The effects of gesture restriction on spatial language in young and elderly adults

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Abstract

There is contradictory evidence on whether speech production gets impaired or enhanced when people are restrained from gesturing. There is also very little research on how this effect can change with aging. The present study sought evidence for these by asking young and elderly adults to describe two different routes on a map in spontaneous speech and when gestures were prohibited. We found that elderly adults produced more spatial language when they were restricted to use gestures compared to their spontaneous speech, whereas young adults produced comparable levels of spatial language in both conditions. Young and elderly adults used comparable levels of gestures in their spontaneous route descriptions. Yet, only young adults' gesture use correlated positively with their spatial language production. Thus, the results of gesture prohibition on speech production are different for young and elderly adults.

Keywords: gesture restriction; speech production; aging; spatial language

Introduction

People produce spontaneous gestures as they speak. Gestures improve communication as listeners understand a spoken message better when it is accompanied by a visible gesture (Hostetter, 2011). This enhanced communication might arise because gestures provide an image that is particularly informative about the spatial or motor aspects of the message that are not easily encoded in speech. That is, gestures, especially the ones accompanying spatial or motor information, improve communication (Alibali, 2005). Apart from the effects on the listener, gestures also benefit speakers. Gestures can directly convey imagistic components of thought due to the isomorphism between spatial-motor images and representational gestures. This might be helpful for speakers describing spatial-motor events (Church & Goldin-Meadow, 1986). The current study investigates the role of gesturing on the use of spatial language in a spatial task in young and elderly adults. We examined the relation between gesture and speech to address two questions: (1) How does people's use of spatial language change when they are restricted from using gestures in a spatial task? (2) How does aging influence the link between gesture production and spatial language use?

How does gesture restriction affect speech production?

There are multiple accounts suggesting that gesturing benefits speakers as they speak (e.g., Kita, 2000; Krauss, Chen, & Gottesman, 2000; Melinger & Levelt, 2004). However, these accounts differ in the proposed mechanism for this benefit in speech. The Information Packaging Hypothesis (Kita, 2000) states that gestures help speakers to organize and package visual-spatial information into the linear and segmented units of language. Forming an image of the referent by gesturing might induce attention on the specific properties of that image, thus, helping speakers to break their rich spatial representations into units that are codable in speech. According to this model, when people are restricted from gesturing while talking about spatial information, people have difficulty in organizing their rich spatial-motor ideas into the units of language. As a result, they produce less spatial information in their speech compared to the cases in which they can spontaneously produce gestures. Indeed, Rimé and colleagues (1984) found that when people are restricted from gesturing, their speech contained less vivid descriptions. In line with the Information Packaging Hypothesis, when producing motor descriptions (e.g. how to tie a shoe), people who were free to produce gestures used more semantically rich verbs referring to key elements in motoric descriptions (Hostetter, Alibali, & Kita, 2007).

Another account, the Lexical Access Hypothesis, suggests that gestures might facilitate speech to retrieve words especially when expressing spatial information (Hadar & Butterworth, 1997; Krauss, Chen, & Gottesman, 2000). One prediction of this account is that if speakers are restricted from gesturing, they will have problems in retrieving the correct words particularly when they describe spatial-motor events. Thus, in line with Information Packaging Hypothesis, this account argues that speech will be impaired in the absence of gesture use. Many studies support this account (Krauss, 1998; Rauscher, Krauss, & Chen, 1996). For example, Hostetter, Alibali, and Kita (2007) found that speakers who were restricted from gesturing started their speech with more connectors such as “and” compared to speakers who were free to use gestures when describing motoric events. The disfluencies observed in the absence of gesture is more evident in spatial contents. When restricted from gesturing, speakers were found to be speaking slower when talking about spatial information compared to the non-spatial aspects of a cartoon (Krauss, 1998). Also, speakers produced higher proportion of filled pauses (e.g. um, uh) when they could not gesture, indicating that they had difficulty in accessing the lexical items.

