Raise your hand if you're spatial: Relations between verbal and spatial skills and gesture production

Article *in* Gesture · January 2007

DOI: 10.1075/gest.7.1.05hos

2 authors:

Autumn B. Hostetter
Kalamazoo College

Martha W. Alibali
University of Wisconsin–Madison

Raise your hand if you're spatial

Relations between verbal and spatial skills and gesture production

Autumn B. Hostetter and Martha W. Alibali
University of Wisconsin-Madison

Individuals differ greatly in how often they gesture when they speak. This study investigated relations between speakers' verbal and spatial skills and their gesture rates. Two types of verbal skill were measured: semantic fluency, which is thought to index efficiency with lexical access, and phonemic fluency, which is thought to index efficiency with organizing the lexicon in novel ways. Spatial skill was measured with a visualization task. We hypothesized that individuals with low verbal skill but high spatial visualization skill would gesture most often, due to having mental images not closely linked to verbal forms. This hypothesis was supported for phonemic fluency, but not for semantic fluency. We also found that individuals with low phonemic fluency and individuals with high phonemic fluency produced representational gestures at higher rates than individuals with average phonemic fluency. The findings indicate that individual differences in gesture production are associated with individual differences in cognitive skills.

Keywords: verbal skill, spatial skill, individual differences

Speakers differ in how often they gesture when they speak. Little is known about the sources of these individual differences, although many possible correlates of gesture rate have been suggested, including: gender (Briton & Hall, 1995), age (Cohen & Brosoi, 1996; Feyereisen & Havard, 1999), culture (Graham & Argyle, 1975), presence of psychopathology (Gillstrom & Hare, 1988), presence of certain developmental disorders (Bello, Capirici, & Volterra, 2004), personality traits (Campbell & Rushton, 1978; Wiens, Harper, & Matarazzo, 1980), and cognitive skills (Baxter, Winters, & Hammer, 1968; Bucci & Freedman, 1978; Frick-Horbury & Guttentag, 1998). Although many of these factors may contribute to individual differences in gesture production, the present research is concerned with this last

Gesture 7:1 (2007), 73–95.
ISSN 1568–1475 / E-ISSN 1569–9773

possibility, that individual differences in gesture production are related to differences in cognitive skills, namely verbal and spatial skills.

Gestures can be defined as movements made with the hands or arms during speaking. Gestures can be classified in a number of different ways, but for present purposes, we will group them into two broad categories. We will call the first category *representational gestures*. Representational gestures are movements that convey information that is related to the content of the verbal message. This category encompasses several sub-categories that are sometimes distinguished, including deictic, metaphoric, and iconic gestures (see McNeill, 1992); however, we are not concerned with these distinctions here. We will call the second category *beat gestures*. Beat gestures are small, rhythmic movements that emphasize certain words or phrases without conveying specific information about the meaning of those words or phrases. This category of beat gestures may also include motorically simple gestures that seem to facilitate interaction between discourse partners, called interactive gestures (see Bavelas, Chovil, Coates, & Roe, 1995); however, such gestures are rare in the discourse situations we examined. Our primary focus throughout the paper is on representational gestures.

In the following sections, we first review evidence and theory about relations between verbal skills and representational gestures, and we then do the same for spatial skills and representational gestures. Finally, we consider how possible combinations of verbal and spatial skills may relate to representational gestures.

Verbal Skills

There are many theories about how representational gestures and speech are related, and some of these theories make predictions about how verbal skills and representational gestures are related. One group of theories posits that representational gestures facilitate speech production processes (e.g., Kita, 2000; Krauss, Chen, & Chawla, 1996; Wesp, Hesse, Keutmann, & Wheaton, 2001). According to such theories, representational gestures actually help speakers verbalize their thoughts, and they are thus especially likely to occur when speakers are having trouble producing speech. Theories within this group differ in terms of their specific claims about the types of speech production problems that are most likely to give rise to representational gestures. However, most theories within this group would predict that some type of verbal skill, or some aspect of how skilled individuals are at expressing their thoughts in words, is related to representational gesture production. Individuals who have poor verbal skill (and thus more trouble producing speech) may need to use representational gestures while speaking more than individuals with strong verbal skill.

Empirical evidence on the relations between verbal skill and gesture production is mixed. Baxter, et al. (1968) measured verbal skill with a verbal category differentiation test, in which participants were asked to sort common occupations into different semantic categories and roles. They found the predicted inverse relation between verbal skill and representational gestures only when speakers were talking about an unfamiliar topic. When talking about a familiar topic, speakers with stronger verbal skills actually gestured more than those with poorer verbal skills, and this effect appeared to be even stronger than the opposite, predicted pattern found for unfamiliar topics. Along similar lines, Frick-Horbury and Guttentag (1998) predicted that individuals with low verbal scores on the SAT would use more representational gestures during retrieval of single, difficult words than individuals with high verbal scores. However, no effect was found.

Bilingual speakers provide a natural, within-subjects comparison of gestures that occur in conjunction with strong verbal skills (when individuals are speaking their native language) and with poor verbal skills (when individuals are speaking their second language). Gullberg (1998) found that French/Swedish bilinguals produced more gestures per phrase when speaking in their second language than when speaking in their native language. However, the difference was significant only for speakers whose second language was French and not for speakers whose second language was Swedish. Moreover, when iconic gestures (which are the category closest to our representational gestures) were considered separately from other types, Gullberg found the opposite pattern; speakers gestured more when speaking their native language than when speaking their second language. This finding is similar to that of Dushay (1991, as cited in Krauss et al., 1996) who showed that speakers produced more gestures when they described a synthetic tone in their native language than when they described the tone in their second language. On the other hand, Hadar, Dar, and Teitelman (2001) report a trend that speakers gesture more when speaking extemporaneously in their second language than in their native language, but with only five participants, the pattern was not statistically significant.

It appears, then, that the relationship between verbal skill and gesture production is not entirely straightforward. We next consider two reasons why previous work may have failed to find clear relationships between verbal skill and gesture production. The first problem is that previous studies employed verbal skill measures that are overly general and may not be relevant to gesture production. The second problem is the expectation that the relationship between verbal skill and gesture production is linear.

How should verbal skill be measured?

The first potential problem with previous studies involves the measurement of verbal skill. Most past studies have considered only one measure of verbal skill, and it has often been a measure based on performance on a written test, such as the SAT. Because gestures occur during speech production, a measure based on written comprehension and vocabulary size may not be the most appropriate measure of verbal skill. Other studies have relied on differences between native and second language production as a proxy for verbal skill level. The increased trouble speakers have producing speech in a second language could be due to a variety of factors, including a smaller vocabulary size, weaker knowledge of grammatical structure, a less efficient strategy for translating thoughts into words (one that is via the native language), or a less developed sense of cultural norms and expectations regarding conversation in the second language. It is thus problematic to assume that all speakers speaking in a second language are having trouble with the same aspects of speech production, or that the aspect any one speaker struggles with is a difficulty that gestures could potentially compensate.

