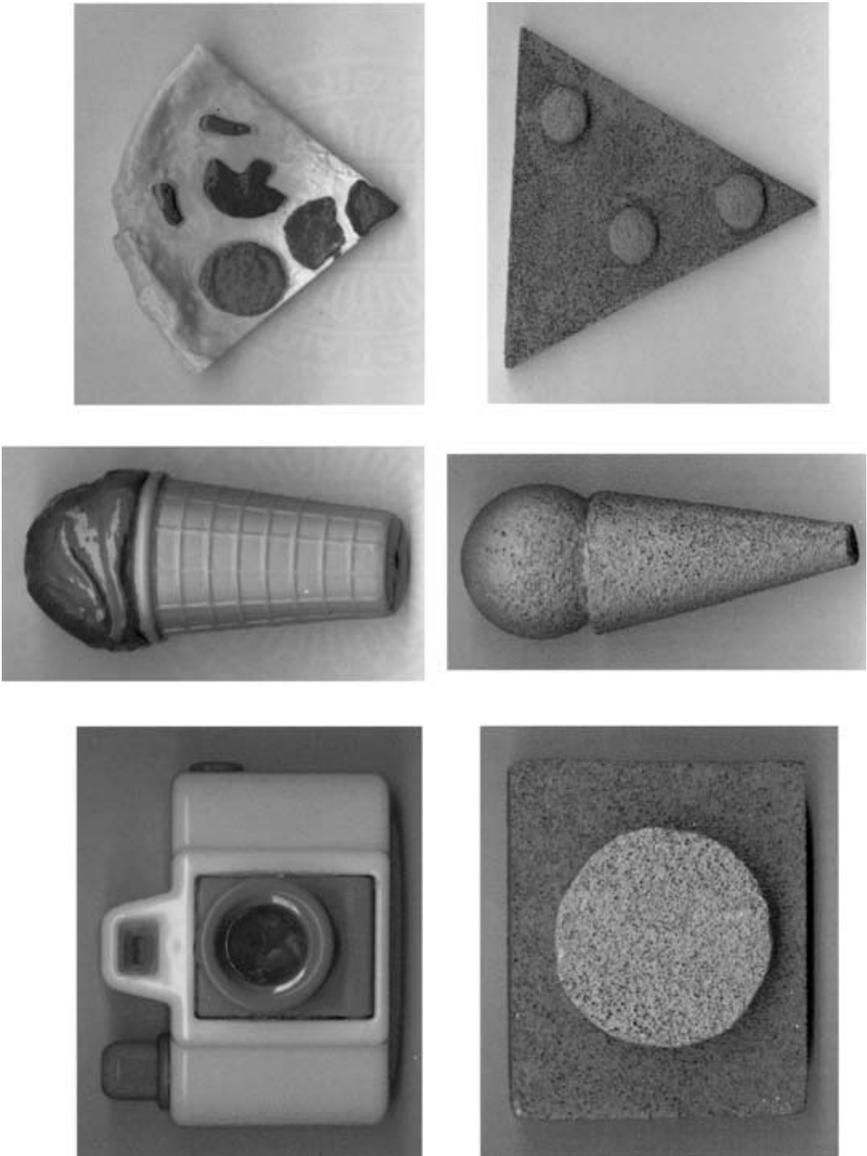


Fig. 1. Experiment 1. Three test objects – ‘pizza’, ‘ice cream’, and ‘camera’ – represented as (a) Lifelike objects; (b) Shape caricatures, employed in a named object recognition task.

this shape information also sufficient for object recognition by late-talking children?

#### METHOD

Although our focus is on how late talkers comprehend the names of familiar objects, the subject population is defined, not by comprehension, but by their lower than average rates of word production. Therefore, in the following experiment, we identified a group of children between 2;0 and 3;0 whose total productive vocabularies placed them in the bottom 20% of their age group.<sup>1</sup> We compared these late talkers' ability to recognize familiar objects by shape with that of a group of typically-developing children closely matched for age, and with a second group of children, 7 months younger on average, matched for productive vocabulary size.

#### *Participants*

A large sample of children between the ages of 1;6 and 3;0 was identified from birth announcements and recruited via letter and telephone. Each child's productive vocabulary was assessed using Part 1A – Vocabulary Checklist of the *MacArthur Communicative Development Inventory – Words and Sentences* (Fenson *et al.*, 1993). The MCDI's Vocabulary Checklist is a reliable measure of the first 680 words typically learned by children up to 2;6.