Another account suggests that speakers use gestures to supplement and/or complement their speech (Melinger & Levelt, 2004). It is easier to convey the imagistic properties of spatial-motor events with gestures in a more global manner compared to speech (see also Kita, 2000). Yet, according to this account, speakers use speech and gesture concurrently; but if a gesture expresses necessary information, then, that information can be omitted in speech. For instance, Melinger and Levelt (2004) found that speakers who produced iconic gestures representing the spatial relations omitted the required spatial information from their speech more compared to speakers who did not gesture. Also, when restricted from gesturing, speakers used more spatial language when describing the spatial relations between objects (Graham & Heywood, 1975).

Although all three accounts state that gesturing not only benefit communication of the listener but also of the speaker, they diverge on the mechanism of this benefit. They also propose different predictions on how speech will be affected in the absence of gesture use. The Information Packaging Hypothesis and the Lexical Access Hypothesis predict that speech will be impaired when speakers are restricted from gesturing, whereas the third account by Melinger and Levelt (2004) suggests that speech and gesture work as two different channels of expression, mutually compensating each other. Thus, speech can be enhanced in the absence of gesture use.

How does aging affect gesture production?

Although the effect of aging on communication has been studied considerably in the literature, the impact of aging on gesture use has received less attention. Studies investigating the effects of aging on gesture show that production (Cohen & Borsoi, 1996), imitation (Dimeck, Roy, & Hall, 1998), and comprehension (e.g., Cocks, Morgan, & Kita, 2000) of gestures are all impaired by aging.

Aging can either affect cognition globally or increase problems in specific components of the cognitive system, such as working memory and spatial integration in visual processing (Andersen & Ni, 2008; Copeland & Radvansky, 2007). People with poor visual-spatial working memory and spatial transformation ability used more representational gestures (Chu, Foulkes, Meyer, & Kita, 2014). Thus, it is possible that elderly people use fewer representational gestures in spontaneous speech due to problems in their working memory system. Cohen and Borsoi (1996) found that in an object description task, elderly adults produced fewer descriptive (i.e., representational) gestures compared to young adults; however, the use of non-descriptive (i.e., beat) gestures did not differ between young and elderly adults. These findings were interpreted as a specific consequence of reduced use of visual imagery in elderly people. No difference in the description quality of speech was found as a function of age. This study, in contrary to the Information Packaging Hypothesis (Kita, 2000), suggests that the less frequent use of gestures did not impair speech in elderly. Feyereisen and Harvard (1999) also investigated the production of representational and beat gestures in different description contents varying the likelihood of generating mental images. Elderly adults used fewer representational gestures when they talked about visuospatial content generating more mental imagery, whereas the use of beats for low mental imagery events was comparable between young and elderly.

The findings on the gesture use of elderly adults are not conclusive. Although elderly adults less frequently use representational gestures in spontaneous speech in spatial contents, the effects of gesture restriction on their speech is unknown. To our knowledge, no study has investigated how the effects of gesture restriction on speech, particularly spatial information, differ between young and elderly adults.

The Present Study

The purpose of the present study is to further understand the effects of gesture restriction on speech production as a function of aging. We asked young and elderly adults to describe two different routes on a directional map task without mentioning gesture use (i.e., spontaneous gesture production) and by prohibiting them from gesturing.

First, in line with the previous studies (e.g., Feyereisen & Harvard, 1999; Cohen & Borsoi, 1996), we expect that elderly adults would use fewer gestures compared to young adults when spontaneously describing the routes on the map. If gestures facilitate speech production by either helping speakers to organize and package visual-spatial information into units of speech (as suggested by the Information Packaging Hypothesis) or helping them to retrieve words (as suggested by the Lexical Access Hypothesis), then we would expect that young and elderly adults should use more spatial language in the gesture unrestricted condition compared to the gesture restricted condition. However, when we consider the already sparse use of gestures in elderly, we might also observe no difference between spatial language use in spontaneous speech and gesture restricted conditions in elderly adults. If, on the other hand, gesture helps speakers by easily conveying information that is not necessarily available in speech (Melinger & Levelt, 2014), then, young adults should use more spatial language when restricted from gesturing compared to spontaneous speech. However, if elderly adults use fewer gestures compared to young adults, then elderly adults would use more spatial language in spontaneous speech compared to young ones and use comparable levels of spatial language across spontaneous speech and gesture restriction conditions.