The present study utilizes measures of verbal fluency, or the speed with which individuals can generate, access, and produce words orally, to assess verbal skill. Verbal fluency tasks are commonly used in neuropsychological assessments (Spreen & Strauss, 1991), and they typically require an individual to produce as many words as possible that meet specified criteria in a 60 s period. Performance on verbal fluency tasks is not due solely to vocabulary size (although it is correlated with verbal IQ; Cohen & Stanczak, 2000), but is rather driven by proficiency at using various strategies to access the lexicon, as well as speed of word generation and motor articulation (Cohen & Stanczak, 2000; Martin, Wiggs, Lalonde, & Mack, 1994). If gestures occur when speakers are having trouble producing speech, then speakers who score poorly on verbal fluency tests should gesture more than speakers who perform well on these tests.

Furthermore, two different types of verbal fluency have been distinguished (semantic and phonemic) and they are thought to tap two different types of production skill: lexical access (semantic fluency) and organizational efficiency (phonemic fluency). Both of these skills are important for real time speech production, and thus they may also be relevant to gesture production. Determining which type of fluency is more closely related to gesture production might provide some insight into the type of speech problems that are related to gestures. Specifically, theories about how gestures aid speech production have proposed two different types of problems that are likely to give rise to representational gestures. These problems may be reflected by the two different verbal fluency measures.

One view about how representational gestures facilitate speech production is the Lexical Access Hypothesis (Krauss et al., 1996), which contends that gestures serve as a cross-modal prime to activate particular words in the lexicon and facilitate their production. One type of verbal fluency, semantic fluency, is thought to index individuals' efficiency at accessing and retrieving words from existing semantic categories (Martin, et al., 1994). In semantic fluency tasks, participants are given 60 seconds to list as many words as they can that fall in a given semantic category (e.g., "animals"). Such tasks rely on the inherent structure of the lexicon, and they seem to be mediated primarily by temporal lobe activation (Troyer, Moscovitch, & Winocur, 1997). Performance on semantic fluency tasks depends on participants' skill at accessing and producing words quickly, the very skill that gestures are thought to facilitate according to the Lexical Access Hypothesis. If representational gestures are especially likely to occur when words are difficult to access in the lexicon, then individuals who have particular trouble with lexical access (as evidenced by poor performance on a semantic fluency task) should gesture at high rates.

The Information Packaging Hypothesis (Kita, 2000), on the other hand, contends that representational gestures help speakers organize complex ideas into the linear structure of speech. This function of representational gestures may be related to the other type of verbal fluency, known as phonemic fluency. Phonemic fluency is thought to involve skill at organizing and keeping track of lexical space (Martin et al., 1994). In phonemic fluency tasks, participants are given 60 seconds to name as many words as they can that begin with a given letter (e.g., 's'). Because the lexicon is not naturally organized around first-letter connections, the phonemic fluency task requires a large amount of executive control as participants must effectively organize their lexicon into new subcategories. Success with the task is thought to rely on frontal lobe abilities such as task switching, strategic search, and effortful planning (Troyer et al., 1997). These same frontal lobe processes are presumably necessary for taking a holistic image and breaking it down into component parts for speaking, as speakers must efficiently organize the image in a way that coincides with the linear demands of speech and quickly switch their attention between different components that need to be mentioned. According to the Information Packaging Hypothesis, representational gestures are particularly useful at facilitating these types of organizational processes (Hostetter, Alibali, & Kita, in press). If gestures occur when speakers have trouble organizing ideas for speaking, then individuals who have particular trouble with the organizational demands of speaking (as evidenced by poor performance on a phonemic fluency task) should gesture at high rates.

Is the relationship between verbal skill and gesture production linear?

The second potential problem with previous studies' attempts to find a relationship between verbal skill and gesture production might lie with the expectation that the relationship between verbal skill and gesture production is linear. The idea that speakers with low verbal skill gesture more than speakers with high verbal skill is appealing from the standpoint that gestures facilitate speech production. However, not all theories about the relationship between gestures and speech focus on facilitation. Instead, some theories posit that gestures are expressive, in the sense that they express information that is important to a speaker's communicative effort. For example, Kendon (1980; 2004) describes each utterance and its accompanying gestures as part of the same communicative action, such that both are integral to the speaker's communicative goals. Along similar lines, McNeill and Duncan (2000) propose that gestures, together with speech, express "growth points" of utterances, which are the new ideas being developed in the utterance. Such theories would not predict an inverse relation between verbal skill and gesture production. On the contrary, such theories focus on the integration of speech and gesture into a single, tightly coupled system, with gestures occurring during the production of fluent speech (see also Mayberry & Jacques, 2000; Mayberry, Jacques, & DeDe, 1998). These theories would most likely predict a positive relation between verbal skill and gesture production. Speakers with superior verbal skills may have particularly strong connections between words in their lexicon and the ideas they represent, so they may be especially likely to produce gestures that express those ideas. Additionally, if speakers produce gestures to make their speech more engaging or entertaining for the benefit of their listeners, they may only be able to add this extra effort when their cognitive resources are not completely taxed by speech production processes. When speakers have high verbal skill, they may have more resources to devote to gesturing. Indeed, prior studies investigating verbal skill and representational gesture production have found a positive relation (Baxter et al., 1968; Dushay, 1991, as cited in Krauss et al., 1996; Gullberg, 1998) more often than a negative one (Hadar et al., 2002).

It seems likely that both facilitative and expressive accounts of the gesture-speech relationship hold some truth; increased representational gesture production might be associated with both strong and poor verbal skills. However, previous studies have been based on the assumption that the only reason speakers gesture is to facilitate speech production when they are having difficulty. This assumption has led researchers to compare gesture production for only two skill levels, "high" and "low" or "native" and "nonnative." Such an approach ignores the possibility that gestures may be used for different reasons by different groups of people. We propose instead that the relation between verbal skill and representational gesture production is not linear; instead, individuals at both the "high" and "low" ends of the spectrum may gesture more than an average group. The present study will investigate this possibility by considering verbal skill at three (rather than two) levels.

Spatial Skill

In addition to verbal skill, gesture production may also be related to spatial skill. Representational gestures clearly reflect spatial thinking (Alibali, 2005), and indeed, such gestures are more likely to occur with spatial words than non-spatial words (Krauss, 1998). When speakers possess mental representations that include rich spatial components (e.g., images), these representations may be easily expressed in the spatial medium of gesture. For example, Hostetter and Hopkins (2002) found that individuals who witnessed events in a highly spatial medium (a cartoon video) gestured more when describing those events than individuals who read about the events in a verbal description. This finding suggests that speakers who describe events that were encoded via spatial images produce more representational gestures than speakers who describe events that were encoded verbally. The presence of spatial images may also result in more frequent gesture at the individual level.

