Referential Production Across the Adult Lifespan: A Virtual Reality Study

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Abstract

Speakers often use modifiers (e.g., color) to distinguish objects, even when such details are unnecessary. Overspecification was traditionally viewed as inefficient, but contemporary accounts suggest it may be adaptive because modifiers can aid comprehension. Prior work also shows that modifier use changes with age, with older adults overspecifying more than younger adults. However, little is known about modifier use across the lifespan, including middle adulthood, or in realistic settings, as most studies rely on simple 2D displays. To address these gaps, we examined referential production across the adult lifespan in an immersive virtual environment, where participants described everyday objects paired with either a competitor differing in color or state, or an unrelated object. Overall, participants exhibited high overspecification rates, with only a modest increase in middle and older ages and no robust age effects on expression length or modifier use, offering new insights into real-world communication across the adult lifespan.

Keywords: referential production; overspecification; lifespan; virtual reality

Introduction

Imagine you are sitting in a café and ask a friend to pass you a cup. When only one cup is present, a basic noun (e.g., cup) is sufficient for your friend to identify the object of reference. When multiple cups are present, an additional modifier (e.g., yellow cup) becomes necessary to support successful identification. However, speakers frequently include such modifiers even when they are not required for disambiguation. For instance, referring to the yellow cup when only a single cup is present in the context. The inclusion of redundant modifiers conflicts with Grice's (1975) Maxim of Quantity, which posits that speakers should provide sufficient information for the listener to accurately identify the referent, but no more than is required.

To date, a large body of work suggests that speakers often go beyond what is strictly required to disambiguate referents, a phenomenon known as overspecification (Pechmann, 1989). Modern theories suggest the inclusion of redundant modifiers is a cooperative behavior (Jara-Ettinger & Rubio-Fernandez, 2022; Rubio-Fernandez, 2019). Such modifiers have been shown to guide visual attention, facilitate faster object identification, and support global comprehension, particularly in visually complex scenes (Rehrig et al., 2021). This perspective challenges traditional views of efficient communication by redefining efficiency not in terms of speaker brevity, but in how language supports robust comprehension for the listener.

Modifier Type

Color has been shown to be the most frequently produced modifier type, regardless of whether it is required for disambiguation (Degen et al., 2020; Heller, 2020; Saryazdi et al., 2019; Tarenskeen et al., 2015). Color may be particularly useful in facilitating listener comprehension because it is perceptually salient (Jara-Ettinger & Rubio-Fernandez, 2022; Koolen et al., 2013; Rubio-Fernandez, 2016) and readily accessible during utterance planning. Importantly, speakers have been observed to overspecify using color in visually complex scenes, suggesting that speakers rely more heavily on salient modifiers when referent identification is more challenging (Degen et al., 2020; Elsner et al., 2018; Koolen et al., 2013).

Beyond color, speakers also produce a range of other modifier types in referential expressions, such as size, shape, and pattern (Long et al., 2020; Rubio-Fernandez, 2019), reflecting a broader tendency to use contextually relevant features when describing referents. These modifiers describe relatively stable and perceptually relevant characteristics. In contrast, state modifiers (e.g., open mailbox, dirty shirt) are transient in nature, as they describe changeable or functional properties of an object. Recent work has shown that speakers produce state modifiers when they are contextually relevant (Parker & Heller, 2019; Saryazdi et al., 2021; Thompson et al., 2023). Furthermore, there is also evidence that the age of the speaker can influence the use and selection of modifiers (Saryazdi et al., 2019).

Aging and Overspecification

Older adults have been shown to produce higher rates of overspecification compared to younger adults and exhibit greater variability in the types of modifiers they produce (Saryazdi et al., 2019). Several accounts have been proposed to explain why older adults tend to overspecify more often than younger adults.

One explanation, grounded in the Transmission Deficit Hypothesis (Burke & Shafto, 2004), suggests that age-related weakening of linguistic representations leads to inefficiencies in language production. To compensate, older adults may

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include additional descriptors, resulting in greater overspecification. However, evidence that older adults use more postnominal modifiers compared to younger adults is not fully consistent with the compensatory account. Cooperative accounts propose that older adults' broader and more variable modifier use reflects a strategic effort to facilitate listener comprehension (Rubio-Fernandez, 2019; Thompson et al., 2023). Under this view, access to a broader vocabulary (Kavé et al., 2022) and greater semantic knowledge may enable older adults to draw on a wider set of descriptive features, including less common modifier types (e.g., gender, such as "men's") to facilitate successful communication. What remains unclear is whether the age-related differences are evident across the adult lifespan (including middle-age). Thus, more research is needed to understand how modifier use changes across the adult lifespan and in more realistic contexts.