Method

Participants

Twenty young (M_{age} = 20.3, SD = 2.18, range: 18-22, 9 females) and 19 elderly (M_{age} = 62, SD = 7.17, range: 52-78, 15 females) adults agreed to participate in the experiment in exchange for course credit or $10 for an hour. All participants were right-handed and native English-speakers. Before the sessions, they were provided with a written, informed consent in accordance with the policies of the University of Pennsylvania's Institutional Review Board.

Stimuli and Procedure

Participants were asked to describe two different routes (Route 1 vs. Route 2) on a San Diego Zoo Map in two different counterbalanced conditions in a quiet room with an individual setting (see Figure 1). All participants were seated on an armless chair to promote gesturing. The map was printed on an A1 size cartoon (594 x 841 mm) so that the routes were visible to the participants. The large and unnecessary identification signs were erased and targets were circled in pink to make finding them easier on the map. Two routes (Route 1 vs. Route 2) were created. Route 1 was from a landmark at the bottom left to another landmark at the top right. Route 2 was the other diagonal route; from a landmark at the top right to another landmark at the bottom left. The map was present throughout the session and the experimenter held the map for the participant to describe the routes.

Figure 1: San Diego Zoo Map

In the first condition (spontaneous gesture condition; SG), participants were asked to describe the path they would take to go from one pink-circled landmark to another. In this condition, they were given no specific information about the use of speech or gesture. In the second condition (gesture restricted condition; GR), however, they were asked to sit on their hands and explain how they would continue from a different marked landmark to another just with speech. Participants always completed the SG condition first and GR condition second not to make them aware of the gesture use in the SG condition. However, the order of routes (Route 1 vs. Route 2) on the map was counterbalanced across different conditions. Sessions were videotaped for further coding.

Coding

Speech. Participants' speech was transcribed verbatim in both conditions by a native English speaker. For each condition, we first calculated the number of utterances coded as the units of speech bounded by silence. Next, we coded three different *spatial information* in speech: (1) *direction* describing the course of movement in relation to other objects (e.g., down, south), (2) *street names* (e.g., Hippo trail or Parkway), and (3) *landmark*s (e.g., restaurant). Participants' frequency of using each spatial information in speech was calculated. We also calculated a composite speech score that was the sum of all spatial information in speech.

Gesture. Participants' use of spontaneous co-speech gestures was coded in SG condition. A change in the path of hand movement determined a new gesture. We coded three different gestures: (1) *pointing* (e.g., pointing at a landmark on the map), (2) *tracing* (e.g., continuously moving the finger or hand on the map to show the route), and (3) *iconic* (e.g., moving the hand off the map to represent a direction).

We also calculated a composite gesture score that was the total of all 3 specific gesture types. Both speech and gesture were coded by the first author.

Results

Young and elderly adults did not differ in the total number of utterances in SG (F (1, 37) = .77, p > .05) and GR (F (1, 37) = .04, p> .05) conditions, and the total trial duration it took to describe the routes in SG (F (1, 37) = .30, p > .05) and GR (F (1, 37) = 2.99, p > .05) conditions. There was also no gender difference in the total number of utterances in SG (F (1, 37) = .57, p > .05) and GR (F (1, 37) = 1.13, p > .05) and, the total trial duration in SG (F (1, 37) = .19, p > .05) and GR (F (1,37) = .31, p > .05) conditions. Thus, we merged gender for further analyses.

To see if the order of the routes (Route 1 first vs. Route 2 first) influenced the number of utterances used and the duration of describing the routes, we conducted 2 separate mixed ANOVA with total number of utterances (SG vs. GR conditions) and total trial duration (SG vs. GR conditions) as within subject variables and the order of routes (R1 first vs. R2 first) as the between subject variable. There was an interaction between the number of utterances and the order of the routes, and between the trial duration and the order of the routes, F (1, 37) = 7.59, p < .01 and F (1, 37) = 6.69, p < .02, respectively. Participants produced more utterances and spent more time in GR (M = 10.25 and M = 78.35 seconds, respectively) compared to SG (M = 6.35 and M = 39.80 seconds, respectively) only when they completed the second route (R2) in GR condition. Thus, for further analyses, we used normalized scores, obtained by the total number of utterances (i.e. raw scores) divided by the number of utterances for each subject in the respective condition. For the next analyses, we used Bonferroni adjusted alpha levels in pairwise comparisons for multiple hypotheses testing and applied Greenhouse-Geisser correction when sphericity assumption was violated (see Tables 1 and 2 for the mean raw scores)