Spatial skill consists of several distinct components, including visualization (skill at mentally forming and manipulating spatial forms), spatial relations (skill at solving spatial problems requiring mental rotation quickly), closure speed and flexibility (skill at distinguishing spatial patterns from surrounding noise), and perceptual speed (skill at comparing multiple visual presentations) (see Carroll, 1993). Of these, visualization seems to be the most relevant to representational gesture production because, as a measure of the ability to form mental images, it can index how likely individuals are to form images of the events they describe. Tests that load on a visualization factor require participants to imagine how a visually presented image would change under specified circumstances. Items in such tests present a series of visual images that represent a physical transformation. Participants must mentally create a number of intervening images that correspond to steps in the transformation, and then choose (from among several possibilities) the picture that accurately represents the transformation's end result. To perform well on these tests, participants must be able to form and manipulate mental images of the intervening steps involved in the transformations. Indeed, performance on visualization tests is predicted by laboratory measures of imagery skills (Poltrock & Agnoli, 1986; Poltrock & Brown, 1984).

We propose, then, that because individuals who perform well on a visualization test have strong skills at forming and manipulating mental images, they are especially likely to evoke mental images of the spatial objects and events they speak about. In contrast, individuals who do not have strong skills at forming mental images (as evidenced by poor performance on a visualization test) are more likely to rely on stored verbal descriptions of objects and events, rather than mental images. We hypothesize that this difference in mental image generation for speaking can be seen in individuals' representational gesture rates. Specifically, individuals who compose spatial descriptions by forming mental images of the spatial events will accompany their descriptions with a large number of representational gestures. On the other hand, individuals who base their descriptions on stored verbal or propositional descriptions rather than images of the spatial events will produce fewer representational gestures.

Little work has tested the hypothesis that there is a link between spatial skill and gesture production. In one study relevant to this issue, Feyereisen and Havard (1999) built on the finding that visual imagery generally declines with age (Dror & Kosslyn, 1994) to predict that younger adults would produce more representational gestures than older adults. This effect was found for representational gestures produced in response to a visual imagery topic, but not for motor imagery or abstract topics. Unfortunately, Feyereisen and Havard did not directly test the spatial skills of their participants, and it is unknown how closely spatial skills and age were related in their study. Nonetheless, this work suggests that a positive relation between visualization skill and representational gesture production may exist for some tasks.

The interaction of verbal skill and spatial skill

In addition to considering both verbal skill and spatial skill separately, the present study will also consider how these two variables might interact to affect gesture production. According to the view that gestures facilitate speech production, representational gestures occur when individuals are having trouble producing speech. However, expressing ideas in the spatial medium of gesture may only be helpful when individuals are using mental images as the basis for their ideas. Individuals who have low verbal skill but high visualization skill may find that representational gestures are especially beneficial for thinking and speaking because representational gestures allow them to capitalize on their strong spatial representations. These spatial representations, once expressed in gesture, can help the speaker identify particular features that should be mentioned and organize them efficiently (Kita, 2000), can prime particular word forms that are not readily available (Krauss et al., 1996), or can serve as an external referent for both speaker and listener that does not need to be verbally encoded at all.

Similarly, views of gesture and speech production as one tightly coupled expressive system might predict that ideas are likely to be conveyed in gesture when the "growth point" for thinking contains strong spatial components in the absence of verbal forms. Such a „mismatch" between the spatial and verbal components of an idea may be more likely in individuals whose spatial skills outstrip their verbal skills. Thus, expressive views of gesture would also predict that, while representational gestures are not generally associated with low verbal skill, they are likely to occur when individuals with low verbal skill have high visualization skill.

The idea that visualization skill and verbal skill together affect representational gesture rates has been addressed in two previous studies. Bucci and Freedman (1978) found that individuals with strong skills at assigning names to visual images produced more representational gestures than individuals with poor skills at assigning names to visual images. The authors suggested that this difference was due to the first group's tendency to base their verbal descriptions on stored spatial images rather than more general information and features stored at the time of encoding. This claim is similar to our hypothesis about the expected interaction between visualization and verbal skills. However, while Bucci and Freedman's findings are suggestive, they did not measure verbal skill and spatial skill independently, and it is difficult to determine whether their measure reflects verbal skill, spatial skill, or a combination of both.

Vanetti and Allen (1988) examined the impact of both verbal and spatial skill on gesture production during route descriptions. They measured spatial skill with two measures of spatial visualization that are similar to those we will use here, but measured verbal skill with tests that primarily measure vocabulary. Vanetti and Allen split their participants into a "high" and a "low" group on each cognitive dimension and then compared representational gesture rates for individuals with different combinations of cognitive skills. They found no significant differences in the number of representational gestures produced, although the "High Spatial-Low Verbal" group did produce the highest number of representational gestures. Vanetti and Allen's lack of significant findings may be due to the fact that participants were split into only two groups for each cognitive skill, thus increasing variability within each group and ignoring the potential for non-linear relationships. It is also possible that route description tasks are very difficult to complete without forming mental images, regardless of ability at doing so.

Hypotheses

In summary, the present study tests the hypothesis that both verbal and spatial skills are associated with representational gesture production. Specifically, we predict that (1) low verbal fluency is associated with greater representational gesture production, but only when it is accompanied by high spatial visualization skill, and (2) verbal fluency and representational gesture production are related quadratically, with individuals at both the "high" and "low" ends of the verbal spectrum producing more gestures than an "average" group.

In addition to testing these hypotheses, we will also examine relationships between representational gesture rates and two different types of verbal fluency (phonemic and semantic) in an attempt to distinguish between two views about how representational gestures may facilitate speech production. Specifically, if representational gestures are particularly helpful at organizing speech and keeping track of ideas and concepts as they occur, then representational gesture rates should be predicted most strongly by low phonemic fluency. If, on the other hand, representational gestures are particularly helpful at priming particular word forms in the lexicon, then representational gesture rates should be predicted specifically by low semantic fluency.

These hypotheses are made primarily with respect to representational gestures, because as the clearest outward manifestation of underlying spatial representations, representational gestures are the type of gesture most likely to be related to both verbal and spatial skills. However, we will also examine beat gestures in an attempt to determine whether the two gesture types are related to the same cognitive factors.

