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Article *in* Journal of Nonverbal Behavior · June 2000

DOI: 10.1023/A:1006657929803

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THE ROLE OF GESTURE IN CHILDREN'S COMPREHENSION OF SPOKEN LANGUAGE: NOW THEY NEED IT, NOW THEY DON'T

Nicole M. McNeil, Martha W. Alibali, and Julia L. Evans

ABSTRACT: Two experiments investigated gesture as a form of external support for spoken language comprehension. In both experiments, children selected blocks according to a set of videotaped instructions. Across trials, the instructions were given using no gesture, gestures that reinforced speech, and gestures that conflicted with speech. Experiment 1 used spoken messages that were complex for preschool children but not for kindergarten children. Reinforcing gestures facilitated speech comprehension for preschool children but not for kindergarten children, and conflicting gestures hindered comprehension for kindergarten children but not for preschool children. Experiment 2 tested preschool children with simpler spoken messages. Unlike Experiment 1, preschool children's comprehension was not facilitated by reinforcing gestures. However, children's comprehension also was not hindered by conflicting gestures. Thus, the effects of gesture on speech comprehension depend both on the relation of gesture to speech, and on the complexity of the spoken message.

What is the role of gesture in the comprehension of spoken language? Previous research has yielded mixed results in answer to this question. Some studies have reported that gestures facilitate comprehension (e.g., Tfouni & Klatzky, 1983), whereas other studies have reported null effects (e.g., Lickiss & Wellens, 1978). Still other studies have reported that gesture hinders comprehension, at least under some circumstances (e.g., Kelly &

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This work was supported by an NIMH Undergraduate Research Fellowship and by a Small Undergraduate Research Grant from Carnegie Mellon University to Nicole M. McNeil. We are grateful to John Pavlik for constructing the experimental stimuli and to Bethany Rittle-Johnson, Petrit Alibali, and the anonymous reviewers for comments on previous versions of the manuscript.

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Church, 1998). In this paper, we attempt to reconcile these contradictory findings by arguing that the influence of gesture on speech comprehension depends on several factors. We focus here on two such factors: (1) the relationship between the information expressed in gesture and that expressed in the accompanying speech and (2) the complexity of the spoken message.

Note that our goal is not to examine comprehension of gestures produced in the *absence* of speech, such as pantomimes (O'Reilly, 1995) or emblems (socially codified gestures such as the "OK" sign, Boyatzis & Satyaprasad, 1994; Hoots, McAndrew, & Francois, 1989). Instead, we aim to address whether or not the gestures produced *along with* speech contribute to the comprehension of spoken language. Consequently, our experiments involve the kinds of gestures that speakers routinely produce along with speech, namely, representational gestures that depict meanings by virtue of their handshape, placement or motion. Our analyses examine whether such gestures facilitate or hinder comprehension of spoken language relative to a condition in which spoken language is presented without any gesture.

We propose that the ability to comprehend spoken language is not a fixed attribute of an individual at a particular point in time. Instead, like skills in other cognitive and motor domains (e.g., Fischer & Bidell, 1998; Muschisky, Gershkoff-Stowe, Cole, & Thelen, 1996; Thelen, 1989; Thelen & Smith, 1994; Vygotsky, 1978), skill at comprehending spoken language may be a dynamic construct that varies both with task demands, and with the amount of external or environmental support available. In this paper, we argue that gestures are one form of external support that may influence comprehension, and we hypothesize that the role of gesture in comprehension should vary depending on the demands of the task. We test these claims in two experiments with young children. We have chosen to study preschool and kindergarten children because at this early point in development, there may be wide variation between children's ability to comprehend spoken language on its own and their ability to comprehend spoken language with external support. Thus, children in this age range provide us with an opportunity to examine how comprehension varies as a function of task demands and amount of external support. We investigate the role of gesture as a form of external support for spoken language comprehension both by comparing children's comprehension with varying types of gestural support, and by assessing whether the effects of gesture depend on the complexity of the spoken message.

When gestures accompany a spoken message, they often *reinforce* the accompanying speech, in the sense that they convey the same semantic

content as speech. We predict that such reinforcing gestures will facilitate children's spoken language comprehension because they provide external support, in the form of a redundant message, for the meanings expressed in speech. This external support should enable children to comprehend speech at a higher level of complexity than they are able to comprehend without such gestures. Thus, we argue that gestures can serve as a "scaffold" for children's comprehension of spoken language (see Vygotsky, 1978; Wood, Bruner, & Ross, 1976). We hypothesize that reinforcing gestures are an effective scaffold for speech comprehension because they guide comprehension toward the semantic content of the spoken message.