From the larger sample, 3 sub-groups ( $n=11$ ) were formed: LATE TALKERS – children at least 2;0 and scoring below the 20th percentile in total number of words in their productive vocabularies as reported on the MCDI; AGE-MATCHES – children who each had a birthday within  $\pm 1$  week (7 children), 2 weeks (1 child) or 3 weeks (3 children) of a different late talker, and who scored above the 20th percentile on the MCDI; and VOCABULARY MATCHES – children with MCDI scores matched as closely as possible to those of individual late talkers, given that those scores were above the 20th percentile for the vocabulary matched child's age. Table 1 shows the ages and total productive vocabulary scores (MCDI) for each late

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[1] Young late talkers are often defined as children whose productive vocabularies lie below the 10th percentile for their age groups. Thal *et al.* (1997) reported that a group of late talkers identified by this criterion at very young ages had percentile rankings between the 20th and 30th percentiles by age 2;6. More recently, Rescorla *et al.* (2000) have described a subgroup of children identified as late talkers at 2;0 to 2;6 who improved their vocabulary scores through their third year. A number of children in the present study were close to 2;6, and we were concerned that the use of a 10th percentile cut-off for these older children would exclude late talkers who were showing improvement, and thus reduce the comparability of our sample to samples in these previous studies. We therefore chose to use a slightly more liberal cutoff point – the 20th percentile.

TABLE 1. *Experiment 1: how late talkers compare to age-matched control and vocabulary-matched control children in age, total words in productive vocabulary (MCDI Total) and number of count nouns in productive vocabulary (MCDI Nouns)*

	Late talkers		Age matches		Vocabulary matches	
	Age (mos.)	Total MCDI	Age (mos.)	Total MCDI	Age (mos.)	Total MCDI
1	25·3	131	25·2	355	19·8	196
2	25·4	123	26·1	540	20·0	114
3	26·5	268	26·3	523	21·4	254
4	26·8	283	26·4	557	20·2	283
5	27·9	269	27·9	367	20·0	275
6	29·2	56	29·0	618	19·7	40
7	29·8	439	29·6	651	22·8	484
8	29·9	397	29·8	481	24·6	386
9	30·1	118	30	671	19·3	67
10	31·5	341	30·7	639	26·0	322
11	31·9	383	32·7	664	23·4	376
	<i>M</i> = 28·6 <i>S.D.</i> = 2·33	<i>M</i> = 255·3 <i>S.D.</i> = 130·4	<i>M</i> = 28·5 <i>S.D.</i> = 2·33	<i>M</i> = 551·5 <i>S.D.</i> = 112·9	<i>M</i> = 21·6 <i>S.D.</i> = 2·29	<i>M</i> = 254·3 <i>S.D.</i> = 139·6

TABLE 2. *Experiment 1: how late talkers compare to age-matched control and vocabulary-matched control children in the proportions of their total MCDI productive vocabularies that are count nouns*

	Late talkers	Age matches	Vocab. matches
1	0·54	0·65	0·75
2	0·71	0·54	0·52
3	0·67	0·59	0·62
4	0·69	0·59	0·57
5	0·68	0·64	0·63
6	0·82	0·52	0·71
7	0·68	0·53	0·66
8	0·56	0·59	0·59
9	0·53	0·54	0·55
10	0·61	0·55	0·64
11	0·67	0·53	0·49
	<i>M</i> = 0·65 <i>S.D.</i> = 0·085	<i>M</i> = 0·57 <i>S.D.</i> = 0·045	<i>M</i> = 0·612 <i>S.D.</i> = 0·078

talker and for his or her age and vocabulary matches. The Table also gives means, standard deviations, and ranges for the ages and vocabulary sizes of the groups.

Table 2 shows the proportion of each child's MCDI productive vocabulary made up of count nouns. Paired t-tests showed that the late talkers did not

OBJECT NAMING AND PERCEPTION

TABLE 3. *Target and distractor objects for Experiments 1 and 2. Equal numbers of children were tested with lists A and B. Order of parts 1 and 2, and whether each part was presented as lifelike or shape caricature (Exp. 1)/ grey-texture-painted (Exp. 2) were counterbalanced across subjects*

Trial	Target	Distractor 1	Distractor 2	Target	Distractor 1	Distractor 2
		List A-1			List A-2	
1	Basket	Pizza	Banana	Hammer	Telephone	Chair
2	Butterfly	Ice Cream	Cat	Boat	Carrot	Pizza
3	Cat	Chair	Boat	Apple	Hammer	Camera
4	Pizza	Banana	Toothbrush	Banana	Boat	Telephone
5	Ice Cream	Basket	Lollipop	Carrot	Cat	Cake
6	Cake	Apple	Telephone	Lollipop	Toothbrush	Basket
7	Toothbrush	Lollipop	Butterfly	Chair	Camera	Carrot
8	Telephone	Cake	Apple	Camera	Butterfly	Ice Cream
		List B-1			List B-2	
1	Hammer	Telephone	Pizza	Basket	Camera	Telephone
2	Boat	Chair	Lollipop	Butterfly	Carrot	Toothbrush
3	Apple	Toothbrush	Boat	Cat	Apple	Ice Cream
4	Banana	Basket	Telephone	Pizza	Cat	Cake
5	Carrot	Butterfly	Apple	Ice Cream	Banana	Basket
6	Lollipop	Hammer	Camera	Cake	Boat	Banana
7	Chair	Ice Cream	Carrot	Telephone	Lollipop	Butterfly
8	Camera	Cake	Cat	Toothbrush	Pizza	Chair

