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Does language about similarity play a role in fostering similarity comparison in children?

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ABSTRACT

Commenting on perceptual similarities between objects stands out as an important linguistic achievement, one that may pave the way towards noticing and commenting on more abstract relational commonalities between objects. To explore whether having a conventional linguistic system is necessary for children to comment on different types of similarity comparisons, we observed four children who had not been exposed to usable linguistic input – deaf children whose hearing losses prevented them from learning spoken language and whose hearing parents had not exposed them to sign language. These children developed gesture systems that have language-like structure at many different levels. Here we ask whether the deaf children used their gestures to comment on similarity relations and, if so, which types of relations they expressed. We found that all four deaf children were able to use their gestures to express similarity comparisons (point to cat + point to tiger) resembling those conveyed by 40 hearing children in early gesture + speech combinations (*cat* + point to tiger). However, the two groups diverged at later ages. Hearing children, after acquiring the word *like*, shifted from primarily expressing global similarity (as in *cat*/*tiger*) to primarily expressing single-property similarity (as in *crayon is brown like my hair*). In contrast, the deaf children, lacking an explicit term for similarity, continued to primarily express global similarity. The findings underscore the robustness of similarity comparisons in human communication, but also highlight the importance of conventional terms for comparison as likely contributors to routinely expressing more focused similarity relations.

1. Introduction

Similarity is a central construct in explanations of knowledge acquisition, and underlies much of children's early learning about categories (Gentner & Namy, 1999; Samuelson & Smith, 2000; Smith, 1983). For example, 18-month-olds can sort objects into categories based on shared perceptual features (e.g., boxes vs. balls; Gopnik & Meltzoff, 1992; Sugarman, 1983), and even preverbal children can use perceptual similarity to categorize animals or human faces (see Oakes & Madole, 2000, for a review). The fact that preverbal children, as well as other nonverbal animals (including pigeons, Hernstein, Loveland, & Cable, 1976, and chimpanzees, Oden, Thompson, & Premack, 1990), respond systematically to similarity makes it clear that having a codified language is not essential to recognize similarities between objects. But does learning an explicit term for comparison help promote the routine expression of more abstract similarity relations?

All languages have symbolic markers designed to highlight similarities between objects. The word *like* in the 'x is like y' construction (e.g., *the tiger is like a cat*) plays this role in English and is frequently found in the talk English-

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learning children hear (Özçalışkan, Goldin-Meadow, & Gentner, 2009). This construction thus offers children a model for their early expressions of similarity. And children take advantage of this model, using the word *like* to express similarities at a relatively young age. Three- to 4-year-old children spontaneously produce novel expressions that highlight similarities between objects (Billow, 1981; Chukovsky, 1968; Clark, 1973; Elbers, 1988; Winner, 1979), describing, for example, a long pencil as looking *like a rocket ship* (Gardner, Winner, Bechhofer, & Wolf, 1978). Children of this age are also able to reliably choose sentence endings based on similarity when asked about expressions that involve comparisons between objects in experimental contexts (e.g., *a river is like a snake*) (Billow, 1975; Epstein & Gamlin, 1994; Gardner, Kircher, Winner, & Perkins, 1975;Gentner, 1988; Mendelsohn, Robinson, Gardner, & Winner, 1984; Vosniadou & Ortony, 1983; Winner, McCarthy, & Gardner, 1980).

Does having constructions that make comparison explicit (for example, *x is like y*) in their linguistic input play a role in getting children to comment on similarities between objects? On the one hand, the need to communicate about similarities may be so basic that we might guess that learning words for comparison would make no difference; children might be able to express the same types of similarity comparisons regardless of whether they have explicit terms for comparison in their lexicons. On the other hand, although the simple, global similarity that often holds between objects from the same category (e.g., the similarity between a cat and a tiger) may be salient even to very young children, there is considerable evidence that more focused partial similarities (e.g., the similarity between a red apple and a red book, objects from different categories) is not as obvious (Gentner & Rattermann, 1991; Smith, 1989). Thus, their emergence in child conversation might be more closely tied to the emergence of explicit terms for comparison.

To explore these possibilities, we examined children who have had no exposure to a usable language model and thus no exposure to an explicit term for similarity (i.e., the word *like*). We asked whether these children comment on similarity between objects and, if so, whether their similarity comparisons resemble those produced by hearing children who do have access to an explicit term that highlights comparison and who can communicate about global similarities between objects from the same basic category (cat is like tiger), as well as more focused, partial similarities between objects from different categories (red apple is like red book).

Deaf children who have hearing losses so profound as to preclude the acquisition of spoken language are unable to profit from the conventional spoken language that surrounds them. If these deaf children are born to hearing parents, they may not be exposed to a conventional sign language until adolescence. Despite their lack of a usable conventional language model, these children invent gesture systems, called *homesigns*, to communicate with the hearing individuals in their worlds (Feldman, Goldin-Meadow, & Gleitman, 1978; Goldin-Meadow, 2003; Goldin-Meadow & Mylander, 1998). The deaf children use pointing gestures and invent iconic gestures to refer to objects (Goldin-Meadow, Butcher, Mylander, & Dodge, 1994) and therefore might be able to use their gestures to communicate about similarities between objects. We explore here whether deaf children use their homesign gestures to express similarity relations even if they are never exposed to an explicit term for comparison (the word *like*). If so, we ask whether their similarity comparisons resemble those produced by hearing children who have access to the word *like*.

How might a deaf child with only a homemade gesture system express a similarity relation? One strategy would be to invent a gesture for *like*. However, this turns out to be difficult, as the deaf children's gestures were rarely arbitrary in form. All of the deaf children in our study were being educated using oral methods (e.g., lip-reading and auditory training) and their parents had been advised by educators to talk to their children whenever possible and avoid using sign language or gesture. The children's gestures therefore had to be transparent enough to be understood by people who shared neither their gesture system nor their desire to communicate with gesture. It is apparently not easy to invent a gesture form that transparently conveys the meaning *like* and, indeed, none of the deaf children did. An alternative strategy would be to juxtapose two gestures and let the listener infer the similarity relation between them (e.g., point to balloon + point to lollipop). This, in fact, is the strategy that the deaf children adopted.

One problem immediately arises, however – we cannot be certain that a child who merely juxtaposes two gestures intends to convey a similarity comparison. Our solution to this problem was to use similarity expressions produced by young hearing children as the standard against which to assess the deaf children's gesture + gesture combinations. Before young hearing children produce the '*x is like y*' construction during the early stages of language-learning (e.g., *lollipop is like a balloon*), they produce similarity comparisons without using the word *like* by juxtaposing a gesture and a word (e.g., *balloon* + point to lollipop, Özçalışkan & Goldin-Meadow, 2006). We used the similarity expressions that hearing children produce with and without *like* as a standard against which to measure the deaf children's gesture + gesture similarity expressions (all of which lacked a term for *like*).

