Grammatical Complexity and Gesture Production of Younger and Older Adults

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ABSTRACT: Age-related effects are observed in both speech and gesture production. Older adults produce grammatically fewer complex sentences and use fewer iconic gestures than younger adults. This study investigated whether gesture use, especially iconic gesture production, was associated with the syntactic complexity within and across younger and older age groups. We elicited language samples from these groups, using a picture description task (N=60). Results suggested shorter and less complex speech for older than younger adults. Although the two age groups were similar in overall gesture frequency, older adults produced fewer iconic gestures. Overall gesture frequency, along with participants' ages, negatively predicted grammatical complexity. However, iconic gesture frequency was not a significant predictor of complex syntax. We conclude that each gesture might carry a function in a coordinated multimodal system, which might, in turn, influence speech quality. Focusing on individual differences, rather than age groups, might unravel the nature of multimodal communication.

Keywords: gesture, speech, grammatical complexity, aging

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Genç ve Yaşlı Yetişkinlerde Sözdizimsel Karmaşıklık ve Jest Kullanımı

ÖZ: Dil kullanımında yaşa bağlı etkiler hem sözlü dil hem de jest üretiminde gözlenir. Yaşlı yetişkinlerin sözdizimsel olarak karmaşık cümleleri genç yetişkinlere oranla daha az ürettikleri ve daha az ikonik (temsili) el jesti kullandığı gözlemlenmiştir. Bu çalışma, jest kullanımının (özellikle ikonik jest kullanımının), genç ve yaşlı yaş grupları içinde ve arasında sözdizimsel karmaşıklık ile ilişkili olup olmadığını araştırmaktadır. Bu çalışmada, iki yaş grubundan katılımcılardan (N = 60) üç farklı soyut resmi anlatmaları istenmiştir. Sonuçlar, genç yetişkinlerin yaşlı yetişkinlere oranla daha fazla sözdizimsel olarak karmaşık cümle kullandığını gösterdi. Her ne kadar iki yaş grubu genel jest sıklığında benzer olsa da yaşlı yetişkinler daha az ikonik jest üretti. Ayrıca, yaş grubundan bağımsız olarak, genel jest kullanımının sözdizimsel karmaşıklığı negatif yönde yordadığı bulunmuştur. Fakat, özel olarak ikonik jest kullanımı, karmaşık sözdiziminin önemli bir belirleyicisi değildi. Bu çalışma, farklı jest türlerinin farklı yaş grupları için değişken ve çeşitli işlevler taşıyabileceğini, jest ve sözlü dil arasındaki ilişkinin ise yaşa bağlı bilişsel değişimlerden etkilenerek farklılaşabileceğine dikkat çekmektedir.

Anahtar sözcükler: jest, sözlü dil, sözdizimsel karmaşıklık, yaşlanma

1 Introduction

Individuals communicate multimodally as speech production process is mostly accompanied by hand movements called co-speech gestures. How and when speech and gesture are combined to convey a message, and whether these two modalities represent one single system or not have been popular questions in the literature (Alibali et al., 2000; Hostetter & Alibali, 2008; Kita, 2000; Kita & Özyürek, 2003; McNeill, 1992). Speech and gesture might rely on the same system as they are semantically and temporally coordinated (McNeill, 1992). On the other hand, the two modalities might originate from separate systems that deeply interact with each other (e.g., Kita & Özyürek, 2003). Research has suggested that gesturing might help speech production (Krauss et al., 2000; Özer et al., 2017; Rauscher et al., 1996), particularly when individuals explain concepts that are hard to conceptualize (Kita et al., 2017; Morsella & Krauss, 2004). However, the nature of the interplay between speech and gesture production mechanisms remains unclear. Research demonstrated that using gestures affect the speech quality as people are more fluent (Rauscher et al., 1996) and produce syntactically more complex sentences when they gesture (Jenkins et al., 2017). Experimentally restricting hand use is linked to the production of less complex sentences, suggesting that gesturing decreases

cognitive load and thus, enables individuals to construct complex forms of grammar (Jenkins et al., 2017).