differ from their vocabulary matched controls on this measure ( $t_{(10)}=1.14$ ,  $p>0.28$ ). However, the late talkers did have significantly larger proportions of nouns in their vocabularies than their age-matched peers ( $t_{(10)}=2.41$ ,  $p<0.03$ ). Since in typically-developing children, the proportion of nouns diminishes with age (Bates, Marchman, Thal, Fenson, Dale, Reznick, Reilly & Hartung, 1994), these comparisons among our groups of participants underscore the similarity in vocabulary growth between the late talkers and younger, vocabulary matched children.

*Stimuli*

Two sets of test stimuli, both representing the same 16 common object categories, were constructed. Table 3 lists the 16 object names. All of the stimuli ranged in size from 10 cm<sup>3</sup> to 18 cm<sup>3</sup>. One stimulus set consisted of lifelike toy representations of the objects. The second stimulus set consisted of ‘shape caricatures’ of the same 16 objects. Each shape caricature was constructed from 2 to 4 basic geometric shapes carved out of styrofoam and painted grey (see Figure 1 for samples).

### *Procedure*

*Warm-up trials.* Children first participated in 3 warm-up trials designed to familiarize them with the test procedure. On each trial, the child was presented with the same 3 objects – a plastic cup, a small ball that fit into the cup, and a large silver spoon. The child was encouraged to handle the objects for 15 seconds. Then the experimenter produced a tray with 3 compartments, each 25 cm square, made of sturdy white cardboard. The experimenter retrieved the 3 objects and placed each in one compartment of the tray. The child was then asked ‘Can I have the ball? Give me the ball.’ The ball was accepted or retrieved if not offered, returned to its space, and another object was requested. On a third turn, the third object was requested. Then the 3 objects were returned to the child, and the procedure was repeated twice more with the objects in different compartments of the tray on each trial.

*Test trials.* Each child’s ability to identify common objects named by the experimenter was tested on 16 unique trials, with 8 of the 16 categories represented by lifelike objects and the other 8 categories represented by shape caricature stimuli. Table 3 shows the two orders of the target objects, along with the distractor objects used on each trial. The two lists were used equally often. Which segment – A or B – was presented as lifelike stimuli and which as shape caricatures was counterbalanced across children. The lifelike and shape caricature trials were blocked, and the order of the two blocks was also counterbalanced across participants.

The procedure was identical to that employed in the warm-up trials. The positions of the 3 objects on the tray were randomly varied across trials.

Videotapes of the experiment were coded by a scorer blind to the purpose of the study. Children were judged to have made a choice if they lifted or handed over an object on request. Only first choices meeting these criteria were counted. A second scorer coded 10 of the participants’ tapes (30%). The two judges agreed on the object which the child handed over first on 155 of the 160 trials (97%: Cohen’s Kappa = 0.92).

### RESULTS

Figure 2a shows the mean scores (max. = 8) of children in the 3 matched groups when identifying named lifelike objects. As is evident, all 3 groups of children recognize the lifelike objects at comparable levels. This tells us that all of the children ‘know’ the 16 object names, in that they can, in a comprehension task, map the names to typical lifelike instances. Figure 2b shows the children’s performances when asked to identify named shape caricatures. Here the late talkers perform at a level comparable to children 7 months their junior on average, and markedly less well than age mates. These conclusions were confirmed by a (3) group  $\times$  (2) test object type