Referential Production in the Virtual World

To date, research on modifier use in referential communication has primarily relied on highly controlled, 2D paradigms using static images (Long et al., 2020; Rubio-Fernandez, 2019; Thompson et al., 2023, Yoon et al., 2021). Although informative, these paradigms may not adequately capture the complex contexts in which language production naturally occurs. In everyday communication, speakers produce referential expressions in dynamic, spatially rich environments, raising the question of whether patterns of redundant modifier use observed in these highly controlled settings generalize to more realistic environments.

Recent advances in virtual reality (VR) offer a promising solution to this limitation. VR allows us to create immersive 3D environments that more closely resemble everyday communicative settings, such as homes and workplaces (Peeters, 2019; Titus et al., 2024). At the same time, VR affords a high degree of experimental control, as virtual objects and environments can be precisely manipulated and reproduced across participants (Peeters, 2019). Consequently, VR serves as a critical tool for advancing our understanding of natural language production.

The present study uses an immersive VR paradigm to investigate whether speakers continue to produce modifiers (color vs. state) when referring to objects in more realistic 3D environments. A central goal is to characterize how referential production changes across the adult lifespan. To address this question, we included younger, middle-aged, and older adults, allowing for a more continuous assessment of age-related patterns in referential production. By moving beyond simplified 2D displays and binary age comparisons (e.g., younger and older comparison), the present study provides a comprehensive test of how realistic contexts and age-related factors jointly shape referential production.

Method

Participants

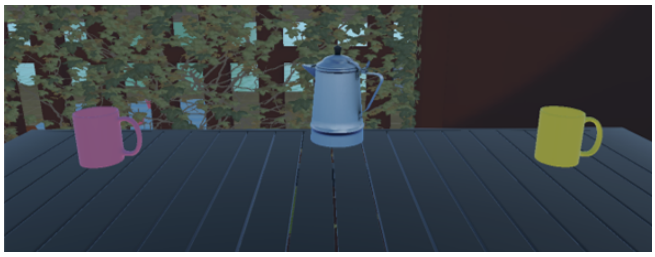
The current study recruited participants across the adult lifespan. The final sample includes 85 participants ranging from 18 to 84 years old (M = 47.32, SD = 21.61). For descriptive purposes, participants were categorized into three age groups representing different stages of adulthood: younger adults (18 – 39 years), middle-aged adults (40 – 64 years), and older adults (65 years and older). This categorization resulted in 31 younger adults (M = 21.52, SD = 4.16, *range* = 18 to 34), 26 middle-aged adults (M = 53.13, SD = 6.93, *range* = 41 to 63), and 28 older adults (M = 70.98, SD = 5.13, *range* = 65 to 84). Younger adult participants were primarily recruited through Trent University's student participant pool and received partial course credit for their participation. The remaining younger, middle-aged, and older adult participants were recruited through community and were compensated with a $25 gift card for their time. All participants were screened for normal or corrected-to-normal vision. Visual acuity was assessed using the Early Treatment Diabetic Retinopathy Study (ETDRS; Ferris et al., 1982); all participants' scores for the better eye were between -0.2 and 0.5 logMAR and considered normal. Color vision was also screened through an online Ishihara color blindness test (Ishihara, 1918), and participants had to score above 70% to be included in the study. Four additional participants were excluded from analyses for not meeting the vision eligibility criteria and were not included in the final sample. All participants reported being native English speakers or having acquired English by age six.

Materials

Participants were immersed in a virtual home environment while wearing a Meta Quest Pro head-mounted display. The experiment was run on a Dell Alienware gaming laptop. Their production data was captured using a dB9 Pro digital voice recorder.

The virtual environment was created using Unity software and consisted of 40 unique indoor and outdoor spaces (e.g., patio, kitchen, bedroom). On each trial, participants were exposed to several everyday objects. Two objects in each trial were experimentally manipulated to include a target object and either a same-category competitor (competitor present) or an unrelated object (competitor absent).

The trials consisted of three conditions: a color competitor condition, a state competitor condition, and a competitor absent condition (Figure 1). In the color competitor condition, objects only differed in terms of their color. In the state competitor condition, the competitor object matched in color but differed in state. In the competitor absent condition, the target object was accompanied by a control object of a completely different category.