Although multimodal communication has been widely targeted in the adult population, there is limited research on multimodal communication of different age groups, such as in healthy aging (e.g., Arslan & Göksun, 2021, 2022; Cohen & Borsoi, 1996; Feyereisen & Havard, 1999; Schubotz et al., 2019, 2020). Language use, both speech and gesture, undergoes certain changes as people age. For example, older adults' discourse is mostly composed of grammatically simple sentences (Kemper, 1987; Kemper et al., 2001), and they produce fewer complex gestures (e.g., iconic gestures that refer to concrete or abstract notions such as drawing a circle with fingers to mean ball) compared to their younger counterparts (Cohen & Borsoi, 1996; Feyereisen & Havard, 1999). It is because their language skills are negatively affected by a decay in cognitive resources (Burke & Shafto, 2004). Therefore, constructing grammatically complex sentences and producing complex forms of gestures (e.g., iconic gestures) might be challenging for older individuals. Given the close link between gesture and speech in language production, healthy aging might provide an interesting picture into the interplay between speech and gesture. Thus, further research is required to understand whether speech-gesture coordination reveals different patterns across younger and older age groups.

This study focuses on speech and gesture production of younger and older adults when they describe paintings. To better understand the possible interplay between speech and gesture across different age groups, we inquire whether and how (1) grammatical (syntactic) complexity and (2) gesture use, particularly the use of iconic gestures differs across younger vs. older adults. We also ask whether and how (3) gesture use and grammatical complexity are related across younger vs. older age groups.

1.1 The Basics of Gesture

Gestures can be defined as a form of nonverbal communication tool that consists of hand, head, or body movements. Our focus in this study, like in many others, is on hand movements that accompany speech. McNeill (1992) differentiated among different co-speech gesture types. *Iconic gestures* are hand movements that refer to concrete or abstract notions (e.g., drawing a circle with fingers to mean ball or leaving a large space between two hands to mean a big idea). There are also *pointing gestures* (e.g., pointing at something with finger(s) or hand(s)) and *beat gestures*, which are rhythmical hand movements that go along with the prosody of speech without directly carrying a propositional content. On the other hand, an *emblem* conveys a message understood by almost everyone without a need for a verbal statement (e.g., thumbs-up sign to mean okay). Among these gestures, iconic gestures are suggested to be complex forms that are closely and

positively linked to one's language skills (Kita & Özyürek, 2003; Özer & Göksun, 2020). Iconic gestures also emerge late in developmental timeline compared to other gesture types (Iverson et al., 1994; Nicoladis et al., 1999; Özçalışkan & Goldin-Meadow, 2005). These gestures are cognitively more demanding than pointing gestures as they require to link a referent and its affordances with the gesture form (Özçalışkan et al., 2012).

1.2 Gesture and Speech in Interaction

From a developmental perspective, gestures are considered to aid early language skills, as children combine gestures with words in the way of achieving language competency (Iverson & Goldin-Meadow, 2005). Gesture-word combinations help children express complex ideas that they cannot produce solely with words yet (Özçalışkan & Goldin-Meadow, 2005). Using gestures with words might also save cognitive effort (Goldin-Meadow et al., 2001), improving children's ability to construct linguistically complex forms.

Previous research with adults has also suggested that using gestures, particularly iconic gestures, might enhance the speech production process by facilitating lexical retrieval (Krauss et al., 2000; Morsella & Krauss, 2004; Rauscher et al., 1996). Gestures also help individuals conceptualize information by activating, manipulating, and packaging information units (Kita et al., 2017). When individuals gesture, their task performance increases, particularly for the spatial content (Chu & Kita, 2011). As tasks become more difficult, people gesture more and use more iconic gestures to handle the cognitive load (Melinger & Kita, 2007) and ease the conceptualization of stimuli (Kita & Davies, 2009). Iconic gestures might come into play where the demand for working memory sources is high.

Gesturing might also aid individuals form mental images in working memory and ease word retrieval (Wesp et al., 2001). People gesture more when they describe images that are not visually present (Morsella & Krauss, 2004; Wesp et al., 2001) as removing stimuli requires people to recreate the image in their working memory to describe it. Similarly, restraining gesture use impairs the language production process, resulting in disfluent speech segments (Morsella & Krauss, 2004; Özer et al., 2017; but also see Avcı et al., 2022). These findings together suggest that gesture and speech production are closely related as gestures enhance speech production processes.