OBJECT NAMING AND PERCEPTION

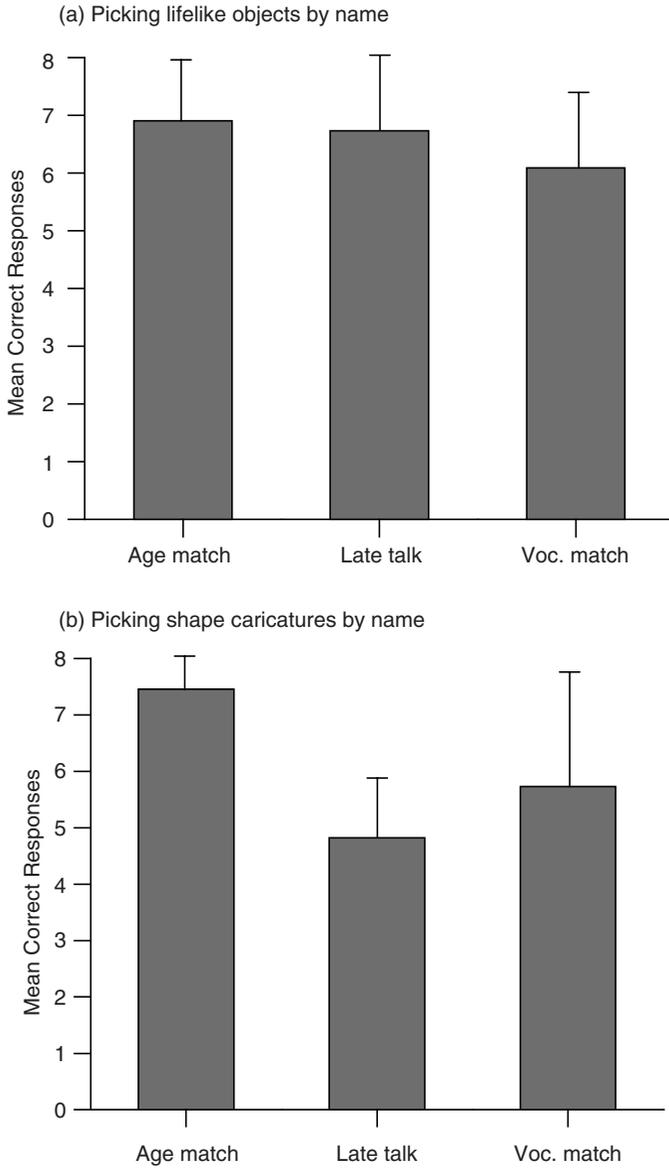


Fig. 2. Mean scores (max.=8) of children in the 3 matched groups when identifying (a) named lifelike objects; and (b) named shape caricatures.

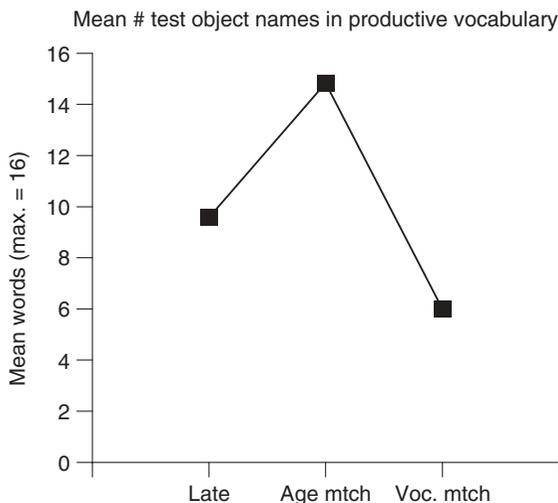


Fig. 3. The mean number (max. = 16) of the names for the lifelike and shape caricature test objects reported in the MCDI productive vocabularies of children in each group.

mixed analysis of variance that yielded a main effect of group ( $F_{(2, 30)} = 56.4$ ,  $p < 0.001$ ), a group  $\times$  test object type interaction ( $F_{(2, 30)} = 4.1$ ,  $p = 0.023$ ), and a *post hoc* comparison of means within the interaction for which Tukey's  $HSD_{(5, 0.05)} = 1.82$ . Thus, late talkers show deficits relative to their age mates in the ability to recognize common category instances when presented only with global information about object shape; and they perform at a level equivalent to that of younger children with comparable productive vocabularies.

All of the groups in the study are defined in whole or in part by the total on a parental report of the words the children produced at the time of the study. Thus, the results can be said to show that global productive vocabulary predicts how well children, in a comprehension task, are able to recognize named objects by abstract shape. Figure 3 shows the mean number of the names for the 16 test objects that by parental report were in the productive vocabularies of children in each group. As is evident in the figure, the three groups differed dramatically ( $F_{(2, 30)} = 8.51$ ,  $p = 0.001$ ), with both late talkers and vocabulary matched controls having produced considerably fewer of the tested object names than the age-matched controls (Tukey's  $HSD_{(3, 0.05)} = 5.21$ ). Comparison of the late talkers' knowledge of these 16 words as measured by parent report of production on the one hand, and by their comprehension of these names given lifelike choice objects on the other, shows a pattern identical to that reported in the literature (e.g. Rescorla & Schwartz, 1990; Thal & Tobias, 1994) – that is, a pattern of

OBJECT NAMING AND PERCEPTION

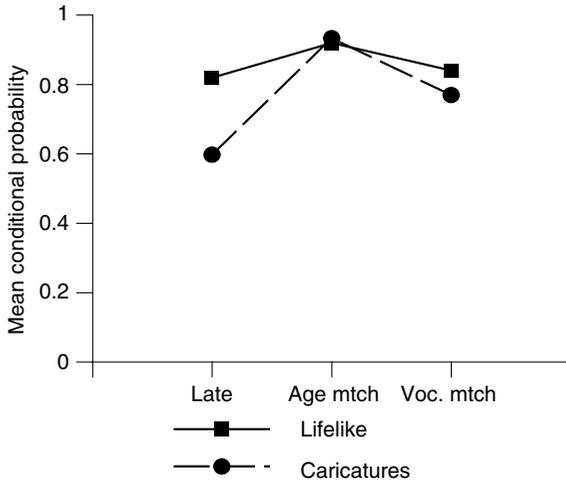


Fig. 4. Mean conditional probabilities that each child in each group would correctly identify a test object in the Lifelike Objects or Shape Caricatures conditions, given that the child had produced the name of the category to which the test object belonged.

comprehension without production. But the results with shape caricatures paint a different picture. Clearly, the late talkers and the younger age-matched controls only comprehend the object names when given richly detailed instances. Unlike more typically-developing age mates, the late talkers do not ‘comprehend’ the object names when given shape caricatures.