If having an explicit term for comparison (i.e., the word *like*) is not instrumental in expressing both global and focused similarity relations, then we would expect the deaf children to gesture about the same kinds of similarity relations that the hearing children talk about. If, however, having an explicit term for comparison is instrumental in expressing the full range of similarity relations, then the deaf children may not communicate about the same types of similarity relations as the hearing children. We describe here the similarity expressions that deaf children produce in the absence of conventional linguistic input, and compare them to similarity expressions produced by hearing children who are learning English.

2. Methods

2.1. Participants

We examined videotapes of four deaf children (two boys and two girls), referred to here as Abe, David, Marvin

and Kathy, each followed longitudinally, starting at ages 2;3, 2;10, 2;11, and 3;1, respectively. The children came from working class families, all of whom spoke English. All four children were profoundly deaf (>90 dB bilateral hearing loss across the entire speech range), and were being educated in preschools by an oral method of deaf education that advocated early and intense training in sound sensitivity, lip-reading, and speech production. It is very difficult to acquire language via lip-reading, and none of the four children in our sample had made progress in acquiring spoken English at the time of our observations. Moreover, all four children were being raised by hearing parents – who themselves did not know a conventional sign language. Consequently, none of the children had been exposed to sign language, either at home by their parents or in preschool by their teachers.

Nonetheless, all four children developed spontaneous gesture systems to communicate, and these gesture systems were structured in language-like ways (see Goldin-Meadow & Mylander, 1984, for further details on the deaf children's communicative capacities). The deaf children were recorded on videotape, gesturing while they played with their parents, siblings, or the experimenters. These video sessions took place in their homes for 70–130 min at a time, at intervals of approximately 2 months. The deaf children were followed longitudinally for an average of 3 years and 3 months from age 2;3 to age 4;2.

Although the deaf children were not exposed to a conventional sign language, they did see the gestures that hearing speakers routinely produce when they talk. In previous work, we have found that the hearing mothers of the deaf children in our sample did produce gestures as they spoke to their children (Goldin-Meadow & Mylander, 1983, 1984). However, the gestures that the hearing mothers produced were different on many levels from their children's gestures. For example, unlike their children, the mothers tended to produce single gestures rather than gesture strings (i.e., gesture + gesture combinations). Moreover, even when mothers did concatenate their gestures into strings, their strings did not show the same structural regularities as their children's gesture strings. To explore whether the gestures that the hearing mothers produce might have served as a model for the deaf children's expressions of similarities, we applied the coding system developed to analyze the deaf children's gestures to the gestures that the mothers produced when talking to their children.

In addition, we examined videotapes of 40 hearing children (22 girls and 18 boys) followed longitudinally for 2 years, from 1;2 to 2;10.[1] The hearing children were observed in their homes for 90 min every 4 months while interacting with their parents. The parents were told to interact with their children as they normally would and ignore the presence of the experimenter. The hearing children's families were a heterogeneous mix in terms of family income and ethnicity, and were representative of the population distribution in the greater Chicago area. All hearing children were being raised as monolingual English speakers. Data collection involved home visits for both the deaf and hearing children. However, the experimenter often interacted with the deaf children along with or instead of the child's parent; the hearing children interacted only with their parents.

2.2. Transcription and coding

We transcribed all of the children's communicative and intelligible words and gestures. The criterion for coding a gesture or a word as communicative was clear behavioral evidence that the child meant to engage the listener. Sounds that were used reliably to refer to entities, properties, or events (*doggie*, *pretty*, and *gone*), along with onomatopoeic sounds (e.g., *meow* and *choo-choo*) and conventionalized evaluative sounds (e.g., *oopsie* and *uh-oh*), were counted as words. Communicative hand movements that did not involve direct manipulation of objects (e.g., twisting a jar open) or a ritualized game (e.g., patty cake) were counted as gestures. The only exception was when the child held up an object to bring it to the listener's attention; although these movements are direct actions on an object, they serve the same function as pointing gestures and thus were considered gestures. We divided all gesture and speech production into communicative acts. A communicative act was defined as a word or gesture, alone or in combination, preceded and followed by a pause, change in conversational turn, or change in intonational pattern.[2]

We extracted all communicative acts conveying relations between two objects. Our first concern was that not all juxtapositions of two objects necessarily involved similarity relations. Consequently, we began our analyses by dividing communicative acts juxtaposing two objects into those that conveyed *thematic relations* (e.g., *mommy* + point to balloon, meaning mommy is holding the balloon) and those that conveyed *similarity relations* (e.g., *lollipop* + point to balloon, meaning the lollipop is like the balloon) (see Özçalışkan & Goldin-Meadow, 2005, 2009, for more information on thematic relations in the hearing children's speech and gestures, and Goldin-Meadow & Mylander, 1984, for information on thematic relations in the deaf children's gestures). We next classified all instances of similarity relations into three categories based on form: (1) similarity comparison in *gesture-only* (e.g., point to lollipop + point to balloon), (2) similarity comparison in *gesture + speech combinations* without the word *like* (e.g., *lollipop* + point to balloon), and (3) similarity comparison in *speech*, with or without gesture, containing the word *like* (e.g., *balloon is like* a *lollipop*; *like a lollipop* + point to balloon).

[1] The deaf children in our sample were, on average, 1-year older than the hearing children when they entered the study. Our decision to use a younger group of hearing children as a comparative base grew out of work by Morford and Goldin-Meadow (1997) showing a year's delay in the onset of communication about displaced objects and events in the same four deaf children. We guessed that the deaf children might also be delayed in other aspects of their communicative development and therefore chose to observe younger hearing children.

[2] For the deaf children, a *pause* was defined as either a long temporal interruption between two gestures, or relaxation of the hand after a gesture or a series of gestures (see Goldin-Meadow & Mylander, 1984, for details).