The literature provides some evidence for the idea that reinforcing gestures scaffold young children's speech comprehension. Several studies have shown that pointing gestures facilitate children's comprehension of the concurrent speech. For example, in a case study by Clark, Hutcheson, and van Buren (1974), a child failed to respond to the sentence, "It's up there," when the sentence was produced without gesture. However, when a small upward point accompanied the sentence, the child responded quickly. Similarly, Morford and Goldin-Meadow (1992) showed that for one-word speakers (ages 15 to 29 months), pointing gestures facilitated children's comprehension of simple spoken sentences such as, "Give the clock." In a slightly older sample (ages 35 to 50 months), Tfouni and Klatzky (1983) found that pointing gestures produced along with deictic terms (e.g., "this") facilitated comprehension of utterances that included the deictic terms.

The benefits of reinforcing gestures also extend beyond points. For example, Allen and Shatz (1983) found that young children were more likely to respond to "what" questions (e.g., "What says 'meow'?") when they were accompanied by a "showing" gesture (e.g., holding up a toy cat) than when they were not accompanied by such a gesture. Volkmar and Siegel (1982) reported that toddlers were more likely to respond to the spoken directive, "Come here," when it was accompanied by a representational beckoning gesture than when it was not accompanied by such a gesture. Finally, Hodapp, Goldfield, and Boyatzis (1984) found that infants playing a "roll-the-ball" game with their mothers were more likely to return the ball when their mothers held out their hands than when their mothers did not hold out their hands. Thus, the available evidence suggests that reinforcing gestures provide external support that scaffolds young children's comprehension.

We hypothesize that the influence of reinforcing gestures varies as a function of the complexity of the spoken message, which in turn depends on the listener's skill level. Research with adults is consistent with this

view. Under ordinary circumstances, adults can understand spoken language without external support, and indeed, several studies have shown that gestures play little role in speech comprehension for adults (e.g., Krauss, Dushay, Chen, & Rauscher, 1995; Krauss, Morrel-Samuels, & Colasante, 1991; Lickiss & Wellens, 1978). However, under some circumstances, gestures do contribute to comprehension for adult listeners, such as when the spoken message is degraded (Riseborough, 1981; Rogers, 1978), ambiguous (Thompson & Massaro, 1986), highly complex (Graham & Heywood, 1976), or uttered in a soft voice (Berger & Popelka, 1971). Based on these findings, we hypothesize that the role of reinforcing gestures as a scaffold for speech comprehension depends on characteristics of the spoken message. In particular, we propose that when the spoken message is simple, reinforcing gestures should not contribute to comprehension, whereas when the spoken message is complex, reinforcing gestures should facilitate speech comprehension.

Although many gestures reinforce the accompanying speech, other gestures do not. Indeed, as several investigators have reported, gestures sometimes *conflict* with spoken language by conveying different or additional information (e.g., Church & Goldin-Meadow, 1986). We suggest that conflicting gestures may hinder speech comprehension because they direct comprehension *away from* the meaning of the spoken message and toward other meanings (specifically, those meanings conveyed in the gestures). Intuitively, one might expect such conflicting gestures to hinder comprehension. When other modalities convey different information from speech, attention may be divided across modalities, and comprehension of speech may suffer. In support of this idea, Macnamara (1977) showed that when 17-month-old infants were presented with messages in speech alone such as "Show me the shoe," they were often able to select the correct object from an array of two objects (e.g., a shoe and a cup). However, when the same verbal message was combined with a conflicting gesture (e.g., an offering gesture in which the *cup* was extended toward the child), speech-based responses were much less common, and instead, infants responded based on gesture.

In contrast to Macnamara's findings, two developmental studies have suggested that when the task is held constant, conflicting gestures hinder comprehension for older, but not younger, participants. Kelly and Church (1998) compared 10-year-old and adult participants' decoding of spoken utterances in which gesture conveyed different information from speech (e.g., "This cup is tall," with a gesture indicating the *width* of the cup). Adults' comprehension of the spoken messages was negatively affected by

the conflicting gestures, but 10-year-olds' comprehension was not (Kelly & Church, 1998). A similar pattern of findings was reported by Thompson and Massaro (1994) in a study of preschool and fourth-grade participants in a referential communication task. On trials in which gesture conflicted with speech, fourth-grade students tended to focus on information conveyed in both speech and gesture, whereas preschool children tended to focus only on speech.