Speech Analyses

First, we conducted a mixed ANOVA with composite speech score (SG vs. GR conditions) as within subject variable and group (young vs. elderly) as the between subject variable to see if total spatial information used in speech from SG to GR conditions differed between young and elderly. There was a main effect of the condition on the composite speech scores, F (1, 37) = 27.68, p < .001. However, this main effect was qualified by interaction, F (1, 37) = 7.07, p < .05. Young participants (M = 2.18) used more spatial information compared to elderly (M = 1.42) in SG condition. However, no difference was found for the use of spatial information between young (M = 2.58) and elderly (M = 2.62) participants in GR condition. In addition, elderly adults used more spatial information in GR compared to SG, whereas young participants produced comparable spatial information in speech in SG and GR conditions (see also Table 1 for raw scores). Thus, even though young adults used similar spatial information in both conditions, when gesture use was restricted, elderly adults' use of spatial information increased.

To see if specific spatial information used in speech (street name, landmark or direction) in SG to GR conditions differed between groups, we conducted a 2×2×3 mixed ANOVA with group (young and elderly adults) as the between subject variable and condition (SG and GR) and specific spatial information (street name, landmark, and direction) as within subject variables. There was a main effect of condition, F (1, 37) = 27.68, p < .001 and an interaction of condition by group, F (1, 37) = 7.07, p < .02. As reported earlier, elderly, on average, used more spatial information in GR compared to SG conditions, whereas young produced comparable levels of spatial information in SG and GR conditions. There was also a main effect of the specific type of spatial information, F (2, 74) = 16.35, p < .001. Regardless of the condition, all participants used more direction information (M = .99) compared to street name (M = .60) and landmark (M = .61) information in speech. No other interactions among spatial information, group, or condition were found, ps > .05.

Table 1: Mean raw speech scores for each condition (SG and GR) and group. The values in parentheses are standard errors of mean.

	Young		***Elderly***	
	SG	***GR***	***SG***	***GR***
Number of Utterances	9.6 (2.2)	9 (1.5)	7.3 (1.4)	9.5 (1.7)
Composite Speech Score	18.0 (3.5)	21.1 (2.6)	11.6 (2.9)	21.4 (2.6)
Direction in speech	8.3 (1.9)	9.3 (1.5)	5.6 (1.2)	9.3 (1.4)
Landmark in speech	5 (1.3)	6.5 (1.0)	3.5 (1.1)	7.0 (1.2)
Street Name in speech	4.7 (0.6)	5.2 (0.5)	2.4 (0.8)	5.2 (0.6)

Gesture Analyses

There was no difference in the total number of gestures produced by young and elderly participants, F (1, 39) = 1.15, p > .05. We conducted a mixed ANOVA with different gesture types (pointing, iconic and tracing) as the within subject variable and group (elderly vs. young) as the between subject variable. There was a main effect of gesture type, F (1.20, 44.34) = 46.59, $p < .001$. There was also a marginally significant interaction between gesture type and group, F (1.20, 44.34) = 3.79, $p = .051$. Both young and elderly adults used more tracing gestures ($M = .80$ and $M = 1.23$, respectively) compared to pointing ($M = .29$ and $M = .16$, respectively) and iconic gestures ($M = .06$ and $M = .06$, respectively). However, the difference between pointing and iconic gestures was only significant for young adults, $M_{diff} = .23$, $p < .01$. Elderly adults produced comparable number of pointing and iconic gestures, $M_{diff} = .10$, $p > .05$.

Table 2: Mean raw gesture scores. The values in parentheses are standard errors of mean.

	Young	***Elderly***
Composite Gesture Score	8.4 (1.6)	7.3 (1.2)
Pointing Gestures	2.5 (0.6)	1.2 (0.3)
Tracing Gestures	4.9 (0.9)	5.9 (1.0)
Dynamic Gestures	1 (0.5)	0.2 (0.2)

Gesture & Speech Analyses

Young adults' total number of gestures and spatial language positively correlated in both SG ($r = .54$, $p < .05$) and GR ($r = .70$, $p < .01$) conditions. There was also a positive correlation for spatial language use in SG and GR conditions ($r = .58$, $p < .01$) in young adults. The total number of gestures did not correlate with spatial language use in SG ($r = -.42$, $p > .05$) and GR ($r = .01$, $p > .05$) conditions in elderly adults. Moreover, the spatial language use in SG and GR conditions did not correlate in elderly adults as well, $r = .08$, $p > .05$.