Some gesture + gesture and gesture + speech combinations were inherently ambiguous; notably, gestures pointing to two items from the same basic-level category (e.g., point to a toy whale + point to picture of a whale). The child could be pointing out the similarity between the toy whale and the picture of the whale. But he might also be using the picture of the whale to identify the toy whale as a whale, akin to a gesture + speech combination in which a hearing child points at the toy whale and says *whale*. Because of the inherent ambiguity in gesture + speech and gesture + gesture combinations of this type, we decided to be conservative and exclude all combinations in which the two entities in the comparison were from the same basic-level category; for example, *dog* + point to dog toy, a gesture + speech combination; point to toy dog + point to dog picture, a gesture + gesture combination. On average, the deaf children produced $M = 6.12$ (SD = 6.74) gesture + gesture combinations of this type per hour, and the hearing children produced $M = 13.5$ (SD = 8.62) gesture + speech combinations of this type per hour.

We further coded all similarity relations in terms of the category membership of the objects compared: the objects either belonged to the *same* superordinate category or to *different* superordinate categories. In addition, we coded all similarity relations in terms of the degree of feature overlap: the similarity between objects could be based either on a single feature or on multiple features. *Single-feature* comparisons always involved one-dimension of similarity between the two objects, for example, color, shape, size, smell, sound, or action. *Multi-feature* comparisons involved two or more dimensions along which the two objects were compared. Single-feature comparisons involving objects from different superordinate categories highlight the partial overlap of features between two objects and thus require a focus on similarity; we therefore refer to these comparisons as focused similarity comparisons. In contrast, multi-feature comparisons involving objects from the same superordinate category are comments on the overall similarity between two objects; we therefore refer to these comparisons as global similarity comparisons. We also classified the objects described in the similarity relations into types: *people*, *animals*, *body parts*, *vehicles*, *clothing*, *furniture*, *appliances*, *kitchen utensils*, *tools*, *musical instruments*, *food*, *plants*, *activity toys*, and *places* (see examples in Table 1). To assess the gestural model that the deaf children had for the expression of similarity relations, we coded the gestures that the deaf children's hearing mothers produced when talking to their children for the same three distinctions: category membership of the objects being compared (same or different), degree of feature overlap between the objects (single- or multiple-feature), and type of object (people, animals, etc.).

Reliability for gesture coding was assessed on a subset of the videotaped sessions by independent coders. For the hearing children, agreement between coders was 88% for identifying gestures (i.e., presence or absence of a gesture), 91% for assigning meaning glosses to each gesture, and 96% for coding semantic relations (e.g., thematic vs. similarity relation) in multi-word speech and supplementary gesture–speech combinations. For the deaf children and their hearing mothers, agreement ranged between 93% and 97% for identifying gestures, between 93% and

Table 1
Examples of types of comparisons and types of objects that hearing and deaf children used in their similarity expressions.[a,b]

	Hearing children		Deaf children
	Similarity with *like*	Similarity without *like*	Similarity without *like*
Types of comparisons			
Same category	*It is like a dancing one* as child is holding an underskirt [30]	*Cat* + child points at tiger [22]	Child points at train + child points at car [39]
Different category	*You will get bigger like me*; child is talking to a small toy horse [34]	*Ladybug* + child points at drop of syrup on table [30]	Child points at red fruit + child points at red socks [39]
Single feature	*It is brown like my hair*; child is referring to a brown crayon [34]	*Milk* + child points at sour cream [34]	Child points at blue square + child points to blue man [41]
Multiple feature	*They look like strawberries* + child points at toy tomatoes [30]	*Look candy* + child points at balls [26]	Child points at walrus' tusks + child points at his teeth [46]
Types of objects			
Person	*He looks like you*; child is looking at a hulk picture [34]	*Mailman* + child points at policeman [18]	Child points at himself + child points at cowboy [45]
Animal	*Like a lion* + child is looking at a polar bear [30]	*Duck* + child points at penguin [18]	Child points at frog + child points at fish [48]
Food	*Like ice-cream cone* as child holds up a mushroom [26]	*Pizza* + child points at bread [26]	Child points at corn + child points at banana [41]
Vehicle	*That is like a sailboat* as child is looking at a block structure [34]	*Truck* + child points at train [22]	Child points at train + child points at car [50]
Body part	*His tail like a birdie* as child is looking at a squirrel [34]	*They have a penis* + child points at pig's tail [30]	Child points at bird's beak + child points at his own nose [35]
Clothing	*It looks like a skirt* as child holds up an underskirt [30]	*Hat* + child points at helmet [22]	Child points at fireman's helmet + child points at fisherman's hat [44]

[a]Speech is displayed in italics and relevant nonverbal information, including gesture, is displayed in lower case; the age of the child who produced the expression is indicated in brackets in months. We did not code the order in which gesture and speech were produced in a gesture + speech combination; all of these combinations are marked with a '+' with the word arbitrarily listed first and the gesture second.
[b]'Category' refers to superordinate category.
[c]Names for points at toys or pictures representing any of the object kinds are included in their respective categories.

95% for assigning meaning to gestures, and between 94% and 100% for coding semantic relations in gesture–gesture combinations.

3. Results

3.1. Similarity vs. thematic relations in hearing and deaf children's communications about objects

Fig. 1 shows the mean percentage of thematic (black bars) and similarity (white bars) relations observed in the hearing children's multi-word speech and gesture + speech combinations and in the deaf children's gesture + gesture combinations across all the observation sessions.[3] The majority of the communicative acts conveying relations between two objects involved thematic relations (e.g., *mommy* + point to juice) for both the hearing (speech: 91%, gesture + speech: 61%) and deaf (70%) children. Nevertheless, both groups also expressed a substantial percentage of similarity relations (e.g., *cat* + point at lion; point to car + point to truck; 10–30% for the hearing and deaf children.

Thus the deaf children, who were not exposed to a usable language model, were nevertheless able to express similarity relations in their homesigns. Moreover, the percentage of similarity vs. thematic relations expressed was comparable in the deaf and hearing children, $t(41) = 0.34$, $p = 0.73$, $\eta^2 = .003$[4] – in both groups, approximately one-third of the children's early expressions conveying relations between two objects involved similarity comparisons.

We turn next to the types of similarity relations that the children produced. We begin by describing the similarity comparisons that the 40 hearing children expressed in speech using the word *like*. These descriptions will establish the standard against which we can evaluate the deaf children. We then describe the hearing children's similarity comparisons in gesture + speech without the word *like*. Finally, we describe the deaf children's similarity comparisons expressed in gesture + gesture.