Does actually having a particular word in productive vocabulary signal that children know that particular category well enough to recognize its shape caricature? To address this question, we calculated the conditional probability that children selected the right object in our experimental task given that their parents reported that the label was in the child’s productive vocabulary. Figure 4 provides the mean conditional probabilities for the 3 groups of children for the lifelike and the shape caricature test objects. As is apparent, scores for recognizing the lifelike objects by name were equally high for all 3 groups ( $F_{(2,27)}=0.66$ , NS). Recognition of the shape caricatures was equally good in the age-matched and vocabulary-matched controls. However, late talkers did significantly less well in recognizing shape caricatures, even though the object names were in their productive vocabularies ( $F_{(2,27)}=3.75$ ,  $p=0.037$ ; Tukey’s  $HSD_{(3,0.05)}=0.30$ ). This result is intriguing because it is the first in this experiment in which late talkers differ from the vocabulary matched controls. Thus, it is the first evidence that the normally-developing YOUNGER children might know something that the late talkers do not know about the shapes relevant to common noun categories. Again, both of these groups were equally good at

recognizing lifelike objects, given that the object category name was in the child's productive vocabulary. However, the relation between producing the name of an object and recognizing its shape caricature existed in the younger vocabulary-matched children but not in the late talkers. This pattern of findings makes sense on two assumptions: first, that recognition of shape caricatures depends on more extensive knowledge of the lexical category than does naming, or success in a comprehension task, with typical instances; and secondly, that younger normally-developing children are developing this knowledge about the categories they name, whereas late talkers may not be.

#### DISCUSSION

In Experiment 1, late talkers often did not recognize a shape caricature even when the name of the object that the shape caricature represents was part of their productive vocabulary. This finding suggests that late talkers may not be learning about the overall shapes that characterize common lexical categories in just the same way as typically-developing children do.

Experiment 2 examines two hypotheses pertinent to this difference. Hypothesis 1 is that late talkers know less than their normally-developing peers about the abstract shape characteristics shared by lexical category members. Hypothesis 2 is that, for late talkers, the links between name and appearance are fragile enough that any degradation of the perceptual information afforded by familiar objects would interfere with their ability to link object appearance with object name.

Experiment 2 was designed to distinguish between these possibilities. The same familiar object categories used in Experiment 1 were again represented by lifelike toys and by perceptually altered stimuli. This time, however, the perceptually altered stimuli were simply duplicates of the lifelike toys sprayed with textured grey paint. Thus, all colour and texture cues that might serve to identify the objects were obscured, but the true shapes of the objects were preserved. The question was whether late talkers would have trouble identifying these realistic shapes, given the absence of colour and texture cues.

#### EXPERIMENT 2

##### *Participants*

Eighteen children aged 1;7 to 2;6 (mean age = 22.1 mos, *S.D.* = 3.3) participated. Nine were recruited via newspaper announcements of research involving '... children who seem to talk less than other children their age'. All 9 had productive vocabularies below the 20th percentile for their ages ( $M = 10.0$  percentile, *S.D.* = 6.6) as reported by their parents on the

## OBJECT NAMING AND PERCEPTION

TABLE 4. *Experiment 2: how late talkers compare to age-matched controls in age (months) and total productive vocabulary as measured by the MacArthur Communicative Development Inventory*

	Late talkers			Age-matched controls		
	Age	MCDI Total	Count nouns	Age	MCDI Total	Count nouns
1	19·1	8	7	19·6	195	148
2	19·7	0	0	19·9	116	80
3	19·7	30	25	19·9	135	97
4	19·9	56	40	19·9	342	192
5	21·9	79	54	21·1	520	290
6	22·1	84	55	22·7	520	371
7	23·1	177	146	24·2	639	334
8	23·5	27	13	24·3	316	186
9	29·9	84	56	26·1	471	261
<i>M</i> =	22·1	60·56	44·0	22·0	361·6	217·7
<i>S.D.</i> =	3·34	54·2	43·9	2·43	187·4	102·6

MacArthur Communicative Development Inventory Part 1A – Vocabulary Checklist (Fenson *et al.*, 1993). An additional 9 children closely matched for age were recruited from birth records via mail and telephone. All children in this comparison group had MCDI total productive vocabularies above the 20th percentile. Table 4 compares the ages and productive vocabularies of the individual matched pairs of late talkers and comparison group children. In comparison to the children in Experiment 1 (see Table 1), the present sample was younger by an average of about 6 months, and predictably, had smaller total vocabularies: late talkers in Experiment 2 had produced on average only about 61 of the words on the MCDI, compared with about 255 total words for the late talkers in Experiment 1; and the age-matched controls in Experiment 2 had produced only about 360 words on average, compared with about 550 for age-matched controls in Experiment 1. The fact that the present sample of late talkers is younger and has fewer words than the sample in Experiment 1 is at best neutral for and may work against our finding that the late talkers can name everyday objects by shape alone when the shapes are detailed and not abstract.