Gesture use is also associated with the grammatical complexity of speech. Jenkins et al. (2017) examined the content, length, grammatic complexity, and organization of adults' narratives. In one condition, participants spontaneously gestured, and in the other, gesture use was restricted by instructing subjects to grip the bottom of their seats. They found that individuals' narratives were similar in terms of length and content across the two conditions. However, their

discourse was better organized and grammatically more complex in the spontaneous gesture condition than in the gesture restricted condition. One could suggest that gesturing might facilitate conceptualization and save cognitive sources, enabling individuals to construct more complex sentences. It is important to note that although Jenkins et al. (2017) focused on gesture use, they did not differentiate between specific gesture categories.

In sum, gesture use might facilitate speech production processes which are manifested in better conceptualization of the message-to-be-spoken, more fluent speech and higher grammatical complexity.

1.3 Aging and Multimodal Language

Individuals' cognitive and motor skills are influenced by the aging process (Mather, 2010). Age-related changes are also observed in speech (Burke & Shafto, 2004). Older adults experience more tip of the tongue states (Burke et al., 1991) and reveal higher disfluency rates than younger adults (Bortfeld et al., 2001). Older adults also produce fewer grammatically complex sentences than their younger counterparts (Kemper, 1987; Kemper et al., 2001). Although younger and older age groups gesture at comparable rates, older adults use fewer representational gestures (e.g., iconic concrete and abstract) than younger adults (Arslan & Göksun, 2021; Cohen & Borsoi, 1996; Feyereisen & Havard, 1999).

Age-related changes in syntactic complexity have been studied across several tasks. In a longitudinal study, Snowdon et al. (1996) obtained autobiographical writing samples from individuals first when they were in their 20s and then again after 58 years. The writing samples of the first time point were grammatically more complex than the ones at the second time point. Studies using storytelling and picture description tasks to obtain speech samples from healthy adults reveal complementary results. When participants were asked to tell stories, older adults produced shorter and grammatically fewer complex sentences than middle-aged and younger adults (Kemper et al., 1990). Similarly, Marini et al. (2005) showed that both in a single and a sequential picture description task, the grammatical complexity of speech was lower in the older age group than the younger and the middle-aged adults (see also Cooper, 1990). However, studies using life story interviews reveal mixed results. Glosser and Deser (1992) showed that although older individuals' speech was syntactically less complex than speech of middle-aged adults, the difference was not statistically significant. In contrast, Kynette and Kemper (1986) showed that 50-year-old adults produced grammatically more complex speech than 70- and 80-year-olds, who rather relied on simple grammatical forms. Together, these findings suggest that age of the individuals seem to be a factor of older adults' complex language use.

Previous research has suggested that age group differences in language production appear mostly when individuals perform a cognitively demanding

task (Arslan & Göksun, 2021; Bortfeld et al., 2001), in which they are constrained by the context of their upcoming linguistic output (Kemper et al., 2011). Constrained tasks, such as picture description, are cognitively demanding as they narrow down the context by requiring individuals to inhibit responses related to personal experiences (for a review, see Mortensen et al., 2006). Although younger and older individuals' speech samples are mostly similar when they talk about their personal experiences (Arbuckle et al., 2000), older adults have some difficulties in picture naming and description tasks (Mortensen et al., 2006). Similarly, Arslan and Göksun (2021) showed that younger and older age groups' representational gesture use differed only when individuals described an address rather than their daily activities. Therefore, using either spatial or constrained tasks might be critical to grasp age group differences in speech and gesture production.