3.2. Similarity expressions with the word like in the hearing children

3.2.1. Emergence of similarity relations in hearing children's speech with like

As shown in Fig. 2 (solid lines), only a few hearing children produced similarity relations with the word *like* at 26 ($N = 4$) and 30 ($N = 9$) months. However, by 34 months, more than half of the 40 children were producing similarity expressions in speech with *like*. Across the six observation sessions, 17 of the 40 children never produced similarity relations with the word *like*. Of the 23 children who did express similarity using the word *like*, 18 either maintained or increased their production of this type of comparison over time, compared to five who decreased their production ($p < .01$, two-tailed sign test).[5]

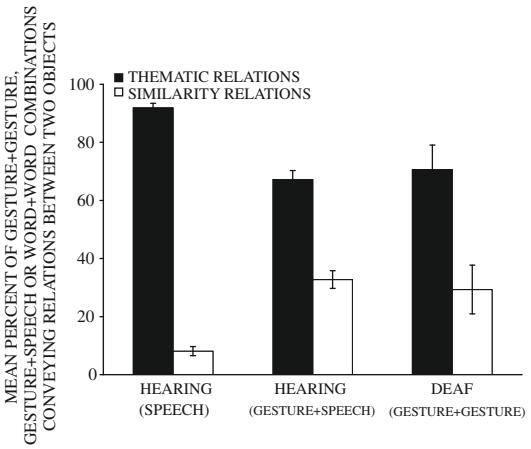

Fig. 1. Mean percentage of thematic (black bars) and similarity (white bars) relations produced by hearing children in speech or gesture + speech combinations and by deaf children in gesture + gesture combinations.

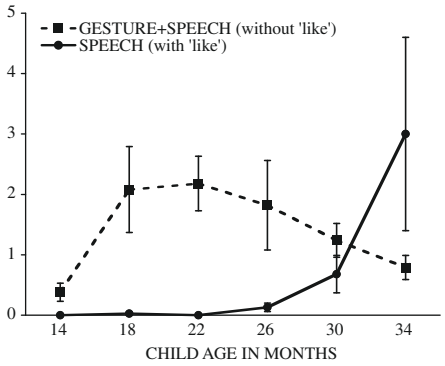

Fig. 2. Mean number of similarity relations hearing children produced per hour of observation at each observation session either in a gesture–speech combination (dotted lines) or in speech with the word 'like' (solid lines).

The number of hearing children who used gesture in their similarity expressions with *like* also increased from 2 at 26 months to 11 at 34 months. The hearing children used these gestures to specify an object of comparison not conveyed in speech (e.g., *like ice-cream cone* + point to mushroom [26 months]) or to clarify an object expressed by a referentially ambiguous proform (e.g., *they look like strawberries* + point to toy tomatoes [30 months]). As these examples suggest, gesture often conveyed the target domain (mushroom and tomatoes) of the comparison,

[3] The hearing children also produced a small number of gesture + speech combinations that appeared to be labeling errors (e.g., *ball* + point to ribbon; *five* + point to number 3). These combinations accounted for 10% of the gesture + speech combinations that the hearing children produced and are not included in Fig. 1.

[4] We examined the skewness of the distribution separately for the deaf and hearing children. The ratio of skewness to standard error of skewness was less than 1.96, indicating no significant skewness in the data. We report only one *t*-value because the data for similarity and thematic relations were reciprocal and thus perfectly correlated.

[5] The word *like* became homophonous at 26 months, functioning not only as a comparison term (e.g., *ice-cream cone is like mushroom*) but also as a verb (e.g., *I like ice-cream*). Beginning at 30 months, a few children used *like* as a discourse marker as well. Here we focus exclusively on the uses of *like* as a comparison term.

rather than the source domain (ice-cream cone and strawberries). Indeed, in their early similarity expressions with *like*, children virtually always conveyed the source in speech, relying on gesture or context to convey the target (Özçalışkan & Goldin-Meadow, 2006). This marked asymmetry between source and target is consistent with the general pattern found in adult speech expressing similarity and metaphor (Bowdle & Gentner, 2005; Gentner, 1983; Gleitman, Gleitman, Miller, & Ostrin, 1996; Ortony, 1979; Tversky, 1977).

3.2.2. Types of similarity relations conveyed by hearing children in speech with like

We turn next to the *types* of similarity comparisons that the children conveyed in similarity expressions containing *like*. We examine the types of similarity comparisons before, at, and after the 30-month observation session, the moment when *like* became frequent in the hearing children's similarity comparisons.

Fig. 3A displays the proportion of similarity comparisons with *like* that the hearing children produced before 30 months, at 30 months, and after 30 months, classified according to whether the objects compared belonged to the *same* or *different* superordinate categories. The majority of similarity comparisons in speech with *like* before 30 months and at 30 months involved objects from the same superordinate category (90% and 67%, respectively). However, after 30 months, we see a shift from same category object comparisons (e.g., cat and tiger) to different category object comparisons (e.g., balloon and lollipop). By 34 months, only 30% of the similarity comparisons the hearing children produced in speech with *like* involved objects that belong to the same superordinate category; 70% involved objects belonging to *different* superordinate categories.

The same pattern emerges if we consider the degree of feature overlap. Fig. 4A displays the proportion of similarity comparisons with *like* that the hearing children produced before 30 months, at 30 months, and after 30 months, classified according to the degree of feature overlap (single feature vs. multiple features). The majority of similarity comparisons in speech with *like* that the hearing children produced before 30 months and at 30 months were based on multiple features (80% and 92%, respectively). Children's comparisons became more targeted after 30 months and by 34 months, only 30% of the comparisons the children produced in speech with *like* were based on multiple features; 70% were based on a single feature (e.g., color, shape or size similarity between two objects).

3.3. Similarity expressions without like in hearing children

3.3.1. Emergence of similarity relations in hearing children's gesture + speech without like

The hearing children did not express similarity by juxtaposing two words without *like* (e.g., *balloon lollipop*) or by juxtaposing two gestures (e.g., point to balloon + point to lollipop). However, they did produce what appeared to be similarity expressions without *like* in their gesture + speech combinations (*balloon* + point to lollipop [26 months]). Can we be sure that combinations of this sort were used to highlight the similarity between two objects (e.g., roundness of balloon and lollipop)? One type of confirmatory evidence comes from the developmental offset of gesture + speech combinations without *like* in relation to the onset of similarity expressions with *like*.

As seen in Fig. 2 (dotted lines), the hearing children produced a small number of gesture + speech combinations without *like* when first observed at 14 months and increased their production of these combinations at 18 months. Interestingly, the number of gesture + speech combinations expressing similarity without *like* remained stable until 30 months when it began to decline – precisely the age at which the children began producing a sizeable number of similarity expressions with *like*. Thus, the children became less likely to produce similarity expressions without *like* at just the point when they were able to produce an explicit comparison marker (i.e., *like*).