By definition, conflicting gestures convey information that is different from that conveyed in speech. As suggested above, instead of supporting speech comprehension, conflicting gestures may hinder it. But why might conflicting gestures hinder comprehension for older but not younger participants on the same task? We suggest that, as for reinforcing gestures, the influence of conflicting gestures may depend on the complexity of the spoken message. For simple spoken messages, the processing demands of the speech fall well within listeners' capacity, so listeners may distribute their attentional resources across modalities. However, if listeners are unable to process both modalities successfully, comprehension of speech may suffer (e.g., the adults in Kelly & Church, 1998). In contrast, when spoken messages are complex, the processing demands of the message may tax, or even exceed, listeners' capacity. In such cases, listeners may not distribute their attentional resources across both modalities, but may instead focus on only one modality. In essence, listeners may "simplify" the task of comprehension by attending to only one modality.

This framework can account for the findings reported by Macnamara (1977) with infants, as well as those reported by Kelly and Church (1998) and Thompson and Massaro (1994) with older participants. Infants rely heavily on context in comprehending spoken language (Chapman, 1978), so it is not surprising that they focus on gesture at the expense of speech (e.g., Macnamara, 1977). Later in development, children develop lexical and syntactic strategies for comprehending speech, and they rely less exclusively on context (Chapman, 1978; van der Lely & Dewart, 1986). Hence, when older children or adults zero in on a single modality, that modality tends to be speech (Kelly & Church, 1998, see also Volkmar & Siegel, 1982; Thompson & Massaro, 1994).

Thus, we hypothesize that the role of conflicting gestures in speech comprehension depends on the complexity of the spoken message. When spoken messages are simple, listeners may distribute their attention across modalities, and some resources may be expended to process the additional information expressed in gestures. In such cases, conflicting gestures may hinder speech comprehension. When spoken messages are complex, lis-

teners may not attempt to distribute their attention across modalities, and may instead focus only on speech. In such cases, conflicting gestures should not influence comprehension.

Up to this point, we have outlined a framework for considering the role of gesture in children's comprehension of spoken language. This framework yields specific predictions about the roles of reinforcing and conflicting gestures in young children's speech comprehension. Consider two groups of children, a younger group and an older group, who are presented with the same spoken message. Suppose that the spoken message alone (i.e., without gestures) is not complex for the older children, but that it is for the younger children. For younger children, reinforcing gestures should facilitate comprehension, and conflicting gestures should not influence comprehension. Conversely, for older children, reinforcing gestures should not influence comprehension, but conflicting gestures should hinder comprehension.

Now suppose that children of a single age group are presented with two different spoken messages, a less complex one and a more complex one. Suppose further that these children are able to comprehend the less complex message, but not the more complex message, when it is presented alone (i.e., without gestures). We hypothesize that, for the more complex message, reinforcing gestures should facilitate comprehension, and conflicting gestures should not influence comprehension. Conversely, for the less complex message, reinforcing gestures should not influence comprehension, and conflicting gestures should hinder comprehension.

We tested these hypotheses in two experiments with preschool and kindergarten participants, using a modified version of a referential communication task (Krauss & Glucksberg, 1969). Previous studies have shown that children in this age range can perform successfully on such tasks. Further, we could readily construct verbal messages that at least some children in this age range could not successfully comprehend without external support. In both experiments, we examined whether children's spoken language comprehension varied as a function of the complexity of the spoken message, and the relation of the gesture to the accompanying speech.

Experiment 1

In Experiment 1, we examined how gesture influences the spoken language comprehension of preschool and kindergarten children. We were specifically interested in whether the role of gesture in comprehension varies as a function of the complexity of the spoken message. Thus, in the experiment

we used spoken messages that we expected to be complex for preschool children but not for kindergarten children (specifically, sentences that included a compound relative clause). Based on the framework outlined by Chapman (1978), preschool children were expected to rely on context-based comprehension strategies and kindergarten children were expected to rely on lexical and syntactic comprehension strategies. Thus, we predicted that reinforcing gestures would aid comprehension of spoken messages for the preschool children but not the kindergarten children.

Further, we hypothesized that, when gestures conflicted with speech and thus added additional information to the spoken messages, preschool children would be unable to simultaneously attend to both speech and gesture, because of the resource demands of processing the complex spoken messages. Thus, we predicted that preschool children's comprehension of speech with conflicting gestures would be comparable to their comprehension of speech presented without gesture (and of course, poorer than their comprehension of speech with reinforcing gestures). In contrast, we predicted that kindergarten children, for whom the spoken messages were less complex, might attempt to distribute their attention across speech and gesture, but without perfect success. Hence, we predicted that kindergarten children's comprehension of speech with conflicting gestures would be poorer than their comprehension of speech presented without gesture.