Studies focusing on age-related changes in language mostly target either speech or gesture production. It is important to examine gesture and speech in a relational manner across different age groups as speech and gesture are coordinated both during language production and comprehension (McNeill, 1992). They bidirectionally influence each other by serving as a context for the interpretation of the other (Hostetter & Alibali, 2008; Kita & Özyürek, 2003; Krauss et al., 2000). Özer and colleagues (2017) examined how younger and older adults' spatial speech (describing routes on a map) change across spontaneous-gesture and restricted-gesture conditions. Results showed that younger and older adults used comparable levels of gestures in their spontaneous route descriptions. However, older adults produced more spatial speech (e.g., landmark, direction) when they were restricted to use gestures compared to their spontaneous speech, whereas young adults produced comparable levels of spatial language in both conditions. This suggests that gesture use might be important for speech production processes, particularly for older individuals. In a similar vein, older adults' use of fewer iconic gestures (Arslan & Göksun, 2021, 2022; Cohen & Borsoi, 1996, Feyereisen & Havard, 1999) might be linked to their decreasing syntactically complex sentence production.

1.4 The Present Study

Understanding the effects of aging on language requires a multimodal approach (see Göksun et al., 2022). This study examines age-related effects on multimodal communication by focusing on the link between gesture production and grammatical complexity of speech across younger and older adults. We ask whether gesture use is associated with the grammatical complexity within and across the age groups. Since difficult tasks elicit more gestures (Kita & Davies, 2009; Melinger & Kita, 2007) and reveal age group differences in language

(Arslan & Göksun, 2021; Bortfeld et al., 2001), we used a picture description task consisting of three paintings with abstract contents.

We expect that (1) older adults would produce grammatically less complex speech than younger adults (Kemper et al., 1990; Marini et al., 2005), (2) although the two age groups might gesture at similar rates, older adults would use less iconic gestures compared to younger age group (Arslan & Göksun, 2021; Cohen & Borsoi, 1996; Feyereisen & Havard, 1999). For the relation between gesture use and grammatical complexity, we expect gesture use to predict the grammatical complexity of speech either positively as in Jenkins et al., (2017), or negatively as individuals with high verbal skills use fewer gestures (Hostetter & Alibali, 2007). However, since iconic gestures are generally studied in relation to facilitate conceptualization (Kita et al., 2017) and speech production (Krauss et al., 2000), we hypothesize that the use of iconic gestures, observed less frequently in older adults, would also be positively associated with more complex speech.

2 Methods

2.1 Participants

We tested a total of 60 healthy Turkish native speakers. Half of them were younger (17 females), and the other half were older adults (16 females). The age range for younger adults was 18-25 (*M*age = 21.43, *SD* = 1.38) and for older adults was 60-75 (*M*age = 65.97, *SD* = 4.45). To check whether older adults revealed a sign of cognitive impairment, we used the Standard Mini Mental Test (Güngen et al., 2002). All participants in the older age group scored higher than 25 out of 30 while the cut-off score was 24. The study was approved by the XX University Ethical Committee on Human Research (2018.276.IRB3.195). Informed consents of participants were obtained before the experiment. We gave 1 course credit to individuals who participated through the university's subject pool. The rest of the participants volunteered to participate and did not receive a reward in return.

2.2 Materials

A picture description task composed of A4 size pictures of three paintings (Appendix A) was used to obtain spontaneous gesture and speech samples. The pictures were acquired via online search. We mainly aimed to use abstract pictures since abstract contexts frequently elicit gestures (Kita & Davies, 2009; Melinger & Kita, 2007). We conducted an online norming study with 35 adults to check whether these pictures were viewed abstract. They were asked to rate the pictures from 1 (totally abstract) to 5 (totally concrete). As we expected, the

pictures were rated as being close to the abstract end of the rating scale (M = 1.65, SD = 0.51).

2.3 Procedure

Participants were asked to sit in front of a table and fill a demographic form. We then gave them three A4 size painting pictures and asked them to describe each picture. Participants were free to choose the order of the pictures. We asked participants to leave some space between the table and their seats to ensure that their hands are visible and free. For the same reason, we asked them not to hold the pictures but to use the holder to place them. However, we did not mention anything related to speech or gesture production to prevent a bias. Participants completed the picture description task in a seated position. There was no time limitation. The sessions were videotaped for transcription and coding.