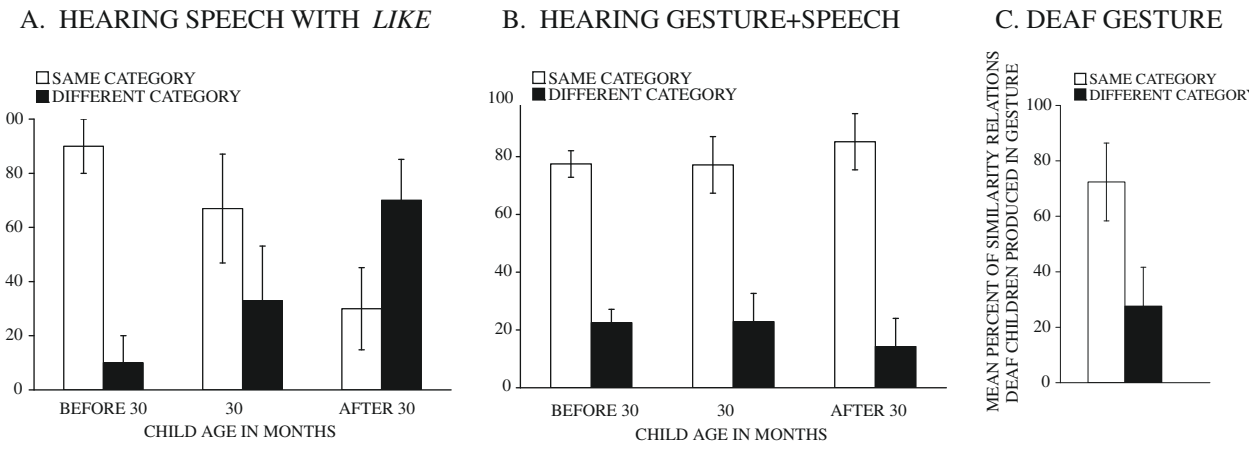

Fig. 3. Similarity relations produced by hearing children in speech with the word 'like' (Panel A) or in gesture + speech without the word 'like' (Panel B) and by deaf children in gesture (Panel C), grouped according to whether the comparison involved objects from different superordinate categories (black bars) or objects from the same superordinate category (white bars). The data are divided into three time points: before, at, after the 30-month observation session, the moment when like became frequent in the hearing children's similarity comparisons. The deaf children were observed between 27 and 50 months of age.

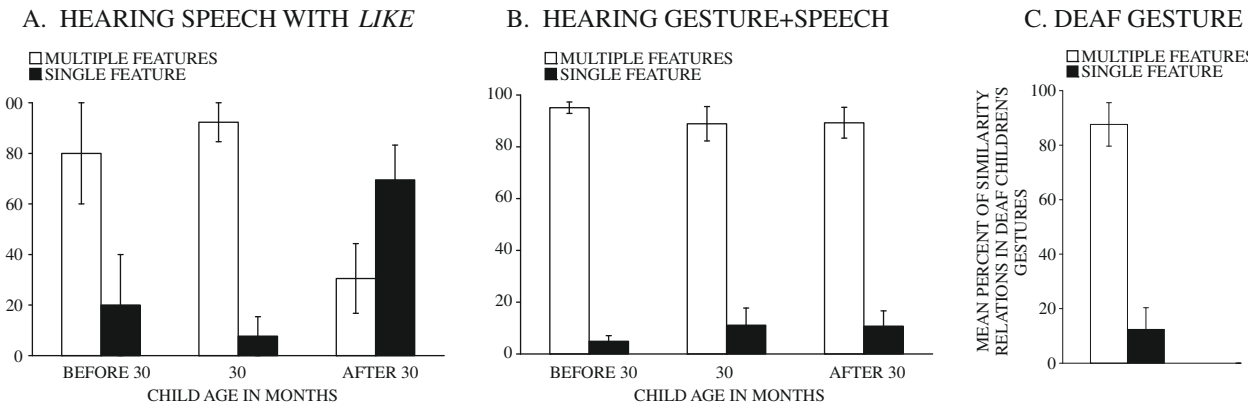

Fig. 4. Similarity relations produced by hearing children in speech with the word 'like' (Panel A) or in gesture + speech without the word 'like' (Panel B) and by deaf children in gesture (Panel C), grouped according to whether the comparison involved a single dimension (black bars) or multiple dimensions (white bars). The data are divided into three time points: before, at, after the 30-month observation session, the moment when like became frequent in the hearing children's similarity comparisons. The deaf children were observed between 27 and 50 months of age.

This pattern was also evident at the individual child level – 20 children produced their first gesture + speech combination expressing similarity without *like* before producing their first similarity expression with *like*; only one child showed the reverse pattern ($p < .001$, two-tailed sign test). On average, these 21 children produced their first similarity expression in gesture + speech without *like* at 20.20 (SD = 5.45) months, significantly earlier than they produced their first similarity expression with *like*, which took place at 30.95 (SD = 3.07) months, $t(20) = 8.57$, $p < .001$, $\eta^2 = .79$. Of the remaining 19 hearing children, 15 produced gesture + speech combinations expressing similarity without *like* during our observation sessions and had not yet produced similarity expressions with *like*; two produced their first similarity expression with and without *like* during the same observation session; and only two had not yet produced similarity comparisons with or without *like* at the time of our last observation.

3.3.2. Types of objects hearing children compare in similarity expressions with and without like

Another line of evidence suggesting that hearing children's similarity expressions without *like* functioned to highlight similarity between objects comes from the fact that the utterances without *like* resembled those with *like* in terms of the kinds of objects compared. Table 2 displays the proportion of objects that hearing children conveyed in their similarity expressions, classified according to type of object. The top row displays the proportion of objects mentioned in the hearing children's similarity expressions in speech with *like*. The second row presents the objects conveyed in the spoken part of the hearing children's gesture + speech combinations without *like*, and the third row presents the objects conveyed in the gestured part of the hearing children's gesture + speech combinations without *like*.