Method

Participants. Seventeen preschool children and 15 kindergarten children from a university laboratory school were screened for participation. Twenty-six of the children were tested during the regular school year, and six during a day camp held at the school in June. The preschool children ranged from 46 to 57 months ($M = 51$ months), and the kindergarten children ranged in age from 59 to 72 months ($M = 64$ months). One kindergarten child was excluded from the sample because she had difficulty paying attention to the experimental tasks, and two preschool children were excluded because they did not demonstrate understanding of "above" and "below" on the experiment pretest (see below). Thus, the final sample consisted of 15 preschool children (9 girls, 6 boys) and 14 kindergarten children (7 girls, 7 boys). All were monolingual English speakers.

Procedure. Children were individually tested in a laboratory setting by a female experimenter. Children were seated at a small table directly across from the experimenter for the entire experiment.

Children first completed a pretest of their understanding of the words

"above," "below," "up" and "down." Children were presented with a card with three smile faces on it, one with a rectangle above it, one with a rectangle below it, and one with a rectangle beside it. Children were asked to indicate the rectangle that was *above* a smile face and the rectangle that was *below* a smile face. Next, children were presented with a card with three arrows, one pointing up, one pointing down and one pointing sideways. Children were asked to indicate the arrow pointing *up* and the arrow pointing *down*.

Following the pretest, children played a communication game based on the referential communication task developed by Krauss and Glucksberg (1969). In the game, children were asked to select certain blocks from among a set of blocks, according to instructions given by a speaker on a video. In the first part of the game, children were asked to select blocks with particular animals on them from among a set of blocks with various animal designs. For each block, the speaker gave an instruction such as, "Find the block that has a picture of a pig." Children chose from among four possible animal blocks, and they stacked their choice on a post. The animal block trials were used to ensure that children understood the game. Children stacked a total of three animal blocks.

In the second part of the game, children chose blocks with particular features, according to instructions given by the speaker on the video. On one face of each block there were three stickers: a smile face, a rectangle, and an arrow. The smile face was positioned in the center of the block, with the rectangle either above it or below it. The arrow was positioned to the right of the smile face, and pointed either up or down. Thus, there were four different types of blocks (rectangle above + arrow up, rectangle above + arrow down, rectangle below + arrow up, rectangle below + arrow down).

Children selected and stacked a total of six blocks according to the instructions given by the speaker on the video. For each block, the speaker gave an instruction such as, "Find the block that has an arrow pointing up, and a smile face with a rectangle above it." The speaker used a neutral facial expression for all trials. After the instruction, children chose from among the four possible blocks and placed their chosen block on the post. The experimenter then replaced the chosen block with an identical new block in the choice array.

On each trial, the speaker used one of three types of gesture: *reinforcing gesture* (e.g., saying "up" and "above" while producing gestures depicting "up" and "above"), *no gesture* (e.g., saying "up" and "above" with no accompanying gesture), or *conflicting gesture* (e.g., saying "up" and "above" while producing gestures depicting "down" and "below"). A sam-

ple script including both speech and gestures for each condition is presented in the appendix. Each child completed two trials in which the arrow and rectangle were described with reinforcing gestures, two trials in which they were described with no gestures, and two trials in which they were described with conflicting gestures. Trial order was randomized across children.

Results and Discussion

Children's block choices were compared against the speaker's spoken instructions, and choices consistent with her *speech* were considered to reveal accurate comprehension of that spoken message. Because each trial included two pieces of information in the spoken message (rectangle position and arrow direction), children received a score of 0 to 2 for each trial. Because there were two trials for each gesture type, children could receive a total score of 0 to 4 for each gesture type. Note that this score reflects children's accuracy at comprehending the *spoken* messages.

As stated earlier, we designed the spoken messages to be complex for preschool children, but not for kindergarten children. Thus, we first examined whether the two groups of children differed in their ability to comprehend the spoken messages when they were presented on their own, without any gestures. As expected, the kindergarten children were better than the preschoolers at comprehending the spoken messages in the speech-alone condition, $t(27) = 3.70$, $p < .01$. Thus, for the preschool children, the messages were sufficiently complex that they were not easily comprehended in the absence of external support.