Color Competitor Condition: Yellow Cup

State Competitor Condition: Clean Cup

Competitor Absent Condition: Cup

Figure 1: Example Displays in VR Task

In total, the experiment included 10 trials in the color competitor condition, 10 trials in the state competitor condition, and 10 trials in the competitor absent condition. In addition, 10 filler trials were included in the absent condition to balance the present/absent trials. Most of the object states used in the present study were adapted from a previous study that employed 2D versions of the same objects (Thompson et al., 2023).

Procedure

All participants completed a brief pre-screening questionnaire to ensure the safe use of VR. Those with pre-existing health conditions that could compromise the safe use of VR were excluded (e.g., history of seizures, head trauma, or wearing pacemaker). All testing sessions were conducted at Trent University Durham. The study received institutional research ethics board approval (#29132).

After obtaining informed consent, participants completed a demographic and health questionnaire, and a motion sickness questionnaire (Golding et al., 2021; Keshavarz et al., 2019). Participants then completed the aforementioned vision tests. Middle-aged and older adult participants additionally completed the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) as a standardized measure of global cognition.

Participants sat on a swivel chair and received instructions on how to use controllers and perform the task. Next, they wore the VR headset and began the study. On each trial, a red arrow indicated the target object to be described. Participants were asked to imagine they were giving instructions to a future player and phrase their descriptions in the form of *"Select the…"*. Any modifiers deemed appropriate could be used to describe the target object; however, the use of spatial information (e.g., left or right) was discouraged. After a practice trial, participants completed 40 trials presented in a pseudo-randomized order.

In addition to the production task, participants completed a series of cognitive tasks that are not the focus of the current paper. Finally, participants were thanked for their time and received their compensation for participating. The study took place in one session lasting approximately 1.5 to 2 hours.

Results

All referential descriptions were transcribed verbatim and coded for multiple linguistic features. The data was coded for expression length (the number of words in the utterance excluding filled pauses such as uh and um), modifier use (whether or not they used a modifier), modifier count (number of modifiers in the utterance), referential quality (overspecified, sufficient, underspecified), modifier position (prenominal, postnominal, both), and modifier type (e.g., color, state, other). These measures constituted the dependent variables of interest.

Analyses were performed in R version 4.4.3 (R Core Team, 2025). Linear mixed effect models were fitted using the lme4 package version 1.1-37 (Bates et al., 2015). Statistical significance was analyzed using the lmerTest package version 3.1- 3 (Kuznetsova et al., 2017). For each model, competitor condition (present = 1 vs. absent = -1), age (centered continuous variable), and their interaction were included as fixed effects. Subject and item were included as random effects, with random slopes where appropriate. Models that failed to converge or produced singular fit warnings were further simplified.

Expression Length

Expression length was measured by counting the number of words produced in each condition. Values falling more than 2.5 standard deviations from the mean were adjusted to the nearest threshold. The results revealed that participants produced a similar number of words regardless of the competitor condition type (competitor present or competitor absent), *Estimate* = -0.03, *SE* = 0.15, *t* = -0.21, *p* = .831, and age, *Estimate* = 0.01, *SE* = 0.10, *t* = 0.07, *p* = .946. There was also no significant interaction effect, *Estimate* = 0.004, *SE* = 0.01, *t* = 0.51, *p* = .608. To illustrate this, we plotted the relationship between the average number of words and

continuous age (Figure 2). The averages illustrated are prior to outlier replacement for analysis.

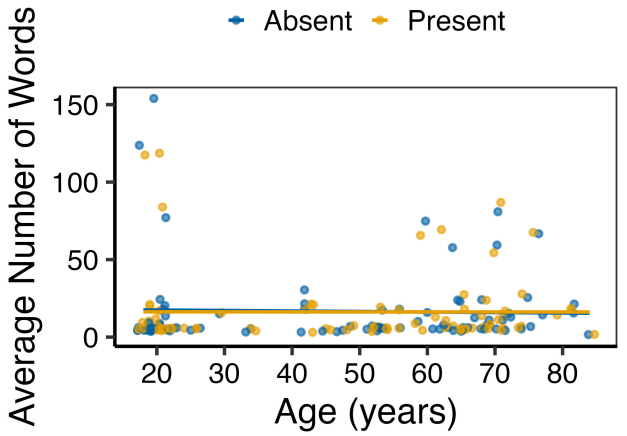


Figure 2: Average Number of Words

Modifier Use

The modifier use was coded according to the presence or absence of at least one modifier in the referential expression (yes = 1, no = 0). We analyzed this binary outcome using a logistic mixed-effect model that included the competitor condition, age, and their interaction as fixed effects. As expected, the model indicated that the presence of a competitor significantly increased the likelihood of producing at least one modifier, *Estimate* = 1.09, *SE* = 0.18, $z = 6.04$, $p < .001$. However, age, *Estimate* = 0.01, *SE* = 0.02, $z = 0.33$, $p = .744$, and the interaction, *Estimate* = -0.01, *SE* = 0.01, $z = -1.39$, $p = .164$ did not significantly predict modifier use. Figure 3 shows a distribution of modifier use across age groups.