### *Stimuli*

There were two sets of test stimuli. One was the same set of lifelike representations of 16 common object categories that had been used in Experiment 1. The second set comprised duplicates of the lifelike stimuli, each sprayed with a grey, sand-textured paint. Examples are shown in Figure 5.

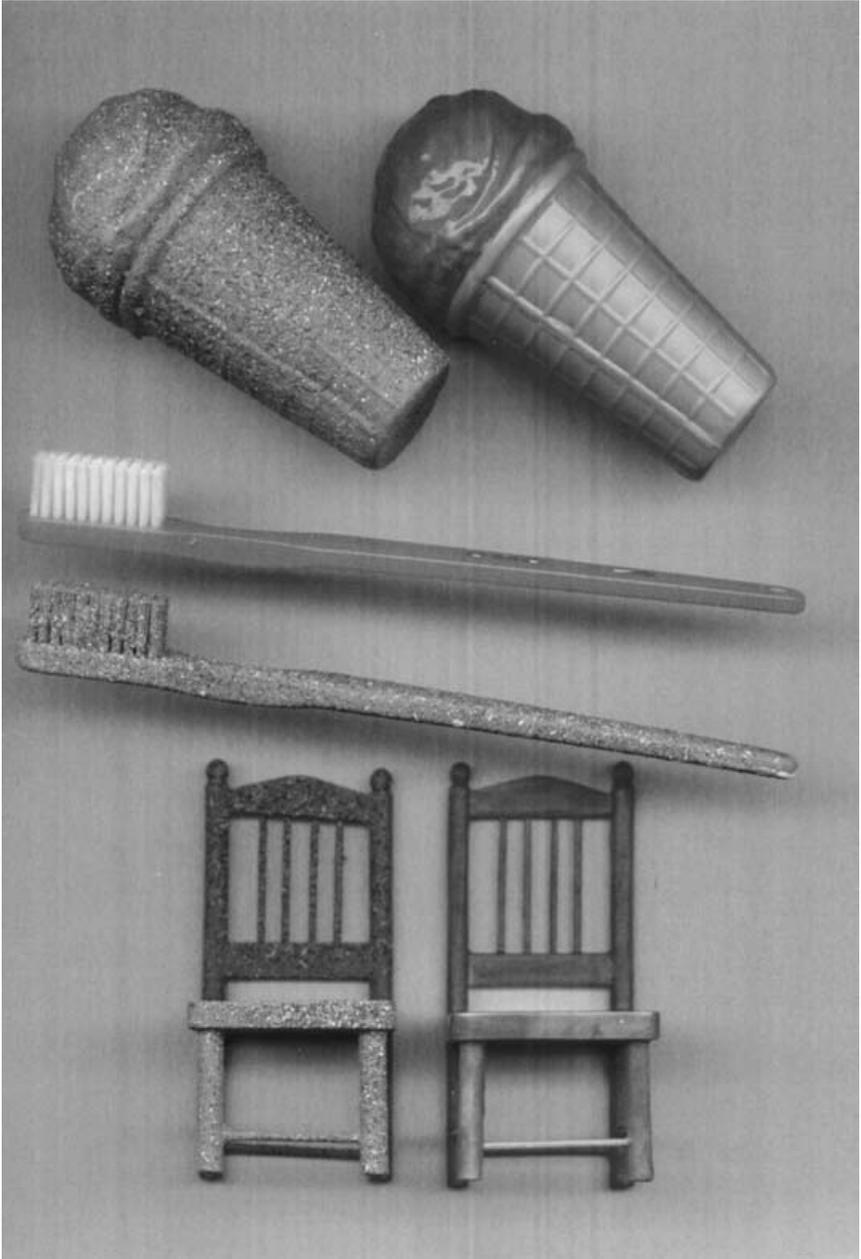


Fig. 5. Experiment 2: Three test objects represented as (a) Lifelike objects; and (b) Grey-texture-painted objects, employed in a named object recognition task.