We hypothesized that, for children in the younger group, reinforcing gestures should facilitate speech comprehension, and conflicting gestures should not influence speech comprehension. Conversely, for children in the older group, reinforcing gestures should not influence speech comprehension, and conflicting gestures should hinder speech comprehension. To test these hypotheses, we compared the effects of gesture type on speech comprehension for preschool children and kindergarten children. As predicted, there was a statistically significant interaction between group (preschool or kindergarten) and gesture type (none, reinforcing, conflicting), $F(2, 54) = 4.21$, $p = .02$ (see Figure 1). Preschool children made choices consistent with speech more often when the speaker used reinforcing gesture than when she used no gesture, $M = 3.80$ vs. 2.87; $F(1, 54) = 17.79$, $p < .0001$; 11 of the 15 preschool children showed this pattern. In contrast, kindergarten children made choices consistent with speech almost

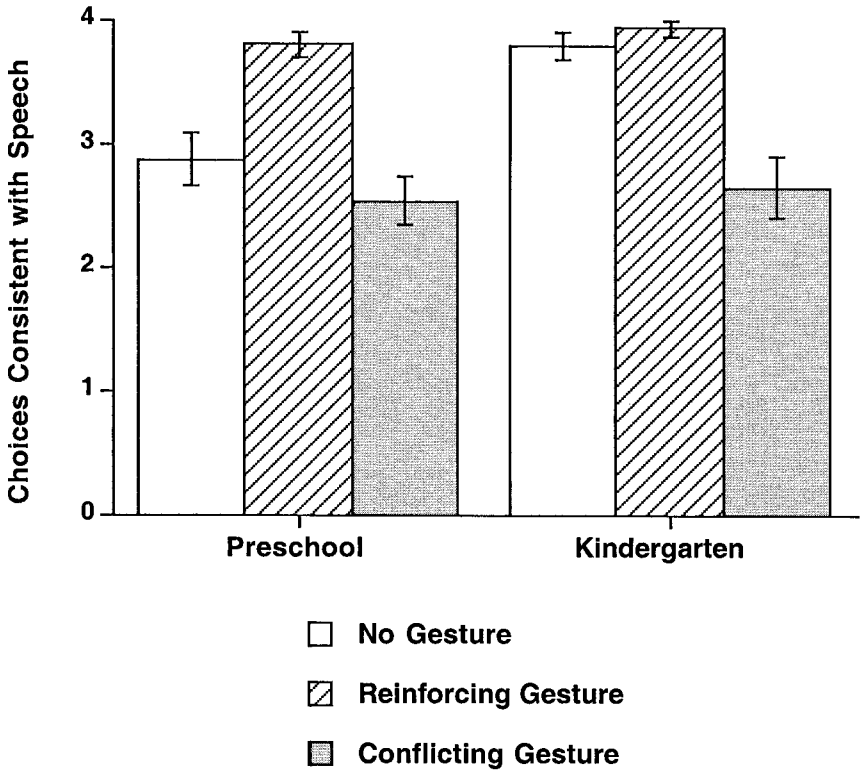

Figure 1. Number of choices consistent with speech for kindergarten children and preschool children (Experiment 1).

equally often (near ceiling) in both conditions, $M = 3.93$ vs. 3.79; 12 of the 14 kindergarten children showed this pattern.

Further, kindergarten children made choices consistent with the speaker's verbal message less often in the conflicting-gesture condition than in the no-gesture condition, $F(1, 54) = 24.90$, $p < .0001$. Nine of the 14 kindergarten children showed this pattern, and the remaining five showed no difference across conditions. Thus, for kindergarten children, conflicting gestures appeared to hinder speech comprehension. For preschool children, the difference between the two conditions was not statistically significant, $F(1, 54) = 2.27$, $p = .14$. Seven of the 15 preschool children showed no difference across conditions, whereas six showed better performance in the no-gesture condition, and two showed better perfor-

mance in the conflicting gesture condition. For preschool children, speech comprehension was relatively poor in the no-gesture condition, and conflicting gestures did not influence speech comprehension. Thus, when the spoken messages were complex (as for preschool children), conflicting gestures did not influence speech comprehension. When the spoken messages were not complex (as for kindergarten children), conflicting gestures hindered speech comprehension.

Overall, these results support the hypothesis that the influence of both reinforcing gestures and conflicting gestures depends on the complexity of the message. For younger children, the spoken messages were complex, and as predicted, the speaker's reinforcing gestures facilitated speech comprehension, but conflicting gestures did not influence speech comprehension. For older children, the spoken messages were not complex, and the speaker's reinforcing gestures did not influence speech comprehension, but conflicting gestures hindered comprehension.