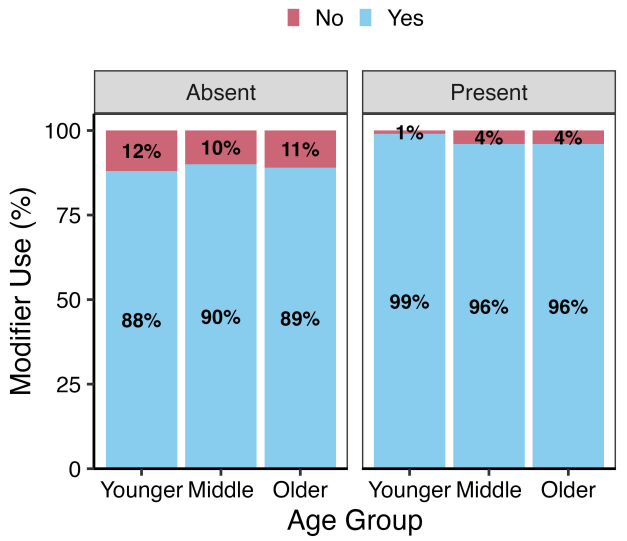


Figure 3: Percentage of Modifier Use

Modifier Count

Next, we examined the number of modifiers produced in participants' referential expressions. Any value more than 2.5 standard deviations above or below the mean was adjusted to the nearest cutoff. The results showed no effect of competitor condition type, *Estimate* = 0.05, *SE* = 0.03, $t = 1.81$, $p = .082$, age, *Estimate* = 0.01, *SE* = 0.01, $t = 0.46$, $p = .647$, and their interaction, *Estimate* = 0.001, *SE* = 0.001, $t = 0.77$, $p = .443$. To illustrate the relationship between age and modifier count across participants, we plotted age as a continuous variable with average modifier count (Figure 4). The plot (data points are prior to outlier replacement) is consistent with the absence of significant age effect observed in the other analyses.

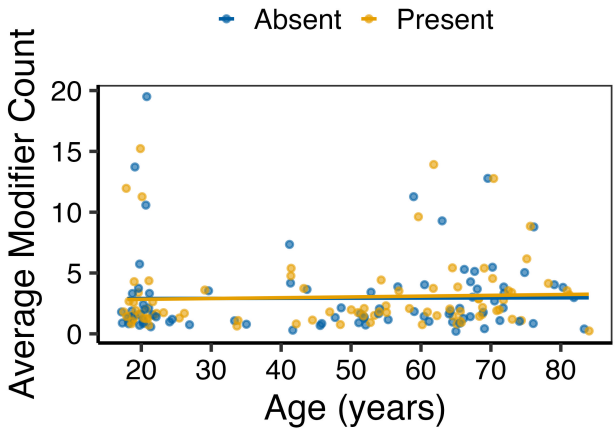


Figure 4: Average Modifier Count

Referential Quality

We further assessed referential quality by coding each expression as sufficient (just enough detail for referent identification), overspecified (more detail than necessary for referent identification), or underspecified (insufficient detail for referent identification). Across all age groups, participants frequently overspecified in their referential expressions. The rate of underspecification was relatively low across all age groups. For the analysis, we excluded underspecification and included a binary measure of whether or not participant overspecified (overspecified = 1, sufficient = 0). The main effect of competitor condition was significant, with participants more likely to overspecify when the competitor was absent, *Estimate* = -0.13, *SE* = 0.01, $z = -9.19$, $p < .001$. There was no effect of age, *Estimate* = 0.001, *SE* = 0.001, $z = 1.18$, $p = .243$. However, there was a marginal effect of age by competitor condition, *Estimate* = 0.001, *SE* = 0.001, $z = 1.93$, $p = .057$. This was mainly driven by performance in the present condition (see Figure 5).