OBJECT NAMING AND PERCEPTION

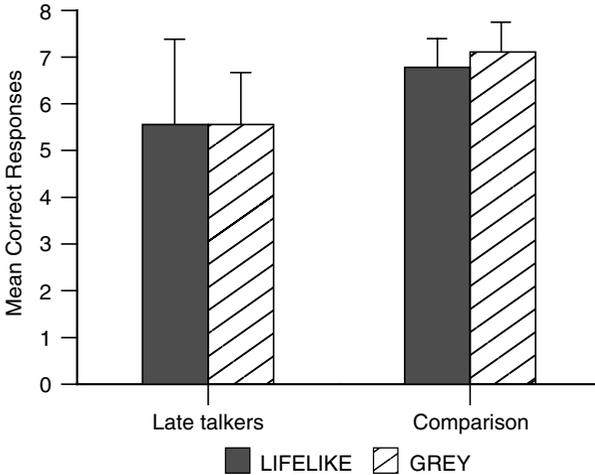


Fig. 6. Experiment 2: Mean scores (max. = 8) of Late Talker and Comparison Group children when identifying (a) lifelike objects; and (b) grey-and-texture-painted lifelike objects.

*Procedure*

The warm-up and test trial procedure was exactly as in Experiment 1. Again, all experimental sessions were videotaped and the tapes were coded by a single judge for children's first choices (lifting or handing over an object) following the experimenter's request for an object by name. A second judge coded 7 of the participants' tapes (39%). The two judges agreed on the object which the child handed over first on 110 of the 112 trials (98%).

RESULTS

Figure 6 shows the mean scores (max. = 8) of children in the late talker and comparison groups when identifying named lifelike objects versus named grey-and-texture-painted objects. Children's scores on identification of each kind of object were entered into a (2) group: late talker vs. comparison  $\times$  (2) test object type: lifelike vs. grey mixed analysis of variance. The analysis yielded a main effect of group: as indicated in Figure 6, the comparison group children identified more objects correctly in both the lifelike and grey stimulus conditions ( $F_{(1,16)} = 7.143, p < 0.02$ ). There was no main effect of stimulus type, and more importantly, no interaction. That is, although the comparison group children did better than late talkers with both kinds of test objects, late talkers were equally good at identifying lifelike and grey-texture-painted stimuli.

It is not true, then, that any degradation of perceptual information will have a negative effect on late talkers' ability to recognize familiar objects by

name. The main difference between the shape caricatures in Experiment 1 and the grey-texture-painted test objects in Experiment 2 was in the kind of information about object shape. The results of the two experiments indicate that late talkers are able to identify familiar objects from realistic shape information in the absence of other perceptual cues, but not from abstract shape information alone. Thus, the deficit shown by late talkers relative to their normally-developing peers appears to be a deficit specifically in knowledge of the abstract shape properties that encompass the otherwise variable shapes of category members.

#### DISCUSSION

Three main conclusions emerge from these results. First, the ability to recognize the global abstract forms characteristic of common categories is developmentally linked to early lexical learning. The data show both that children who are more advanced in lexical knowledge are also more advanced in their recognition of these abstract forms; and that children who are delayed in lexical learning are also delayed in their recognition of these forms. These findings are significant in that they tell us that the perception of shape is not a developmental constant.

Past research has established the importance of shape in early noun learning – and indeed children appear biased to extend object names to new instances by sameness in shape (Clark, 1973; Landau *et al.*, 1988; Imai *et al.*, 1994; Graham *et al.*, 1999). But what counts as sameness in shape? In the literature on the shape bias and its role in early noun learning, this question has not been considered, and shape has not been defined. But this is the very issue that dominates the literature on adult and machine object recognition (Hummel & Biederman, 1992; Edelman & Duvdevani-Bar, 1997). A definition of sameness in shape is seen as the key theoretical issue in object recognition because a theory of shape is needed to explain how perceivers see, for example, all varieties of chairs as having the same abstract form despite real differences in the details of their specific shapes. The present results suggest that such a category-encompassing definition of shape is a developmental product. Thus, the relation between shape and early lexical learning is more complicated than a simple shape bias would suggest. What is developing is not merely increased attention to shape, but perhaps the very definition of what counts as sameness in shape.

The second main conclusion concerns late talkers and the reasons for and the nature of their delay. By standard measures, many late talkers show age-appropriate word comprehension skills but delayed production skills. The late talkers who show this pattern are the ones who eventually ‘catch up’ in language development (Thal, Bates, Goodman & Jahn-Samilo, 1997; Rescorla, Mirak & Singh, 2000). This profile has given rise to the idea that

these children have the same lexical and categorical knowledge as typically-developing children, but have difficulties in those aspects of language specific to production (Gershkoff-Stowe *et al.*, 1997; Thal *et al.*, 1997). The present results suggest that these children's difficulties span a broader range of ability and knowledge. When given a comprehension test more demanding than the usual one of mapping a typical category instance to the label, late talkers show broader deficits. Like younger vocabulary-matched children, they fail to recognize highly abstract but category-relevant shapes. Moreover, the late talkers differ from the younger vocabulary-matched children in that their production of a specific category name is not a good predictor of their recognition of that category's abstract shape representation. This raises the possibility that when these children learn a lexical category, they do not learn it as deeply as do their typically-developing peers given the same information.