Experiment 2

The results of Experiment 1 suggest that the influence of both reinforcing gestures and conflicting gestures depends on the complexity of the spoken message. However, it is unclear whether these results were actually due to differences in the complexity of the spoken messages for children in the two groups, or whether they could also be attributed to other factors that may differ between the two age groups. Experiment 2 addressed this question by examining whether the role of gesture varied for children of a single age group who are presented with spoken messages of varying complexity. We tested a second group of preschool children using simpler spoken messages than those used in Experiment 1, and then compared their performance on this "simpler" game to the preschool children's performance on the original game in Experiment 1.

Method

Participants. Thirteen preschool children (7 girls, 6 boys) from the same university lab school as Experiment 1 participated in Experiment 2. Children ranged from 44 to 58 months (M = 50 months). All children were monolingual English speakers and completed the pretest (as in Experiment 1) that assessed understanding of "up," "down," "above," and "below." The ages of the children in Experiment 2 did not differ statistically from those of the preschool children in Experiment 1, $t(26) = 1.08$.

Procedure. The procedure for Experiment 2 was identical to that of Experiment 1, with two exceptions. First, each block had either a rectangle or an arrow, but not both. Second, on each trial, the speaker gave an instruction that focused on either rectangle position or arrow direction, but not both, such as "Find the block that has a smile face with a rectangle above it" or "Find the block that has an arrow pointing down." As in Experiment 1, on each trial the speaker used one of three types of gesture: reinforcing gesture (e.g., saying "above" while producing gestures depicting "above"), no gesture (e.g., saying "above" with no accompanying gesture), or conflicting gesture (e.g., saying "above" while producing gestures depicting "below"; see appendix). The spoken messages used in this task were less complex than the spoken messages used in Experiment 1, both in terms of the linguistic complexity of the speakers' instructions, and in terms of the number of pieces of information conveyed in each verbal message. As in Experiment 1, on each trial children chose from among four possible blocks (rectangle above, rectangle below, arrow up, and arrow down), and once children chose a block, the experimenter replaced it in the choice array with an identical block.

Results and Discussion

Because each trial included only one piece of information in the spoken message (rectangle position *or* arrow direction), children received a score of 0 or 1 for each trial. Because there were two trials for each gesture type, children could receive a total score of 0 to 2 for each gesture type.

We designed the spoken messages used in Experiment 2 to be less complex than those used in Experiment 1. As a manipulation check, we compared children's ability to comprehend the spoken messages presented on their own (without any gesture) across the two experiments. As expected, in the absence of gesture, preschool children were more successful at comprehending the simpler spoken messages used in Experiment 2 than the more complex messages used in Experiment 1, 88% vs. 71% correct, $t(26) = 2.08$, $p < .05$. Thus, the spoken messages used in Experiment 2 were indeed simpler for preschool children than those used in Experiment 1.

This experiment was designed to examine whether the effects of gesture type would vary for children of a given age presented with messages of varying complexity. To address this issue, we compared preschool children's performance on this easier task to the preschool children's performance on the original task used in Experiment 1. All scores were converted to proportions for analysis. As predicted, there was a statistically significant

interaction between task (easier or original) and gesture type, $F(2, 52) = 7.65$, $p < .005$. Reinforcing gestures facilitated preschool children's performance for more complex messages (Experiment 1), but did not influence performance for simpler messages (Experiment 2). In fact, for the simpler messages, children's performance was identical in the no-gesture condition and in the reinforcing gesture condition ($M = .89$, $SE = .22$ in each condition). Eleven of the 13 children performed identically in both conditions.

Surprisingly, children's performance was also identical in the conflicting-gesture condition ($M = .89$, $SE = .22$). Eleven of the 13 children showed no difference across the no-gesture and conflicting-gesture conditions. Thus, contrary to prediction, conflicting gestures did not hinder preschool children's performance for the less complex messages used in Experiment 2. When preschool children were presented with spoken messages that were not complex, neither reinforcing nor conflicting gestures influenced speech comprehension.

In sum, the results of Experiment 2 supported the complexity hypothesis for reinforcing gestures but not for conflicting gestures. As expected, for children within a given age group, the effects of reinforcing gestures on comprehension depended on the complexity of the spoken message. For spoken messages that were less complex (Experiment 2), reinforcing gestures did not influence speech comprehension, whereas for spoken messages that were more complex (Experiment 1), reinforcing gestures facilitated speech comprehension. However, counter to the hypothesis, conflicting gestures did not hinder preschool children's comprehension, even when the spoken messages were less complex.