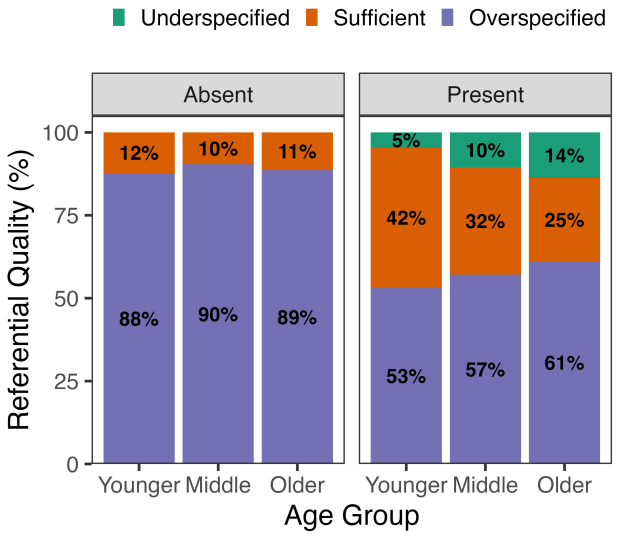


Figure 5: Percentage of Referential Quality

Modifier Position

Descriptive analyses were conducted to further examine the position of modifiers within noun phrases (prenominal, postnominal, or both). The results revealed that younger and middle-aged adults most frequently produced only prenominal modifiers, followed by combined prenominal and postnominal modifiers (Figure 6). Among older adults, the combined use of prenominal and postnominal modifiers occurred most often, followed by only prenominal modifiers. Across all age groups, exclusive postnominal modification was observed least often. However, the use of only postnominal modifiers was more common among older adults.

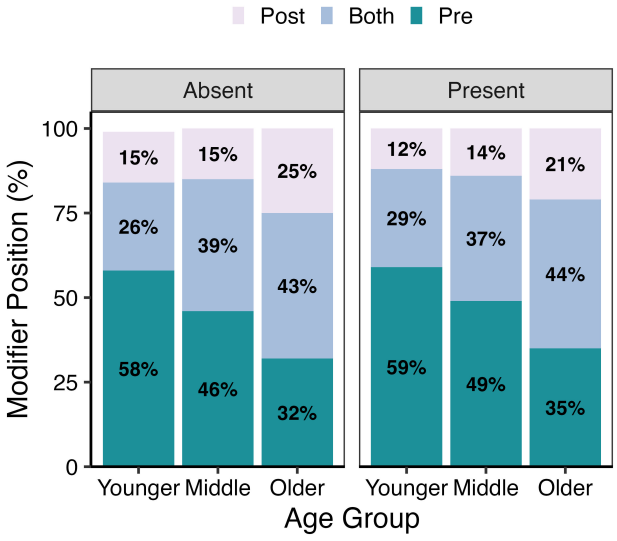


Figure 6: Percentage of Modifier Position

Modifier Type

We additionally examined the types of modifiers produced. Given that we specifically manipulated color and state attributes, we looked at the proportion of color and state modifiers produced. All other types of modifiers were classified as "other." We examined the first modifier in the referential expression, which indicates the most salient feature guiding production. Consistent with previous findings, color modifiers were the most frequently produced across all age groups (Figure 7). State modifiers were used approximately a third of the time in the competitor present condition, reflecting the number of trials in which state was the only differentiating factor. Modifiers classified as "other" were used least frequently but as the figure shows older adults were more likely to use "other" type modifiers.

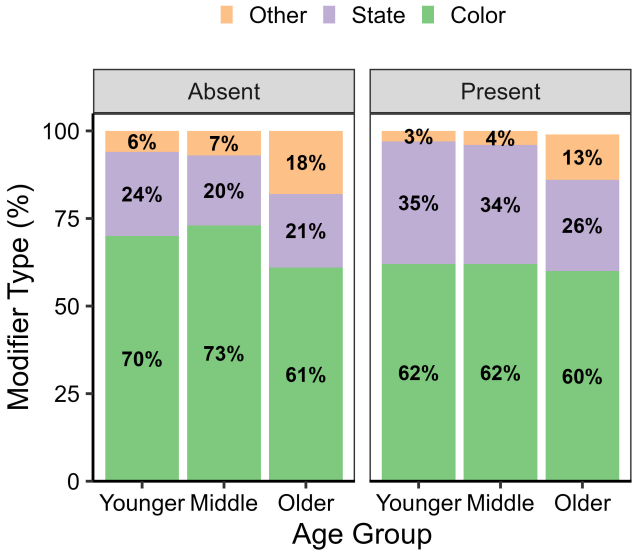


Figure 7: Percentage of First Modifier Type

Discussion

The current study examined whether speakers produce redundant modifiers in more naturalistic communicative contexts and whether referential production varies across the adult lifespan.