Method

Participants

Participants were 100 students (54 female, 46 male) recruited from the Department of Psychology participant pool at the University of Wisconsin-Madison. Speakers who did not learn English in infancy were excluded from analysis, as was one individual for whom a wrist injury impeded gesture and another for whom data were incomplete. The final sample consisted of 90 participants (52 female, 38 male) with an average age of 19.44 years ($SD = 1.92$). Participants were predominantly Caucasian (93%) with a minority of individuals claiming Asian (5%), African (1%), or Native American (1%) descent.

Tasks

Verbal Fluency. We used two common neuropsychological assessment tools to measure verbal fluency (also known as the Controlled Oral Word Association Tests (COWAT), Word Fluency, or the F-A-S tests). For phonemic fluency, participants generated as many words as they could during a 60 s period that began with a given letter ("s" or "t"). For semantic fluency, participants generated as many words as they could during a 60 s period that fell in a given category ("animals" or "fruits and vegetables"). Retest reliability for these tests has been assessed at .88 (desRosiers & Kavanagh, 1987).

Following neurological convention for test administration, proper nouns and morphological changes on the same word were not counted as additional words (see Spreen & Strauss, 1991). For each of the four 60 s trials, the total number of different words produced was summed. The average of the two phonemic trials was used as a measure of phonemic fluency in further analyses and ranged from 8 to 27.5 ($M = 15.6$, $SD = 3.48$). The average of the two semantic trials was used as a measure of semantic fluency in further analyses and ranged from 12 to 40 ($M = 22.8$, $SD = 4.53$).

Performance on verbal fluency tests depends on many factors, including educational level, age, and the specific letter or category being tested (Spreen & Strauss, 1991). Our sample scored similarly on phonemic fluency to other samples in the same educational and age category that also used 's' as a target letter (e.g., Yeudall, Fromm, Reddon, & Stefanyk, 1986: $M = 15.87$, $SD = 4.52$, *one-sample* $t(90) = .72$, $p = .47$). Our sample scored marginally better on semantic fluency than other samples in the same educational and age category that used "animals" as a target semantic category (e.g., Troyer, et al., 1997; $M = 21.81$, $SD = 5.65$, *one-sample* $t(90) = 1.91$, $p = .06$). Finally, both phonemic and semantic fluency were positively correlated with the average number of words participants produced in our two description tasks ($r(85) = .374$, $p < .001$ (phonemic) and $r(85) = .373$, $p < .001$ (semantic)), providing a general indication that both verbal fluency measures were related to participants' verbosity during their open-ended descriptions.

Paper Folding Test. Taken from *The Kit of Factor-Referenced Cognitive Tests* (Ekstrom, French, Harman, & Derman, 1976), this task measures the ability to mentally form, manipulate, and store spatial forms. In the factor analysis performed by its developers on normative samples of over 300 high school males and over 300 high school females, this test loaded on a spatial visualization factor. This factor consisted of tests that required "figures to be mentally restructured into components for manipulation while the whole figure is manipulated in spatial orientation" (Ekstrom et al., 1976, p. 173). The test has a demonstrated reliability of .75 for males and .77 for females (Ekstrom et al., 1976). It was not altered here in any way from its original form.

The test included two pages with ten items on each page. Each item depicted a square piece of paper folded along dotted lines and then hole-punched (denoted by a small circle). Participants had to choose, from among five alternatives, the correct representation of how the paper would look if it were unfolded. Participants had 3 minutes to complete the 10 items on each page. Scores were calculated by taking the number of items correct (out of 20) and subtracting one-quarter of the number incorrect. There was no penalty for items not answered.

Scores in our sample ranged from 2.5 to 20 ($M = 12.43$, $SD = 3.80$). The performance of the females in our sample ($M = 12.20$, $SD = 3.38$) was significantly higher than the mean for the normative high school female sample ($M = 10.40$, $SD = 3.70$), *one-sample* $t(51) = 3.89$, $p < .001$, but given our college sample and advances in women's education in the past decades, this is not surprising. The performance of the males in our sample ($M = 12.73$, $SD = 4.36$) was slightly but not significantly higher than the performance of the males in the normative high school sample, ($M = 11.50$, $SD = 3.70$), *one-sample* $t(38) = 1.76$, $p = .09$.

Matrix Equation Test. This task was intended to measure spatial working memory, but unfortunately, many participants did not follow the instructions for the task and therefore, the data were not usable. For a complete description of the task, see Miyake, Friedman, Rettinger, Shah, and Hegarty (2001). Briefly, participants were asked to verify whether two spatial arrays combined to form a third array, while simultaneously remembering the location of randomly placed dots presented during the delay between displays. Participants were asked to remember the locations of the dots without using their hands or writing utensils to help mark the dots' locations, but many participants did use such manual or visual strategies. Because the present study addresses cognitive skills that exist independently of such external strategies, it was not appropriate to include this task in the final analyses

Mouse Cartoon. Participants watched a 90 s clip from the German cartoon series "Die Sendung mit der Maus." The cartoon was displayed on a Macintosh Powerbook G3 laptop with a 35 cm color screen. The cartoon depicted a mouse and a small elephant playing on a pull-up bar. Participants watched the cartoon twice and then narrated what they had just seen to the experimenter. The experimenter sat across from the participants and maintained eye contact throughout the descriptions.

Package Description. Participants described how they would wrap a package. They were told to imagine that they had a square box about the size of the experimenter's lap (approximate size was conveyed through gesture) that they were going to cover with wrapping paper to give to someone. The experimenter sat across from them and maintained eye contact throughout the description.

Procedure

Participants arrived for testing individually and were told that the experiment addressed how people remember and communicate information. After filling out a consent form, they completed a dot description task for another study (see Hostetter & Alibali, 2004) that took about 10 minutes. They then completed the tasks for this study in the same fixed order: phonemic fluency "S", Paper Folding Test, semantic fluency "animals", Mouse cartoon, phonemic fluency "T", Matrix Equation Test, semantic fluency "fruits and vegetables", and Package Description. Participants were told that their descriptions were being audio-recorded for later analysis, and the experimenter pressed "record" on an audio tape recorder before each task. However, there was also a hidden video-camera recording a head-on view of the participants from the waist up throughout the entire session. At the end of the session, the experimenter revealed the true purpose of the study and the presence of the video camera. All participants declined the opportunity to have their video data erased.