As in similarity expressions with *like*, in similarity expressions without *like*, the *person*, *animal*, *food*, and *body part* categories accounted for approximately 65% of the objects conveyed in speech, and 65% of the objects conveyed in gesture; *activity toys*, *vehicles*, *clothing* and *places* accounted for another 15–25% in speech and in gesture. There was a significant, positive correlation between the different types of objects conveyed in speech in similarity expressions with *like* and in speech in similarity expressions without *like* (rows 1 and 2 in Table 2, Spearman's *rho* = .81, $p < .01$); and between the different types of objects conveyed in speech in similarity expressions with *like* and in gesture in similarity expressions without *like* (rows 1 and 3, Spearman's *rho* = .71, $p < .01$).[6]

The developmental timing of similarity expressions without *like* relative to similarity expressions with *like*, in conjunction with the comparable patterns in types of objects, suggests that the utterances we have been calling similarity expressions without *like* really do express a similarity relation. But perhaps the child is merely trying to label an object for which he does not have a word. For example, the child might point at a small hole and call it a *balloon* because he does not know the word *hole*, and *balloon* is his best substitute. We think this possibility unlikely simply because children did have words for 51% (SD = 26.88) of the objects that they indicated in gesture in their similarity expressions. True errors (where there was no apparent similarity between objects, e.g., *ball* + point at ribbon) were infrequent in the hearing children (10% of all gesture–speech combinations conveying relations between objects; $M = 0.52$ [SD = 0.81]) and the rate of these errors did not systematically increase or decrease over time.[7]

[6] We examined children's percent mention of different kinds of objects separately for similarity expression in speech with *like*, and similarity expressions in gesture + speech without *like* (in speech and in gesture), and found skewed distributions throughout (standard skews ranged between 2.25 and 4.11). We therefore used *Spearman's rho* rather than *Pearson's r* to assess correlations between variables.

[7] Of the 40 children in our sample, 16 never produced errors of this type at any of the six observation sessions; 13 did not show either consistent decreases or increases in their production of these errors; 10 decreased their errors from $M = 0.6$ (SD 1.58) at 14 months to none at 34 months; and one increased her errors from none at 14 months to 1 at 34 months.

Table 2
Proportion of different kinds of entities hearing and deaf children compared in their similarity expressions.

		Person	Animal	Food	Body part	Activity toy	Vehicle	Clothing	Place	Furniture	Appliance	Utensil	Plant	Tool	Music Instrument	Other
Hearing children																
With like	Speech	.27	.19	.15	.04	.17	.02	.01	.05	<.01	.00	.01	<.01	<.01	.00	.08
Without *like*	Speech	.28	.26	.09	.06	.04	.08	.03	.01	.03	.01	.01	.01	.01	.01	.08
Without *like*	Gesture	.27	.25	.08	.05	.02	.08	.04	.02	.03	.01	<.01	.03	.01	.01	.09
Deaf children																
Abe	Gesture	.39	.05	.00	.11	.17	.00	.00	.00	.00	.22	.00	.06	.00	.00	.03
David	Gesture	.21	.10	.03	.42	.06	.06	.06	.00	.01	.00	.00	.01	.01	.02	.01
Marvin	Gesture	.00	.25	.00	.50	.00	.00	.00	.25	.00	.00	.00	.00	.00	.00	.00
Kathy	Gesture	.00	.31	.00	.50	.00	.00	.13	.00	.00	.03	.00	.00	.00	.03	.00
Mean		.15	.18	.01	.38	.06	.02	.05	.06	<.01	.06	.00	.02	<.01	.01	<.01

3.3.3. Types of similarity relations hearing children convey in gesture + speech without like

The findings thus far suggest that children can convey similarity relations between objects across gesture and speech several months before they begin to convey similarity relations explicitly marked with *like*. But are these early similarity comparisons without *like* as sophisticated as the later similarity comparisons with *like*? It is possible that learning the word *like* helps children express similarity relations that they might not have otherwise expressed.

Fig. 3B shows the proportion of similarity comparisons that the hearing children produced in a gesture + speech combination without the word *like* before, at, and after 30 months, classified according to whether the objects compared belonged to either the same or different superordinate categories. At all three age points, the majority of similarity comparisons that the children produced in gesture + speech without *like* involved objects from the same superordinate category (77%, 77%, and 85%, respectively).

The same pattern was true for the degree of feature overlap. Fig. 4B displays the proportion of similarity comparisons without *like* that the hearing children produced in a gesture + speech combination before, at, and after 30 months, classified according to the degree of feature overlap (single feature vs. multiple feature). The majority of similarity comparisons that the children produced in gesture + speech without *like* were based on multiple features at all three of these early time points (95%, 89% and 89%, respectively).

Thus, the types of similarity comparisons the hearing children produced in gesture + speech without *like* resembled the comparisons that they produced in speech with *like* before 30 months: both involved objects from the same superordinate category and were typically comparisons based on multiple features, that is, overall comparisons that express global similarity. With the onset and continued use of the comparison marker *like*, children's comparisons changed; by 34 months, the majority (70%) of their similarity comparisons compared objects that were from different superordinate categories and that shared a single feature – that is, they produced highly focused comparisons. These focused similarity comparisons were extremely rare or nonexistent in the children's gesture + speech combinations without *like* at any time point, suggesting that the routine use of an explicit word for comparison makes it easier for the child to comment on – and perhaps notice – more focused similarity comparisons.

3.4. Similarity expressions without like in deaf children

Having discovered that hearing children convey similarity relations without *like*, we are now ready to examine the similarity expressions that the deaf children produced, none of which contained a gesture for *like*.

3.4.1. Emergence of similarity relations in deaf children's gesture + gesture combinations

All four deaf children produced similarity comparisons in their gesture + gesture combinations, but, for at least two of the deaf children, similarity comparisons were

Table 3
Mean number of similarity relations in children's early communications.

		Mean per hour	Range
Hearing children			
With like	Speech	3.31 (SD = 8.24)	0–6.78
Without like	Gesture + speech	1.35 (SD = 1.27)	0–5.11
Deaf children			
Abe	Gesture + gesture	0.84	
David	Gesture + gesture	6.11	
Marvin	Gesture + gesture	0.94	
Kathy	Gesture + gesture	1.49	
Mean		2.35 (SD = 2.53)	0.84–6.11

delayed compared to hearing children.[8] Abe produced his first similarity comparison at 34 months and Marvin at 50 months (recall that the average onset of similarity expressions for hearing children was 21 months). David and Kathy produced similarity expressions during their first observation sessions at 34 months and 37 months, respectively; we therefore cannot pinpoint age of onset for these two children.

Table 3 presents the number of similarity expressions without *like* that each deaf child produced per hour (beginning when the child first produced similarity expressions). For comparison, the table also presents the mean number of similarity expressions with and without *like* that hearing children produced per hour (beginning when the child first produced similarity expressions). The numbers of similarity expressions that the deaf children produced clearly fall within the range for the hearing children. Note also that hearing and deaf children both exhibited wide individual variability in their overall production of similarity comparisons.