2.4 Coding

2.4.1 Grammatical (syntactic) complexity

For each participant, we transcribed Turkish speech samples in Microsoft Excel files. We used the coding schema of Berman and Slobin (1994) by parsing discourse into *verbed clauses*, "…expressing a single situation (activity, event, or state)" (Berman & Slobin, 1994, p.660) and placing them sequentially per line. A clause consists of at least one predicate. If a clause included a single predicate, it was coded as a simple clause (e.g., *There are different colors*). If, under a single clause, two or more predicates were linked with conjunctions (e.g., and, or, but), adverbials (e.g., while, when), relative clauses (e.g., *I see that there are different colors*), reported speeches, or if-then statements, it was considered a complex clause (for a detailed coding table for the Turkish language, see Kızıldere et al., 2020). It is important to highlight that this coding schema is mainly based on the extent to which the sentences are embedded, and it does not concern with the number of morphemes, functional categories, and argument structures. The total number of complex clauses was divided by the total number of clauses to calculate the grammatical complexity score for each participant. The coding was done by two trained assistants. Another trained assistant independently coded 20% of participants with a high interrater reliability both with the first (r = .99, p < .001), and the second coder (r = .99, p < .001).

2.4.2 Gesture

We used ELAN software (Lausberg & Sloetjes, 2009) to code gestures. We coded iconic gestures, along with deictic, beat, and emblem gestures (McNeill, 1992). All participants' gestures were coded both by the first author and a

research assistant. The gesture rates suggested by the coders were strongly correlated ($r = .87$, $p < .001$). The interrater agreement was also high in terms of categorizing gestures ($\kappa = .86$, $p < .001$). We then counted the total number of words each participant produced to describe paintings. The overall gesture frequency was calculated for each participant by dividing the total number of gestures by the total word count. Gesture frequency for specific categories was also calculated per words.

3 Results

3.1 Speech

We conducted an independent samples *t*-test to see whether younger and older adults differed in terms of the total amount of speech produced. Results indicated that younger adults ($M = 223.83$, $SD = 100.66$) produced more words than older ones ($M = 115.33$, $SD = 85.43$), $t\ (58) = 4.50$, $p < .001$, $d = 1.16$.

3.2 Grammatical Complexity of Speech

We carried out an independent samples *t*-test to examine whether the proportion of complex clauses in the total number of clauses differed between the younger and the older age groups. Results showed that younger adults' speech ($M = .50$, $SD = .21$) was grammatically more complex compared to those of older adults ($M = .39$, $SD = .22$), $t\ (58) = 2.00$, $p = .050$, $d = .51$.

3.3 Gesture Production

We conducted independent samples *t*-tests to examine whether gesture frequencies differed between the younger and the older adults. Results indicated that younger and older adults were similar in terms of overall gesture frequency, $t\ (58) = .30$, $p > .05$, $d = .08$. However, the frequency of using iconic gestures was higher for the younger ($M = .07$, $SD = .04$) than the older age group ($M = .03$, $SD = .03$), $t\ (58) = 3.64$, $p = .001$, $d = .1.13$.

3.4 Gesture and Speech

We carried out a hierarchical linear regression analysis to predict the grammatical complexity of speech samples. The predictor variables were age group (younger or older) and overall gesture frequency. Results indicated a significant regression equation, $F\ (2,59) = 5.70$, $p = .006$, with an R^2 of .167. Both age group ($\beta = -.267$, $p = .032$) and overall gesture frequency ($\beta = -.320$, $p = .011$) significantly predicted the grammatical complexity of speech. Adding

the interaction term between age group and overall gesture frequency to the model did not change the results, and this interaction was not significant (β = .421, $p > .05$). When we ran the same regression analysis replacing the overall gesture frequency with iconic gesture frequency, the model turned out to be non-significant, F (2,59) = 3.02, $p > .05$, with an R^2 of .096. Bivariate correlations among these variables indicated that grammatical complexity was significantly negatively associated with overall gesture frequency, p = .016, but not with iconic gesture use, $p > .05$ (see Table 1).

Table 1. Correlations for main variables

	1	2	3
1. Grammatical complexity	-	-	-
2. Overall gesture frequency	-.309*	-	-
3. Iconic gesture frequency	-.050	.680**	-

Note. *p<.05; **p<.001; N = 60.