General Discussion

The results from both experiments support the hypothesis that the role of *reinforcing* gestures in speech comprehension depends on the complexity of the spoken message. For kindergarten children in Experiment 1, and for preschool children in Experiment 2, the spoken messages were not complex, and reinforcing gestures did not influence speech comprehension. Further, for preschool children in Experiment 1, the spoken messages were complex, and reinforcing gestures facilitated speech comprehension.

We propose that reinforcing gestures are an effective scaffold for children's comprehension of complex spoken messages because they guide comprehension toward the meaning of the spoken message. There are at least two possible reasons why reinforcing gestures scaffold speech com-

prehension. First, reinforcing gestures provide redundancy across channels in the message. That is, addressees comprehend the overall message if they comprehend *either* the spoken message or the gestured message. Second, reinforcing gestures represent meaning either *indexically* (in the case of deictic gestures such as those studied by Tfouni & Klatzky, 1983) or *iconically* (in the case of representational gestures such as those studied by Volkmar & Siegel, 1982). In contrast, linguistic symbols, such as words, map to their intended meanings by convention; that is, they are *arbitrarily* related to message content (see McNeill, 1992, for discussion).

Indexical or iconic relationships may be easier for listeners to comprehend than arbitrary ones. However, indexical and iconic gestures may not be equally beneficial in all situations. Indexical gestures may facilitate comprehension most when speakers make reference to particular objects and locations, whereas iconic gestures may facilitate comprehension most when speakers describe actions or attributes of objects or scenes. We suggest that the influence of different types of reinforcing gestures may depend, at least in part, on the nature of the information being communicated. In the present study, the videotaped speaker used iconic gestures that conveyed either an attribute (direction) of the arrow or the relative locations of the smile face and the rectangle on a given block. Iconic gestures that reinforce speech are well suited for conveying such information.

With respect to *conflicting* gestures, the results of the present study were not definitive. The findings partially supported the hypothesis that the role of conflicting gestures in speech comprehension depends on the complexity of the spoken message. For preschool children in Experiment 1, the spoken messages were complex, and conflicting gestures did not influence comprehension; further, for kindergarten children in Experiment 1, the spoken messages were not complex, and conflicting gestures hindered comprehension. However, contrary to prediction, for preschool children in Experiment 2, the spoken messages were not complex, but conflicting gestures did not hinder comprehension. Thus, the role of conflicting gestures in speech comprehension may depend, in part, on variables other than the complexity of the spoken message.

Spoken messages that are complex make heavy demands on cognitive capacity (Just & Carpenter, 1992). When listeners encounter complex spoken messages, they may not have sufficient resources to attend to both speech and gesture, so they may choose to attend to one modality rather than the other. In contrast, simpler spoken messages require fewer resources to comprehend. If a spoken message is easy to understand, listeners may have sufficient resources available to attend to gesture as well as speech. However, in some cases, distributing attentional resources

across speech and gesture may lead to errors in the comprehension of the spoken message (e.g., Kelly & Church, 1998). Thus, depending on the complexity of the spoken message, conflicting gestures have the potential to hinder speech comprehension.

In the present study, the complexity of the spoken message did not fully account for the influence of conflicting gesture in speech comprehension. Instead, the influence of conflicting gestures differed for preschool children and kindergarten children. One possible interpretation of this finding is that the spoken messages used in Experiment 2 were so simple that all of the children successfully processed *both* the spoken message and the gestured message. A second possible interpretation is that children of preschool age are unable to distribute their attention across modalities, even when the spoken message is not complex.

According to the latter interpretation, the developmental differences we observed in the effects of conflicting gestures may be due to developmental changes in resource capacity or resource management (see, e.g., Bisanz, Danner, & Resnick, 1979; Case, Kurland, & Goldberg, 1982; Halford, 1993). If resource capacity or resource management improves over development, then children should also become better able to comprehend multiple messages over developmental time. When the verbal and gestural channels convey two different pieces of information, a younger child might disregard one channel altogether in an effort to manage working memory load, whereas an older child may attempt to process both pieces of information. In the present study, we did not measure children's memory capacity, so we cannot directly address this hypothesis. In future studies, we plan to examine the role of children's memory capacity in comprehending messages that contain conflicting information in speech and gesture.

The spoken messages we used in Experiment 2 differed from those we used in Experiment 1 both in terms of linguistic complexity, and in terms of the number of pieces of information conveyed in the verbal message. We suggest that the resource demands of these messages may vary across children, depending on their language skills and on their cognitive skills. The preschool children and kindergarten children in the present study presumably differed in *both* language skills and cognitive skills; therefore, our data do not allow us to pull apart the relative contributions of language and cognitive skill in determining whether a given spoken message is complex for a given child. As a result, it is unclear which aspects of children's skill are responsible for the group differences we observed. It should be noted that all of the children in both experiments demonstrated understanding of "above," "below," "up" and "down" on the experimental pretest we used.