First, we examined differences in expression length. Participants produced a comparable number of words across the competitor present and absent conditions and there were no age-related differences. Interestingly, referential expressions in the present study were significantly longer than those reported in the Thompson et al. (2023) which used the same target items in a 2D format (younger = 17.78 vs. 3.18; older = 17.10 vs. 6.02). The immersive virtual scenes likely contributed to this increase, as they introduce greater perceptual complexity and more naturalistic spatial structure

(Peeters, 2019), prompting speakers to rely more heavily on elaborated description.

Consistent with previous findings, participants demonstrated high rates of modifier use, even in the competitor absent condition (Saryazdi et al., 2019; Thompson et al., 2023). Given that participants were instructed to imagine giving instructions to a future player, they may have used redundant modifiers to help guide visual attention and facilitate object identification for an imagined player (Arts et al., 2011). It is also possible that participants treated the VR environment as a privileged internal world rather than a shared communicative context, leading them to provide more detailed descriptions across all conditions.

Analyses of referential quality further support the interpretation that participants produced highly elaborated expressions, with greater overspecification in the competitor absent condition. Age did not have a main effect on the rate of overspecification in our study; however, there was a marginal interaction with competitor condition, with greater increase in overspecification in middle-age and older adults compared to younger adults. These results are consistent with other studies showing that older adults overspecified more than younger adults (Saryazdi et al., 2019; Thompson et al., 2023; Yoon et al., 2026); however, here we show this tendency may emerge earlier, during middle age. Nonetheless, there was no main effect of age, and the interaction effect was small in magnitude. One possibility is that adopting a lifespan approach attenuates age effects that are more apparent in binary younger-older comparisons. In the present study, we show largely similar patterns across the adult lifespan, including middle age. It is also important to note that despite our effort, there is an uneven distribution of participants with our current sample including relatively fewer adults in their 30s and 40s, limiting our ability to truly capture midlife patterns. Ongoing data collection will allow for a more balanced sample and a clearer assessment of developmental trajectories.

Next, we examined the position of modifiers within the referential expression. Younger and middle-aged adults primarily relied on prenominal modification, whereas older adults more often produced expressions that combined prenominal and postnominal modifiers. This pattern mirrors recent findings by Yoon et al. (2026), who similarly observed that older adults were more likely than younger adults to use both prenominal and postnominal modifiers in a single description. This tendency may reflect an age-related shift in planning strategies. By distributing descriptive content across multiple positions, it may help older adults manage planning demands while still producing informative, listener-oriented expressions.

Finally, we explored the type of modifiers produced across age groups. Color modifiers were used most frequently across the lifespan. This pattern aligns with extensive prior work demonstrating a strong preference for color modification in referential communication (Heller, 2020; Tarenskeen et al., 2015; Thompson et al., 2023). The prominence of color modification likely reflects its high perceptual salience and relative ease of integration into referential expressions. Color properties are visually accessible and often sufficient to uniquely identify a referent, making them an efficient communicative choice. Nonetheless, participants in our study produced state modifiers around a third of a time, corresponding to the proportion of trials involving state manipulations. This finding aligns with prior research showing that when state is manipulated, speakers reliably produce state modifiers, but still comparatively less than color modifiers (Saryazdi et al., 2021; Park & Heller, 2019). Interestingly, older adults also produced a great variety of modifier types beyond color and state. This increased diversity of modifier types is consistent with previous work showing a similar pattern when comparing older to younger adults (Saryazdi et al., 2019).

In sum, the current study shows that the use of redundant modifiers, specifically color modifiers, persists in more realistic environments, perhaps even more so than what has been observed in 2D displays. Despite this increase in descriptive detail, we found no main effect of age on expression length, modifier use, and modifier count, which suggests that age-related differences observed in 2D displays may attenuate when explored across the lifespan and in 3D environment. This pattern may also reflect that in richer 3D environments, increased visual complexity leads speakers across age groups to overspecify at similar rates, whereas age differences are more apparent in simplified 2D tasks where fewer salient features compete for attention. Together, these findings advance our understanding of referential production across the lifespan using a novel virtual reality approach that represents more real-world context.

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