Perhaps some of these children are not learning about the abstract forms that organize object recognition because they are not attending to the shapes of things. In a previous study, Jones (2003) found that late talkers often focused on texture in the name extension tasks in which typically-developing children focused on shape. Perhaps they focused on textural properties because of atypical early experience with texture-based categories, or because of more basic perceptual problems in perceiving global shape. Either possibility might yield an initially slowed rate of object name acquisitions.

The third conclusion from these experiments concerns the relations between comprehension and production. The 3 groups of children differed according to parental report of their productive vocabularies, and also differed in their 'comprehension' of object names when tested with more challenging stimuli than highly typical instances. These findings remind us that category knowledge is not all or none and that children who produce more words have deeper knowledge of the categories they know than children who produce fewer words. This suggests at the very least that children's developing comprehension skills need to be probed more extensively than by simply testing with clear-cut choices among typical and well-known instances (see also McDonough, 2002).

The results also raise new issues for future research. Does lexical learning change object recognition processes? Or is there a third developing process that plays a role in both lexical learning and shape perception? Can one teach children to recognize abstract object shape? And if so, will this facilitate the learning of new object names?

## REFERENCES

- Bates, E., Marchman, V., Thal, D., Fenson, L., Dale, P. S., Reznick, J., Reilly, J. & Hartung, J. (1994). Developmental and stylistic variation in the composition of early vocabulary. *Journal of Child Language* 21, 85-123.

- Biederman, I. (1987). Recognition-by-components: a theory of human image understanding. *Psychological Review* **94**(2), 115–17.
- Bloom, P. (2000). *How children learn the meanings of words*. Cambridge, MA: MIT Press.
- Clark, E. (1973). What's in a word? On the child's acquisition of semantics in his first language. In T. E. Moore (ed.), *Cognitive development and the acquisition of language*. New York: Academic Press.
- Duvdevani-Bar, S. & Edelman, S. (1999). Visual recognition and categorization on the basis of similarities to multiple class prototypes. *International Journal of Computer Vision* **33**, 201–28.
- Edelman, S. & Duvdevani-Bar, S. (1997). A model of visual recognition and categorization. *Philosophical Transactions of the Royal Society of London* **352**, 1191–202.
- Fenson, L., Dale, P., Reznick, J. S., Bates, E., Hartung, J., Pethick, S. & Reilly, J. (1993). *MacArthur Communicative Development Inventories*. San Diego: Singular.
- Gershkoff-Stowe, L., Thal, D. J., Smith, L. B. & Namy, L. L. (1997). Categorization and its developmental relation to early language. *Child Development* **68**(5), 843–59.
- Graham, S. A., Williams, L. D. & Huber, J. F. (1999). Preschoolers' and adults' reliance on object shape and object function for lexical extension. *Journal of Experimental Child Psychology* **74**(2), 128–51.
- Hummel, J. E. & Biederman, I. (1992). Dynamic binding in a neural network for shape recognition. *Psychological Review* **99**(3), 480–517.
- Imai, M., Gentner, D. & Uchida, N. (1994). Children's theories of word meaning: the role of shape similarity in early acquisition. *Cognitive Development* **9**(1), 45–75.
- Jones, S. S. (2003). Late talkers show no shape bias in object naming. *Developmental Science* **6**, 477–83.
- Landau, B., Smith, L. B. & Jones, S. S. (1988). The importance of shape in early lexical learning. *Cognitive Development* **3**, 299–321.
- Leonard, L. B. (1998). *Children with specific language impairment*. Language, speech, and communication, viii. Cambridge, MA: MIT Press.
- McDonough, Laraine (2002). Basic-level nouns: first learned but misunderstood. *Journal of Child Language* **29**(2), 357–77.
- Mervis, C. B. & Bertrand, J. (1995). Early lexical acquisition and the vocabulary spurt: a response to Goldfield & Reznick. *Journal of Child Language* **22**(2), 461–8.
- Rescorla, L., Mirak, J. & Singh, L. (2000). Vocabulary acquisition in late talkers: lexical development from 2;0 to 3;0. *Journal of Child Language* **27**, 297–311.
- Rescorla, L., Roberts, J. & Dahlsgaard, K. (1997). Late talkers at 2: outcome at age 3. *Journal of Speech, Language, & Hearing Research* **40**(3), 556–66.
- Rescorla, L. & Schwartz, E. (1990). Outcome of toddlers with specific expressive language delay. *Applied Psycholinguistics* **11**, 393–407.
- Smith, L. B. (2003). Learning to recognize objects. *Psychological Science* **14**, 244–50.
- Thal, D. J., Bates, E., Goodman, J. & Jahn-Samilo, J. (1997). Continuity of language abilities: an exploratory study of late- and early-talking toddlers. *Developmental Neuropsychology* **13**, 239–73.
- Thal, D. & Tobias, S. (1994). Relationships between language and gesture in normally developing and late-talking toddlers. *Journal of Speech and Hearing Research* **37**, 157–70.