Coding

Participants' speech was transcribed verbatim and all corresponding gestures were coded from the videotapes. Individual gestures were identified from the stream of manual activity by a change in hand shape and/or motion. Gestures were classified as representational gestures if their shape, placement, and/or motion trajectory depicted semantic content. For example, in the Mouse task, if a participant moved her right index finger around in a circle several times while saying "the mouse swung around the bar," this motion was counted as one representational gesture. In the Package task, if a participant turned both his palms inward, from facing up, parallel to the floor, to facing each other, perpendicular to the floor, while saying "Fold the edges of the paper up," this motion was counted as one representational gesture. Motorically simple, rhythmic movements that seemed to coincide with specific words or phrases without conveying any clear semantic content were classified as beat gestures. It is possible that some of the gestures classified as beats in our coding scheme were interactive gestures, as identified by Bavelas et al. (1995). However, given the minimal interaction between speaker and listener in these narrative tasks, such interactive gestures were difficult to identify as such, and they were probably quite infrequent overall. Once all gestures had been coded, representational and beat gesture rates were calculated per 100 words of speech for each gesture task.

One primary coder coded the gestures of all participants on both the mouse and package tasks. To determine reliability, a second coder coded the gestures produced by 18 participants (20% of the sample) on the Mouse task. Agreement was 86% for identifying individual gestures from the continuous stream of manual activity and 85% for classifying each gesture as representational or beat ($N=126$). A third coder established reliability for the package task by coding the gestures produced by a second subset of 18 individuals. Agreement was 84% for identifying individual gestures from the continuous stream of manual activity and 93% for classifying each gesture as representational or beat ($N=233$).

Results

This experiment sought to identify cognitive correlates of gesture production. Two forms of verbal fluency were measured (semantic and phonemic), as was skill at visualizing spatial representations. Two tasks were used to elicit gesture production, a narrative task (Mouse cartoon) and a motor description task (package description), and two types of gesture rates per 100 words (representational and beat) were evaluated for each task. Of the 90 participants in this sample, three did not produce any gestures of either type on either task. Exactly why these individuals did not gesture is unclear, but they fall outside the norm for these tasks, which were generally quite successful at eliciting gesture production.[1] It seems likely that their lack of gesture is not a reflection of their cognitive skills but rather a conscious effort on their part to refrain entirely from gesturing (perhaps because they suspected the true purpose of the experiment). The data from these three individuals were excluded from analyses.[2]

Participants gestured more on the package description task ($M=11.39$ gestures per 100 words, $SD=6.17$) than they did on the Mouse cartoon task ($M=4.52$ gestures per 100 words, $SD=5.00$). This finding is in line with previous reports by Feyereisen and Havard (1999) and suggests that individuals gesture more when describing information that involves motoric processes than they do when describing information that involves spatial imagery. However, gesture production on the two tasks was correlated, $r(85)=.451$, $p<.001$, and the similarity in gesture rates across tasks is of greater interest here than the differences between tasks. Because our focus is on individual differences in overall gesture production rather than task effects, we collapsed across the two gesture tasks.

A complete correlation matrix for the cognitive tasks and gesture rates is presented in Table 1. The two types of verbal fluency were moderately correlated, $r(85)=.57$, $p<.001$, and they were also correlated with spatial skill, semantic: $r(85)=.26$, $p=.02$; phonemic: $r(85)=.23$, $p=.03$. The two types of gesture rates (representational and beat) were moderately correlated, $r(85)=.39$, $p<.001$. Beat

Table 1. Correlation Matrix of Cognitive Tasks and Gesture Rates

	Sem Fluency	Spatial Skill	Rep Rate	Beat Rate
Phonemic Fluency	.574**	.231*	-.072	.035
Semantic Fluency		.257*	-.006	.237*
Spatial Skill			.030	.259*
Representational Rate				.389**

Note. Gesture rates are per 100 words averaged across the Mouse and Package tasks. ** $p < .001$; * $p < .05$.

gesture rates were correlated with both spatial skill, $r(85) = .26$, $p = .02$, and semantic fluency, $r(85) = .24$, $p = .03$.

Participants were divided into three groups on the basis of their scores on each cognitive task. Those in the bottom third on phonemic fluency (< 15 words/trial) were classified as "low phonemic fluency", those in the middle third (between 15 and 18 words/trial) were classified as "average phonemic fluency", and those in the top third (> 18) were classified as "high phonemic fluency". Similar divisions were also made on the basis of semantic fluency (low < 21.5 ≤ average ≤ 25.0 < high) and spatial skill (low < 11.0 ≤ average ≤ 14.0 < high).

We hypothesized that individuals who have trouble producing speech but who have spatial images in mind would produce more representational gestures than other individuals. This hypothesis would be supported by an interaction between verbal skill and spatial skill, with individuals who have the combination of low verbal skill and high spatial skill gesturing more than other individuals in the sample. Furthermore, according to the Lexical Access Hypothesis, this interaction should primarily be seen with spatial skill and semantic fluency, because semantic fluency involves skill in accessing and producing words. On the other hand, according to the Information Packaging Hypothesis, this interaction should primarily be seen with spatial skill and phonemic fluency, because phonemic fluency involves organizational processes such as planning and task switching, the same abilities involved in packaging spatial information for speaking. Because including both phonemic and semantic fluency as factors in the same analysis creates some cells with very small sample sizes, separate analyses were done with the two measures of verbal skill.

First, a 2 (gesture type: representational vs. beat) x 3 (spatial skill: low, average, or high) x 3 (phonemic fluency: low, average, or high) mixed ANOVA with gesture type as a repeated measure was conducted. There was an interaction between phonemic fluency and spatial skill, $F(4, 78) = 2.77$, $p = .03$, $\eta_p^2 = .125$, which is compatible with the Information Packaging Hypothesis. As seen in Figure 1, individuals with low phonemic fluency and high spatial skill gestured more than individuals in any of the other eight groups. LSD planned comparisons revealed

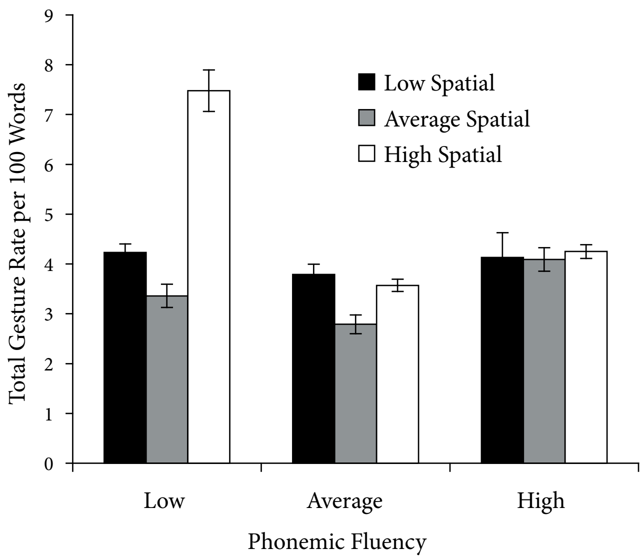

Figure 1. Gesture rates as a function of phonemic fluency and spatial skill. Error bars represent standard errors of the means.

that, as predicted, participants with low phonemic fluency and high spatial skill gestured at a higher rate ($M = 7.48$ gestures per 100 words, $SD = 2.92$) than participants with low phonemic fluency and either average ($M = 3.36$ gestures per 100 words, $SD = 1.88$), $p = .002$, or low ($M = 4.23$ gestures per 100 words, $SD = 2.08$), $p = .006$ spatial skill.