3.4.2. Types of objects deaf children compare in similarity expressions without like

Do the deaf children's similarity expressions resemble hearing children's similarity expressions in terms of the types of objects being compared? The short answer is *yes*. Table 2 presents the data (bottom rows in each table display individual data for the deaf children; last row displays the mean for all four). The deaf children as a group produced at least a few similarity expressions of each object type. As in the hearing children's similarity expressions, *person*, *animal*, *food* and *body parts* accounted for 72% of the objects that the deaf children compared; *activity toys*, *vehicles*, *clothing*, and *places* accounted for another 19%. The biggest difference between groups was that the deaf children tended to highlight similarities between *body parts* whereas the hearing children highlighted similarities most commonly between *people* and *animals*. Nonetheless, there were significant correlations between the different types of objects that the deaf children conveyed in their gestures and those that the hearing children conveyed (1) in gesture in gesture + speech combinations without *like* (rows 8 and 3 in Table 2, Spearman's *rho* = .40, $p < .01$), (2) in speech in gesture + speech combinations without *like* (rows 8 and 2, Spearman's *rho* = .37, $p < .01$) and (3) in speech combinations with *like* (rows 8 and 1, Spearman's *rho* = .44, $p < .01$).

3.4.3. Types of similarity relations deaf children convey in gesture + gesture without like

Taken together, these findings show that the deaf children not only produced comparisons at rates comparable to hearing children, but also expressed similarity relations between comparable sets of objects. However, unlike hearing children, the deaf children did not have access to an explicit word for comparison – namely, a gesture for *like*. If learning and using *like* is instrumental in expressing focused similarity relations, then the deaf children ought not produce single-feature comparisons between objects from different categories, that is, the focused similarity comparisons found in the hearing children's combinations with *like*. They should instead produce only the multiple-feature comparisons between objects from the same superordinate category, that is, the global and relatively simple similarity comparisons found in the hearing children's gesture + speech combinations without *like*. If, on the other hand, access to an explicit word for comparison is *not* instrumental in producing the more focused similarity relations, then the deaf children should be able to produce the full range of similarity comparisons found in the hearing children (i.e., including focused comparisons between objects that are from different categories and that share only one feature found in the hearing children's repertoires after 30 months).

Fig. 3C shows the proportion of similarity comparisons that the deaf children produced in gesture across all observations sessions, classified according to whether the objects compared belonged to the same or different superordinate categories. Over 70% of the similarity comparisons involved objects from the same superordinate category and thus were comparable to the similarity comparisons produced by hearing children before 30 months, the age at which many of the children began to learn the word *like* (cf., Fig. 3A and B).

Turning next to the degree of feature overlap, we see a similar pattern. Fig. 4C displays the proportion of similarity comparisons that the deaf children produced in gesture + gesture across the observation sessions, classified according to the degree of feature overlap (single feature vs. multiple features). Comparisons based on multiple features accounted for 88% of the similarity comparisons that the deaf children produced. Comparisons based on a single feature were quite rare; indeed only two of the four deaf children (Abe and David) produced 16 instances of these targeted comparisons, and color was always the dimension on which the comparison was based (e.g., point at red flower + point at red truck). Again, this pattern resembles similarity comparisons produced by hearing children before 30 months, the age at which many of the children learned the word *like* (cf., Figs. 4A and B). Thus, even though the deaf children were able to convey similarity relations in their spontaneous gestures, the majority of

[8] A similar delay of about a year has been reported for the onset of displaced reference (i.e., information that is spatially and temporally displaced from the location of speaker and listener) in these deaf children's homesign systems, compared to the onset of displaced reference in hearing children's speech (Morford & Goldin-Meadow, 1997).

their comparisons were limited in scope, involving objects that were from the same superordinate category and that shared multiple features.

These findings are particularly interesting because the hearing parents of the deaf children *did* produce instances of focused similarity comparisons in the spontaneous gestures that they produced while interacting with their children. Many of the comparisons that the hearing parents produced in gesture highlighted similarities between objects from different superordinate categories and were based on a single feature (typically the color of the objects). Across all observation sessions, David's mother produced a total of 15 gesture + gesture combinations conveying similarity; more than half of these comparisons were based on a single feature (i.e., color) and 75% involved objects that belong to different superordinate categories (e.g., point to brown rug + point to brown cookie). Abe's and Marvin's mothers each produced six similarity comparisons in their gesture + gesture combinations, and 50% of their comparisons involved objects from different categories and were based on a single feature (the color of the objects). Kelly's mother was the exception; she produced no similarity comparisons at all in her gestures.[9]

Thus, three of the four deaf children received adult models for focused similarity comparisons. Yet in spite of this input, only two of the three children expressed this type of comparison, and the frequency with which they did so was markedly lower than the frequency with which the hearing children produced focused similarity comparisons after they learned the word *like*. Thus, although not having a term for *like* does not preclude expressing focused similarity comparisons, it does seem to dramatically decrease their frequency.

4. Discussion

Similarity plays a key role in conceptual development, as it constitutes the child's first step in aligning two different representations within a unified frame (Gentner & Namy, 1999; Gentner & Rattermann, 1991). As such, the expression of relations between objects based on commonalities in their features (e.g., *an orange is round like the sun*) stands out as an important linguistic achievement – one that is likely to serve as the stepping-stone for the development of categorization (Landau, Smith, & Jones, 1988; Smith, 1983) and more complex metaphorical and analogical abilities (Gentner, 1988, 2003). Prior work (Gentner & Christie, 2008; Loewenstein & Gentner, 2005) has suggested a facilitating effect for language in learning to attend to relational commonalities between objects.

In this paper, we investigated whether language has an effect on children's early similarity comparisons. A language model such as English offers children the lexical item, *like*, that can be used to mark an utterance as a similarity expression. Our findings suggest that this lexical item is not necessary for children to express similarity relationships – deaf children who are not exposed to usable linguistic input can produce similarity comparisons in their gesture sentences at rates comparable to those of hearing children exposed to spoken English.

However, having an explicit term for similarity may influence which *types* of similarities children express. In our findings, the *kinds* of similarity comparisons that the deaf children routinely produce are more limited in scope than the similarity comparisons produced by hearing children after learning the word *like*. In fact, the similarity comparisons that the deaf children produced in their gesture + gesture combinations showed striking parallels to the early similarity comparisons that the hearing children produced in their gesture + speech combinations without the word *like*: both involved comparisons between the same types of objects (e.g., animals, people, food, and body parts) and occurred at comparable rates. Moreover, consistent with earlier work (Gentner & Rattermann, 1991; Kemler, 1982; Smith, 1983), these early similarity comparisons were holistic and global, most often highlighting strong overall similarity between objects that belong to the same superordinate category (point to cat + point to tiger; *cat* + point to tiger).