Discussion

This is one of the first studies investigating how the effects of gesture restriction on speech production differ with aging. We asked whether gesture prohibition impair or enhance spatial speech production of young and elderly adults. Our results showed that the effects of gesture restriction on the production of spatial language differed between young and elderly. Even though elderly and young adults produced comparable number of gestures in spontaneous speech condition, gesture restriction increased the use of spatial information in speech only for elderly adults. Overall, younger individuals produced more spatial language and the use of gestures correlated with their use of spatial information.

In the first task when people were allowed to gesture, young and elderly individuals produced similar number of gestures. This result contradicts with the previous findings that showed evidence for decreased amount of gestures in elderly adults (Cohen & Borsoi, 1996; Feyereisen & Harvard, 1999). However, the majority of the gestures used by young and elderly adults in our study were non-representational (e.g. tracing and pointing gestures). Since the map was present throughout the experiment, this might trigger the frequent use of pointing to the map (i.e. pointing gestures) or continuously moving finger on map to trace the route (i.e. tracing gestures). When people are asked to talk about an object from memory, they use more representational gestures compared to a condition where the object of interest is present when they talk about it (Wesp et al., 2001). Thus, the sparse use of iconic gestures might lead us not to find any difference between young and elderly adults in the use of representational gestures.

Our results showed that elderly adults used more spatial language when they were restricted from gesturing compared to spontaneous speech, whereas young adults produced comparable levels of spatial language in both conditions. The higher use of spatial language when gesture use was restricted in elderly adults is compatible with the account suggesting that gestures are used to supplement and/or complement the speech. That is, when gestures convey the imagistic properties of spatial events, this information can be omitted from speech (Melinger & Levelt, 2004; Graham & Heywood, 1975). Our results, however, did not find support for the Information Packaging Hypothesis (Kita, 2000) or the Lexical Retrieval Hypothesis (Hadar & Butterworth, 1997; Krauss, Chen, & Gottesman, 2000). On the other hand, our findings from young adults did not support any of accounts regarding the relation between speech production and gesture restriction. For young adults, gesture restriction did not affect their spatial speech production. However, we found that the gesture and speech production were positively correlated in young adults. Thus, young adults, who produced more gestures (possibly high in spatial skills) could use more spatial information overall.

Why does gesture restriction influence only elderly adults' speech? We cannot answer this question with certainty, but state some possible explanations. First, people's general verbal skills could be related to their gesture use. Hostetter and Alibali (2007) found that people with low verbal skills produced gestures to facilitate their speech, yet people with high verbal skills only supplemented their speech with gestures. Thus, elderly individuals who had high verbal skills could produce more spatial information in a gesture prohibited context. This does not necessarily explain the difference between young and elderly adults, which require future studies to find answers. Second, not only verbal abilities, but also spatial skills (e.g., Chu & Kita, 2011; Chu et al., 2014) or working memory and spatial integration in visual processing (Andersen & Ni, 2008; Copeland & Radvansky, 2007) could play a role in how people benefit from gestures. Increased problems in working memory and visual-spatial problems might particularly be a problem in the elderly group. Again, we did not examine the participants' spatial skills or working memory in the current study, hence we cannot make a conclusion regarding this issue. Future studies should investigate skill differences between these age groups to draw stronger conclusions. Also, the composition of our two different age groups in terms of sex might create a problem in the interpretation of findings. Finally, even though we told everyone not to gesture, it is possible that some people might have moved other body areas such as lips, eyes or parts of the body (Rimé et al., 1984).

Taken together, the present study provided new evidence for the role of gesture restriction on spatial language use from young and elderly adults. Surprisingly, we did not find detrimental effects of gesture prohibition on spatial language use in either groups. On the contrary, elderly people benefited from not using gestures. These findings suggest that gestures might serve different purposes for young and elderly people in the context of spatial language use.

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