A main effect of spatial skill also emerged, $F(2, 78) = 4.73$, $p = .012$, $\eta_p^2 = .108$. However, as seen in Figure 1, this main effect was qualified by the interaction with phonemic fluency. Nonetheless, overall, participants with high spatial skill produced more gestures per 100 words ($M = 4.72$, $SD = 2.42$) than participants with average spatial skill ($M = 3.42$, $SD = 2.07$) or low spatial skill ($M = 4.05$, $SD = 2.20$).

There was also a main effect of phonemic fluency, $F(2, 78) = 4.35$, $p = .02$, $\eta_p^2 = .100$, that was qualified by an interaction with type of gesture, $F(2, 78) = 3.46$, $p = .04$, $\eta_p^2 = .08$. Separate one-way ANOVAs revealed that phonemic fluency was a significant predictor of representational gesture rates, $F(2, 84) = 3.28$, $p = .043$, $\eta_p^2 = .072$, but not beat gesture rates, $F(2, 84) = .68$, $p = .51$, $\eta_p^2 = .015$. Polynomial contrasts revealed a significant quadratic trend for representational gesture rates as a function of phonemic fluency, $F(1, 84) = 4.84$, $p = .03$, $\eta_p^2 = .058$, but no linear trend, $F(1, 84) = 1.78$, $p = .19$, $\eta_p^2 = .02$. As predicted, individuals with low phonemic fluency ($M = 8.35$, $SD = 4.49$) and individuals with high phonemic fluency ($M = 6.99$, $SD = 3.91$) both produced representational gestures at higher rates than individuals with average phonemic fluency ($M = 5.81$, $SD = 3.36$). See Figure 2.

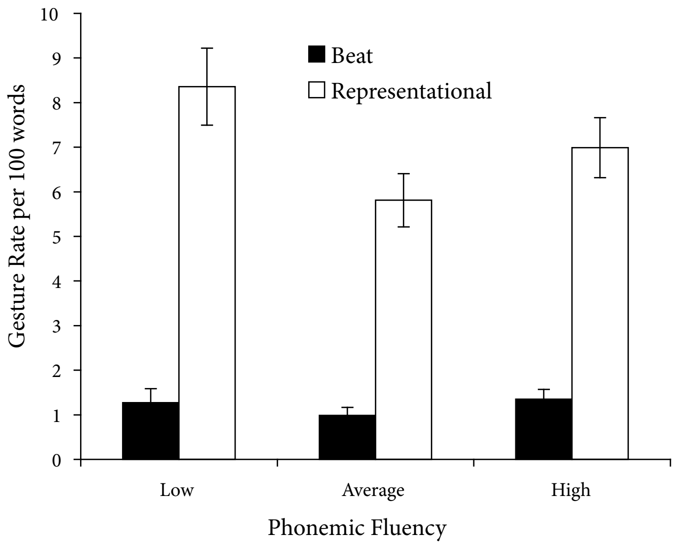

Figure 2. Representational and beat gesture rates as a function of phonemic fluency. Error bars represent standard errors of the means.

Not surprisingly given the spatial nature of the tasks we used, a main effect of gesture type also emerged, $F(1, 78) = 239.37$, $p < .001$, $\eta_p^2 = .754$ such that representational gestures were produced at higher rates per 100 words ($M = 6.98$, $SD = 3.91$) than beats ($M = 1.19$, $SD = 1.28$).

A second analysis was conducted using semantic fluency as the measure of verbal skill. The 2 (type) x 3 (spatial skill) x 3 (semantic fluency: low, average, or high) mixed ANOVA again revealed a main effect of type of gesture, $F(1, 78) = 211.36$, $p < .001$, such that representational gestures were produced at higher rates per 100 words than beats. No other significant effects were found in this analysis.

Discussion

The present analysis addressed two main hypotheses: (1) low verbal fluency is associated with increased gesture production, but only when it is accompanied by high spatial visualization skill, and (2) verbal fluency and representational gesture production are related quadratically, with individuals at both the "high" and "low" ends of the verbal skill spectrum producing more representational gestures than an "average" group. Both hypotheses were supported in the present data.

The first hypothesis was supported by the finding that individuals with low verbal fluency and high spatial visualization skill gestured more than any other group in the sample. This finding can be explained by theories that describe representational gestures as integral components of utterance production (Kendon 1980, 2004) or as "growth points" of utterances (McNeill & Duncan, 2000). Because representational gestures are an expression of spatial images, speakers are more likely to produce them when the ideas underlying their utterances contain spatial components, as may be the case when a speaker's spatial skills strongly outstrip his verbal skills. On this view, gestures work together with speech to more fully express the speaker's meaning. The finding can also be explained by theories that describe representational gestures as facilitating speech (Kita, 2000; Krauss et al., 1996). From this perspective, representational gestures are helpful when speakers have spatial images in mind but are unable to efficiently organize them in speech (Kita, 2000) or are unable to find their appropriate names in the lexicon (Krauss et al., 1996). Producing the image in gestures assists speakers in translating their spatial knowledge into verbal forms.

The purpose of the present study was not to differentiate between speech-facilitative and expressive views of gesture production; on the contrary, our hypotheses were based on the assumption that both perspectives can contribute to explaining the relationship between speech and gestures. This led us to our second prediction that increased representational gesture production would be associated with both low verbal proficiency and with high verbal proficiency. This hypothesis was supported by the observed quadratic relationship between phonemic fluency and representational gesture production. Speakers with low verbal skill may produce representational gestures as a way to compensate for their poorer verbal skills, either by helping themselves translate their ideas into speech or by eliminating the need to translate the ideas into speech at all. Speakers with high verbal skill may produce representational gestures because their verbal representations are tightly linked to spatial or embodied representations that are activated spontaneously while speaking. Alternatively, individuals with high verbal skill may use representational gestures as a way to make their speech more communicatively effective, a luxury they have because speech production is not as difficult for them. As Kendon (2001, p. 202) stated:

> It is only when a certain fluency of linguistic expression is reached that speakers become free to draw on their other expressive resources in supplementation and complementation of the meanings that may now flow freely in words. Speech coordinate iconic gestures can be brought in once the task of speaking itself is possible, not before.

In short, the present research suggests that individuals may produce gestures for different reasons and under different circumstances, depending on their verbal fluency.