4 Discussion

This study examined grammatical complexity and spontaneous gesture production of younger and older adults by a picture description task. We investigated whether grammatical complexity and gesture use differed between the two age groups and whether gesture use, especially iconic gesture production, was associated with the use of complex syntax. We found that younger adults produced more words to describe paintings, and their discourse was grammatically more complex than older adults'. Although the two age groups' gesture rates were comparable, older individuals less frequently used iconic gestures than younger ones. We also showed that, regardless of age, overall gesture frequency negatively predicted the grammatical complexity. However, iconic gesture frequency was not a significant predictor of the use of complex syntax.

As we expected, using a structured picture description task revealed age group differences both in speech and gesture production. Since the task required focusing on a single domain, it restricted individuals to mention their daily activities or past experiences. In our study, older adults' speech was shorter and less complex than their younger counterparts, suggesting that producing a syntactically complex sentences while abiding by a specific context was relatively more difficult for the older age group (Kemper et al., 1990; Marini et al., 2005). Similarly, in line with Arslan and Göksun (2021), using a constrained and difficult task elicited age group differences not in overall gesture frequency but in iconic gesture use. The painting pictures we used were not easy to conceptualize as they were abstract paintings. As gestures mostly come into play when the conceptualization load is high (Kita & Davies, 2009), using a difficult

task, as in our study, encouraged gesture production and revealed age-related differences in gesture.

Our results partially support Jenkins et al. (2017) as we found that overall gesture use was associated with syntactic complexity. However, although Jenkins et al. (2017) suggested a positive association between the use of both modalities, we found that, regardless of age, overall gesture frequency negatively predicted the grammatical complexity of speech. There can be different reasons for these contrasting findings. First, the results of Jenkins et al. (2017) might not be conclusive as it is based on only ten adults. Our sample size is larger as we recruited thirty younger and thirty older adults. Second, Jenkins et al. (2017) used a sequential picture description task, where participants described the pictures of a storybook. Different from the single picture tasks, sequential picture description tasks encourage narrative production as they consist of a series of events that are contextually and temporally related (Capilouto et al., 2005). Although Marini et al. (2005) did not find an effect of using sequential or single picture tasks on syntactic complexity with older adults, the pictures we used did not include simple items such as the commonly used Cookie Theft picture (Goodglass & Kaplan, 1983). Rather, the pictures we presented were relatively abstract, irrelevant to each other, and difficult to conceptualize. Therefore, increased task difficulty in our study might have interacted with cognitive mechanisms associated with multimodal language, indicating a different aspect of gesture and speech interaction.

If gesture and speech represented a single unified system (McNeill, 1992), we would expect syntactic complexity to increase when more gestures are produced, as in Jenkins et al. (2017). However, the negative association between gesture frequency and grammatical complexity in our study signal that gesture and speech might be originated from different but interrelated mechanisms (Kita & Özyürek, 2003). Individuals might differ from each other in terms of using verbal and gestural communication tools. For instance, people with lower verbal but higher visuospatial skills were found to gesture more (Hostetter & Alibali, 2007). Therefore, understanding individual differences in cognitive skills might be critical to understand the gesture-speech interaction (Özer & Göksun, 2020). Unlike Jenkins et al. (2017) that solely focused on overall gesture production, we further differentiated between gesture categories by focusing on the iconic gesture category. As iconic gestures facilitate lexical retrieval (Krauss et al., 2000) and the conceptualization process (Kita et al., 2017), we hypothesized that older adults' fewer iconic gesture use might be associated with their decreased syntactic complexity. However, iconic gesture frequency did not predict to what extent individuals produced complex syntax. These findings lead us to draw two conclusions. First, carrying a propositional content might not be unique to iconic gestures. As each word has a function in speech, each gesture might have a role in a coordinated multimodal system, which might, in turn, influence speech

quality. Second, rather than studying gesture and speech interaction from an age group perspective, focusing on individual differences might be essential. The effects of aging on multimodal communication might be mediated by individual differences in cognitive skills (for a review, see Özer & Göksun, 2020).

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Appendix

Before the Caves by Helen Frankenthaler

Autumn Landscape by Ralph Rosenborg

Astral Nebula by Hans Hoffman