However, the hearing children went on to learn the word *like* and incorporated it into their similarity expressions. At that point, the children's similarity expressions became more subtle. After 30 months, a majority (70%) of the hearing children's similarity comparisons were between objects that belonged to different superordinate categories and that focused on a single dimension (*brown crayon is brown like my hair*). Although the deaf children did produce instances of this more focused similarity comparison (that is, they compared objects that were from different categories and that shared only one feature in their gestures), only two of the four deaf children produced this type of comparison and they did so infrequently. Our data thus suggest that having a word such as *like*, which explicitly marks similarity, may make it easier for children to routinely produce similarity comparisons involving objects that share only a single feature.

In contrast to the deaf children who were creating a language with their hands to convey similarities, the hearing children were learning to convey similarity expressions from a language model provided by their caregivers. Nonetheless, they too produced gestures and those gestures seemed to serve as the supporting context for the children's early '*x is like y*' constructions. The hearing children initially expressed one term of a similarity comparison in speech and used gesture to convey the other term (e.g., *like a sheep* + point to cow). Even when children expressed both domains in speech, they often used ambiguous language, relying on gesture to clarify the referent (e.g., *this like earl grey* + point to coffee). Thus, in the early stages of language-learning, hearing children convey the skeletal structure of the '*x is like y*' construction in speech and use gesture to flesh out the skeleton.

Using gesture to flesh out linguistic constructions is not unique to early similarity comparisons. Recruiting gesture

[9] The deaf children in our study typically directed their attention to the hand movements of their communication partners, as do hearing children of language-learning age (Yoshida & Smith, 2008). As a result, the deaf children rarely attended to their parents' lip movements unless explicitly instructed to do so (which did not happen often); the parents' spontaneous gestures were therefore the most likely source of input for the deaf children's gestures.

to clarify ambiguous speech has also been observed in early constructions involving thematic relations (Goldin-Meadow & Butcher, 2003; Iverson & Goldin-Meadow, 2005; Özçalışkan & Goldin-Meadow, 2005, 2009) and later metaphorical mappings (Özçalışkan, 2007). For example, when 3- to 4-year-old children are questioned about metaphorical mappings (e.g., *How do ideas pass through the mind?*), they produce referentially ambiguous constructions in speech and use gesture to clarify the domain of comparison (e.g., *like this* + child jumps up and down to indicate ideas bouncing in the mind). By age 5;0, children's verbal explanations are more elaborate, but they still involve gesture, although the gestures are now semantically integrated into the response (e.g., *Time drips by means it goes really slowly like that* + child moves finger downward in small pauses like dripping water; Özçalışkan, 2005, 2007). Thus, gesture previews the child's next step into a more complete linguistic construction in these later metaphorical mappings, just as it did in the early similarity expressions produced by the hearing children in our study.

Nonetheless, as noted earlier, the facilitating effect of gesture seems to be limited – the more focused comparisons highlighting similarities across objects that share a single feature became dominant in the hearing children's speech only after they acquired the word *like*. Moreover, only two of the four deaf children in our study produced these more focused comparisons in their gestures, and the number of times they did so was small and the scope limited (typically involving only color). Thus, although having an explicit term for comparison is clearly not necessary for children to express similarity comparisons, it does seem to affect the rate at which certain types of similarity comparisons (comparisons between objects that are from different categories and share only a single feature) are expressed.

The current findings do not tell us about which similarities children notice – only which ones they choose to express. It is possible that not having a word such as *like* simply makes it harder to *communicate* about the more subtle types of similarity. But we suggest that even if the difference between children with and without an explicit term for similarity initially involves only how often they express focused similarity comparisons in their communications, eventually this difference in routine communication could come to influence how likely the children are to notice such similarities and use them in reasoning tasks. Lacking an easy way to convey nonobvious comparisons and to initiate conversation concerning such focused similarities, deaf children may not dwell on them as much in their own thoughts as hearing children do.

Evidence in support of this possibility comes from the finding that having an explicit same–different marker facilitates children's attention to, and ability to reason about, relational commonalities between objects (Gentner & Christie, 2008; Gentner, 2003). For example, 3- to 5-year-old human children (Gentner & Christie, 2008; Gentner & Rattermann, 1991; Loewenstein & Gentner, 2005), as well as symbol-trained nonhuman primates (Premack, 1971; Thompson, Oden, & Boysen, 1997), solve tasks that involve noticing relational commonalities among objects more easily when given relational symbols than when not given these symbols. Thus, it is possible that having an explicit term for comparison might affect the ease with which matches based purely on similar relational structure might be made.

Given the observational nature of our data, we cannot attribute a causal role to language – in particular, to having an explicit term for comparison – in fostering children's similarity comparisons. But our findings are suggestive and highlight the need for future work that manipulates children's language for comparison and explores the effect of this manipulation on the similarity comparisons children express and use in reasoning tasks.

In addition to fostering similarity comparisons based on a single feature, having an explicit term for comparison may have long-term benefits. Even at 34 months of age, the hearing children's '*x is like y*' constructions were restricted to similarity comparisons based on shared perceptual features rather than comparisons based on analogy or metaphor (e.g., a stem is a straw for flowers), providing support for the hypothesis that featural similarity comparisons precede and perhaps are precursors to more abstract mapping abilities (Gentner, 19880, 2003). Will children who produce similarity comparisons using the word *like* at an early age be among the first to produce analogies or metaphors later on, thus providing support for the idea that similarity comparison bootstraps children into more abstract cognitive abilities? If so, then it is an open question as to whether the deaf children will ever be able to produce these more abstract types of similarity relations in their homemade gesture systems, unless they somehow can import or invent an explicit term for similarity.

In sum, children find the overall similarity between objects sufficiently noteworthy to express it in their spontaneous communications. If children are not exposed to a usable conventional language model, they express similarity relations using gesture, the only communicative vehicle available to them. Even if children are exposed to a conventional language, they manage to express similarity relations before they have acquired the linguistic tools to do so (i.e., before acquiring the word *like*) and they do it by integrating gesture into their utterances. These early similarity expressions without *like* precede and set the stage for similarity expressions with *like*. Perceiving and talking about similarity thus appears to be a robust aspect of early human cognition and communication. However, it is only after the acquisition of the word *like* that children routinely produce single-feature comparisons between objects from different superordinate categories, suggesting that conventional terms for comparison may make it easier for children to routinely express the full range of similarity comparisons. Language about similarity can thus play a role in how often children comment on, and perhaps notice, more abstract types of similarity.

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