In addition to supporting the two hypotheses under investigation, the present data also provide some insight into the specific nature of verbal difficulties that are associated with gesture production. We found a relation between phonemic fluency and representational gesture rates, but we did not find a relation between semantic fluency and representational gesture rates. Phonemic fluency is associated with the ability to exert executive control over a task and to focus attention on one specific goal at a time, while maintaining flexibility to switch between goals as the need arises (Troyer et al., 1997). This skill is necessary during speech production, as speakers must transfer a cluster of ideas and concepts into an appropriate chain of linguistic units without perseverating on one or advancing prematurely. If low phonemic fluency can be taken as an indication of a tendency to be less good at organizing ideas, the present data can be taken to suggest that speakers who have difficulty organizing ideas produce more gestures than an average group, perhaps as a way to compensate for or overcome their difficulty. This finding is compatible with the Information Packaging Hypothesis (Kita, 2000), which holds that representational gestures may focus attention on spatial information and help organize that information for speaking.

When rates of gesture were compared with measures of semantic fluency, however, no relationship was found. Semantic fluency is associated with efficiency at accessing the lexicon (Troyer et al., 1997). The fact that semantic fluency is not a strong predictor of gesture rates suggests that representational gestures are not typically the result of difficulty with accessing particular lexical forms, as the Lexical Access Hypothesis (Krauss et al., 1996) has claimed. Individuals who have weak semantic connections (as evidenced by low semantic fluency) do not appear especially likely to use representational gestures to increase activation of particular words.

There was, however, a significant correlation between semantic fluency and beat gesture rates. This correlation was not predicted and must therefore be interpreted with caution. However, this finding is understandable in light of theories regarding the role of motor activation in speech production. Ravizza (2003) has argued that manual actions that have no apparent semantic relationship to current speech, such as finger tapping, are associated with increased motor activation, which can spread to speech-related brain regions and increase the speed with which lexical items can be accessed and produced. Beat gestures, with their repetitive, rhythmic form, may yield similar effects. We speculate that participants who scored well on the semantic fluency task may have done so because they habitually move a lot while they are speaking. They did so during the Mouse and Package descriptions by producing a high rate of beat gestures, and they may have also done so during the semantic fluency trials of this experiment. Future research should further examine the association between beat gestures and semantic fluency.

The main finding of the present study is that individual differences in cognitive skills are related to individual differences in gesture production. Speakers with high and low phonemic fluency gesture more than speakers with average fluency, and speakers with the combination of low phonemic fluency and high spatial skill gesture at especially high rates. However, it is worth noting that gesture production does not depend on or require a general mismatch between verbal and spatial skill. Indeed, almost all of the participants in our sample produced some gestures. For all individuals, some concepts may have stronger spatial components than verbal components, and these concepts may be especially likely to be expressed in gestures.[3] Furthermore, the present study considered only cognitive factors and thus does not rule out the possibility that gesture production is also related to other factors such as personality, the social situation, or even the individual's background and beliefs about gestures. One of the non-gesturers whom we excluded from analysis commented upon being debriefed that she was told as a child that gesturing was impolite and thus she rarely does so an adult. Although anecdotal, this suggests that individuals may be able to control their gestures if they want to and they may do so independently of their cognitive strengths and weaknesses.

In conclusion, the present study has provided a first step toward understanding sources of individual differences in gesture production. Such knowledge will ultimately lead to a better understanding of why speakers produce gestures, and what gestures can tell us about how speakers think.

Notes

* This research was supported by a grant from the Graduate School at the University of Wisconsin-Madison to Martha W. Alibali and by a Marian Schwartz award for research in Cognitive Psychology to Autumn B. Hostetter. We thank Nancy Demerdash, Kristi Kalmoe, Kristin Ryan, and Le'Andrea Vernon for their help with coding and establishing reliability.

1. There were many more participants who completed the mouse cartoon task without gesturing ($n = 32$) than who completed the package task without gesturing ($n = 6$).

2. Of the three individuals who were excluded for not gesturing at all during the experimental tasks, one would have been classified as High semantic – Low phonemic – High spatial; the second would have been classified as Average semantic – Low phonemic – High spatial; and the third would have been classified as Average semantic – Low phonemic – Low spatial.

3. Wagner, Nusbaum, and Goldin-Meadow (2004) have argued that the representations underlying gestures are propositional rather than spatial. The tasks and gestures that were the focus of the present study, however, were largely spatial in nature. Very few of the gestures counted here as "representational" were deictic, the type specifically suggested to stem from propositional representations by Wagner, et al.

References

Alibali, Martha W. (2005). Gesture in spatial cognition: Expressing, communicating, and thinking about spatial information. *Spatial Cognition and Computation*, 5, 307–331.

Bavelas, Janet B., Nicole Chovil, Linda Coates, & Lori Roe (1995). Gestures specialized for dialogue. *Personality and Social Psychology Bulletin*, 21, 394–405.

Baxter, James C., Elaine P. Winters, & Robert E. Hammer (1968). Gestural behavior during a brief interview as a function of cognitive variables. *Journal of Personality and Social Psychology*, 8, 303–307.

Bello, Arianna, Olga Capirici, & Virginia Volterra (2004). Lexical production in children with Williams syndrome: Spontaneous use of gesture in a naming task. *Neuropsychologia*, 42, 201–213.

Briton, Nancy J. & Judith A. Hall (1995). Beliefs about female and male nonverbal communication. *Sex Roles*, 32, 79–90.

Bucci, Wilma & Norbert Freedman (1978). Language and hand: The dimension of referential competence. *Journal of Personality*, 46, 544–622.

Campbell, Anne & J. Phillipe Rushton (1978). Bodily communication and personality. *British Journal of Social and Clinical Psychology*, 17, 31–36.

Carroll, John B. (1993). *Human Cognitive Abilities: A survey of factor-analytic studies.* Cambridge: Cambridge University Press.

Cohen, Melissa J. & Daniel E. Stanczak (2000). On the reliability, validity, and cognitive structure of the Thurstone Word Fluency Test. *Archives of Clinical Neuropsychology*, 15, 267–279.

Cohen, Ronald L. & Diane Borsoi (1996). The role of gestures in description-communication: A cross-sectional study of aging. *Journal of Nonverbal Behavior*, 20, 45–63.

desRosiers, Gabriel & David Kavanagh (1987). Cognitive assessment in closed head injury: Stability, validity, and parallel forms for two neuropsychological measures of recovery. *International Journal of Clinical Neuropsychology*, 9, 162–173.

Dror, Itiel E. & Stephen M. Kosslyn (1994). Mental imagery and aging. *Psychology and Aging*, 9, 90–102.

Ekstrom, Ruth B., J. W. French, Harry H. Harman, & Diran Dermen (1976). *Kit of factor-referenced cognitive tests*. Princeton, NJ: Educational Testing Service.