However, this pretest performance does not rule out the possibility that there may be subtle variations in the strength or stability of children's vocabulary knowledge that may account for the observed effects of gesture on comprehension. Words such as "above" are quite infrequent in speech to young children (Regier, 1997), so it is likely that children's understanding of such terms is quite fragile. Occasional confusions of "up" and "above" in Experiment 2 support this idea.

Future research with other populations may help to disentangle the roles of language skill and cognitive skill in shaping the resource demands of spoken messages. One approach to this issue is to compare groups that have comparable levels of cognitive skill but varying levels of language skill and to explore whether the effects of gesture vary as a function of language skill. We are currently addressing this issue by comparing the role of gesture in comprehension for children who are developing typically and children who evidence language impairments in the absence of cognitive deficits (i.e., children with Specific Language Impairments). We also plan to conduct research to compare groups with comparable levels of language skill but different levels of cognitive skills—namely, novices and experts within a single task domain. Our framework suggests that, for discourse relevant to the domain, gesture should be more crucial to speech comprehension for novices than for experts. In general, our work suggests that, in seeking to understand the role of gesture in speech comprehension, both cognitive and language skill are variables worthy of further study.

Across experiments, we consistently found that reinforcing gestures facilitate speech comprehension for spoken messages that are complex. Based on these findings, we hypothesize that reinforcing gestures may play an important role in situations in which new information is being conveyed or new skills are being taught. In support of this idea, previous studies have shown that gesture is ubiquitous both in classroom communication (Alibali, Sylvan, Fujimori, & Kawanaka, 1997) and in one-on-one tutorial settings (Furuyama, in press). Further, just as our framework would predict, there is growing evidence that gesture plays an important role in students' comprehension in instructional settings (Glenberg & Robertson, 1999; Perry, Berch, & Singleton, 1995). For example, Goldin-Meadow, Kim and Singer (1999) found that teachers' reinforcing gestures supported children's comprehension of their speech. However, as in the present study, reinforcing gestures do not always facilitate comprehension (Kelly & Church, 1998). An important direction for future research will be to investigate the role of gesture in students' understanding of naturalistic instructional discourse.

In sum, our results indicate that comprehending spoken language is a

dynamic skill. Comprehension varies as a function of the interplay of task demands and external support, as do dynamic skills in other domains (e.g., Fischer & Bidell, 1998; Thelen & Smith, 1994). The present study focused on one particular form of external support for comprehension: speakers' gestures. We found that children's comprehension was differentially affected by gestures that reinforced and conflicted with speech. Further, the effects of different types of gestures depended on the complexity of the spoken message. In general, our results indicate that input from the nonverbal channel can lead children to shift into and out of different "comprehension states." In this way, speakers' gestures contribute to patterns of dynamic variation in listeners' spoken language comprehension.

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Appendix

Note: The words that occur with a given gesture are enclosed in curly brackets.

Sample Stimuli: Experiment 1

Speech Alone

Find the block that has an arrow pointing up and a smile face with a rectangle above it.

Reinforcing Gestures

Find the block that has #1 {an arrow pointing up} and #2 {a smile face with a #3 {rectangle above it}}.

1. Right-hand index-finger point *upward*, moves *up* slightly
2. Left-hand fist held in neutral space (held until gesture #3 is completed)
3. Right-hand fingers and thumb depicting a rectangle shape, placed *above* gesture #2

Conflicting Gestures

Find the block that has #1 {an arrow pointing up} and #2 {a smile face with a #3 {rectangle above it}}.

1. Right-hand index-finger point *down*ward, moves *down* slightly
2. Left-hand fist held in neutral space (held until gesture #3 is completed)
3. Right-hand fingers and thumb depicting a rectangle shape, placed *below* gesture #2

Sample Stimuli: Experiment 2

Speech Alone

Find the block that has a smile face with a rectangle above it.

Reinforcing Gesture

Find the block that has #1 {a smile face with a #2 {rectangle above it}}.

1. Left-hand fist held in neutral space (held until gesture #2 is completed)
2. Right-hand fingers and thumb depicting a rectangle shape, placed *above* gesture #1

Conflicting Gesture

Find the block that has #1 {a smile face with a #2 {rectangle above it}}.

1. Left-hand fist held in neutral space (held until gesture #2 is completed)
2. Right-hand fingers and thumb depicting a rectangle shape, placed *below* gesture #1