Feyereisen, Pierre & Isabelle Havard (1999). Mental imagery and production of hand gestures while speaking in younger and older adults. *Journal of Nonverbal Behavior*, 23, 153–171

Frick-Horbury, Donna & Robert E. Guttentag (1998). The effects of restricting hand gesture production on lexical retrieval and free recall. *American Journal of Psychology*, 111, 43–63.

Gillstrom, Brenda J. & Robert D. Hare (1988). Language-related hand gestures in psychopaths. *Journal of Personality Disorders*, 9, 21–27.

Graham, Jean Ann & Michael Argyle (1975). A cross-cultural study of the communication of extra-verbal meaning by gestures. *International Journal of Psychology*, 10, 57–67.

Gullberg, Marianne (1998). *Gesture as a communication strategy in second language discourse: A study of learners of French and Swedish.* Lund: Lund University Press.

Hadar, Uri, Rivka Dar, & Amit Teitelman (2001). Gesture during speech in first and second language. *Gesture*, 1(2), 151–165.

Hostetter, Autumn B. & Martha W. Alibali (2004). On the tip of the mind: Gesture as a key to conceptualization. In K. Forbus, D. Gentner, & T. Regier (Eds.), *Proceedings of the 26th annual meeting of the Cognitive Science Society* (pp. 589–594). Mawah, NJ: Erlbaum.

Hostetter, Autumn B., Martha W. Alibali, & S. Kita (in press). I see it in my hands' eye: Representational gestures reflect conceptual demands. *Language and Cognitive Processes*.
Hostetter, Autumn B. & William D. Hopkins (2002). The effect of thought structure on the production of lexical movements. *Brain & Language*, 82, 22–29.
Kendon, Adam (1980). Gesture and speech: Two aspects of the process of utterance. In M. R. Key (Ed.), *Nonverbal communication and language* (pp. 207–227). The Hague: Mouton.
Kendon, Adam (2001). Gestures as communication strategy. *Semiotica*, 135, 191–209.
Kendon, Adam (2004). *Gesture: Visible action as utterance.* Cambridge: Cambridge University Press.
Kita, Sotaro (2000). How representational gestures help speaking. In D. McNeill (Ed.), *Language and gesture* (pp. 162–185). Cambridge: Cambridge University Press.
Krauss, Robert M. (1998). Why do we gesture when we speak? *Current Directions in Psychological Science*, 7, 54–60.
Krauss, Robert M., Yihsiu Chen, & Purnima Chawla (1996). Nonverbal behavior and nonverbal communication: What do conversational hand gestures tell us? *Advances in Experimental Social Psychology*, 28, 389–450.
Martin, Alex, Cheri L. Wiggs, François Lalonde, & Carol Mack (1994). Word retrieval to letter and semantic cues: A double dissociation in normal subjects using interference tasks. *Neuropsychologia*, 32, 1487–1494.
Mayberry, Rachel I. & Joselynne Jacques (2000). Gesture production during stuttered speech: Insights into the nature of gesture-speech integration. In D. McNeill (Ed.), *Language and gesture* (pp. 199–214). Cambridge: Cambridge University Press.
Mayberry, Rachel I., Joselynne Jacques, & Gayle DeDe (1998). What stuttering reveals about the development of the gesture-speech relationship. In J. Iverson & S. Goldin-Meadow (Eds.), *The nature and functions of gesture in children's communication* (pp. 89–100). San Fancisco: Jossey-Bass Publishers.
McNeill, David (1992). *Hand and mind: What gestures reveal about thought.* Chicago: University of Chicago Press.
McNeill, David & Susan D. Duncan (2000). Growth points in thinking-for-speaking. In D. McNeill (Ed.), *Language and gesture* (pp. 141–161). Cambridge: Cambridge University Press.
Miyake, Akira, Naomi P. Friedman, David A. Rettinger, Priti Shah, & Mary Hegarty (2001). How are visuospatial working memory, executive functioning, and spatial abilities related? A latent-variable analysis. *Journal of Experimental Psychology: General*, 130, 621–640.
Poltrock, Steven E. & Franca Agnoli (1986). Are spatial visualization ability and visual imagery ability equivalent? In R. Sternberg (Ed.), *Advances in the psychology of human intelligence* (pp. 255–296). Hillsdale, NJ: Lawrence Erlbaum Associates.
Poltrock, Steven E. & Polly Brown (1984). Individual differences in visual imagery and spatial ability. *Intelligence*, 8, 93–138.
Ravizza, Susan (2003). Movement and lexical access: Do noniconic gestures aid in retrieval? *Psychonomic Bulletin & Review*, 10, 610–615.
Spreen, Otfried & Esther Strauss (1991). *A compendium of neuropsychological tests: Administration, norms, and commentary.* New York: Oxford University Press.
Troyer, Angela K., Morris Moscovitch, & Gordon Winocur (1997). Clustering and switching as two components of verbal fluency: Evidence from younger and older healthy adults. *Neuropsychologia*, 11, 138–146.

Vanetti, Eric J. & Gary L. Allen (1988). Communicating environmental knowledge: The impact of verbal and spatial abilities on the production and comprehension of route directions. *Environment and Behavior*, 20, 667–682.
Wagner, Susan, Howard Nusbaum, & Susan Goldin-Meadow (2004). Probing the mental representation of gesture: Is handwaving spatial? *Journal of Memory and Language*, 50, 395–407.
Wiens, Arthur N., Robert G. Harper, & Joseph D. Matarazzo (1980). Personality correlates of nonverbal interview behavior. *Journal of Clinical Psychology*, 36, 205–215.
Wesp, Richard, Jennifer Hesse, Donna Keutmann, & Karen Wheaton (2001). Gestures maintain spatial imagery. *American Journal of Psychology*, 114, 591–600.
Yeudall, Lome T., Delee Fromm, John R. Reddon, & William O. Stefanyk (1986). Normative data stratified by age and sex for 12 neuropsychological tests. *Journal of Clinical Psychology*, 42, 918–946.

Authors' addresses

Autumn B. Hostetter & Martha W. Alibali
Department of Psychology
University of Wisconsin-Madison
1202 W. Johnson Street
Madison, WI 53076
USA

E-mail: abhostetter@wisc.edu, mwalibali@wisc.edu

About the authors

Autumn B. Hostetter is a PhD student in the Department of Psychology at the University of Wisconsin-Madison, Madison, WI. She is interested in the relation between gestures and spatial thinking, as well as the role of gestures in speech production and human language evolution.

Martha W. Alibali is Professor in the Department of Psychology at the University of Wisconsin-Madison, Madison, WI. Her research investigates the role of gestures in thinking, learning, development, and instruction.