AGING AND SIMILARITY-BASED INTERFERENCE IN SYNTACTIC PROCESSING: AN EYE-MOVEMENT STUDY

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INTRODUCTION

* Older adults often show difficulty in understanding complex syntax (Kemper et al., 2006; Stine-Morrow et al., 2000), such as object-relative (OR) constructions (e.g., "The banker that the barber praised climbed the mountain") vs. subject-relative (SR) constructions (e.g., "The banker that praised the barber climbed the mountain"). Gordon et al. (2006) suggested that semantic similarity between concepts that need to be integrated in these structures creates interference in working memory (WM) so as to exacerbate the difficulty in parsing OR clauses. Because studies of age differences in processing SR and OR constructions very often do feature experimental materials with concepts from the same semantic class, we investigated whether such interference contributed to age-related difficulty in processing OR clauses.

METHODS

Participants

* Thirty-six community-dwelling older adults (M=70 yrs, 61-83) and 36 college students (M=23 yrs, 19-37) participated in this experiment. The age groups did not differ in education or vocabulary, but younger adults had better working memory (WM) than the old, t(58)=6.58, p<.001 (see Table 1).

Table 1. Participant Characteristics (numbers in parentheses are SEs).

Age Group	Education	WM	Vocabulary
Young	15.4 (0.4)	6.4 (0.2)	46.9 (1.0)
Old	16.4 (0.6)	4.1 (0.2)	45.0 (1.4)

Materials and Design

* Materials were 48 sentences varying in syntactic complexity (OR vs. SR) and conceptual similarity between the to-be-integrated noun phrases (NP) (Table 2; the critical regions is underlined, and post-critical region is italicized). Four stimulus lists were created in which materials were counterbalanced across conditions. Passages were presented in a single random order for all subjects.

Table 2. Examples of Experimental Materials.

SR/Similar	The **banker** that praised the **barber** *climbed* the mountain just outside of town.
SR/Dissimilar	The **banker** that praised **Sophie** *climbed* the mountain just outside of town.
OR/Similar	The **banker** that the **barber** praised *climbed* the mountain just outside of town.
OR/Dissimilar	The **banker** that **Sophie** praised *climbed* the mountain just outside of town.

Procedure

* Participants read sentences on a computer screen while their eye movements were monitored by an Eye-Link II eye-tracker. After reading a randomly selected third of the sentences, participants answered a Yes/No comprehension question to assure that they read for meaning.

RESULTS

* Dependent variables were Gaze Duration on the critical region (GD; the sum of fixation durations when first encountering the region, reflecting early reading processes), Regression Out Ratio on the post-critical region (ROR: the probability of regressing out of the region to the prior text) and Regression Path Duration for the critical region (RPD; the sum of all fixation durations at the region before going forward, including regressive fixations, reflecting later integration processes).

* GDs on the target region were longer for relative clauses with conceptually similar concepts than for those with conceptually dissimilar concepts, F(1,70)=42.12, p<.001. Subject relative clauses were fixated longer than object relative clauses during initial encoding only when the two NPs were dissimilar, F(1,70)=4.24, p<.05 for the syntax by similarity interaction. Neither the main effect of age nor any age-related interactions were reliable, F<1 for all (see Figure 1).
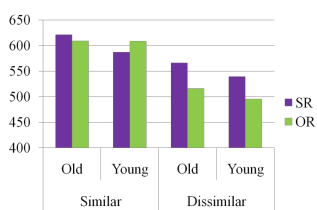

Figure 1. GD at the critical region as a function of Age, Syntax and Conceptual Similarity (in *ms*)

* These counterintuitive findings might be explained by two reasons: 1) Even though readers did not gaze longer at the more complex syntactic structure, they might indeed be more likely to regress to the prior text to fully parse the OR structure;

RESULTS (cont.)

or 2) Readers, regardless of age, initially formed a shallow representation of the syntactic structure ("good enough" representation, Christianson, et al., 2006): when the two NPs were similar, they did not necessarily allocate more time to parse SR clauses than OR clauses; when the two NPs were dissimilar, they actually allocated less time to the more difficult syntactic structures (i.e., OR clauses), t(71)=2.93, p<.01 (see Gordon et al., 2006 for similar findings). The "good enough" representation may result in spill-over effects at the post-critical region.
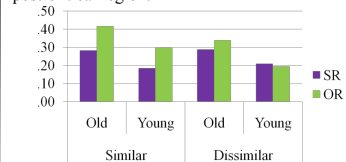

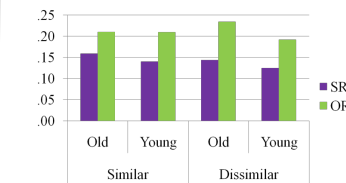Figure 2. ROR at the critical region as a function of Age, Syntax and Conceptual Similarity

Figure 3. ROR at the post-critical region as a function of Age, Syntax and Conceptual Similarity

* As predicted by Hypothesis 1: Readers tended to immediately regress out of the OR clause to adapt to the processing difficulty, F(1,70)=15.20, p<.001, but only when the two NPs were similar, F(1,70)=14.55, p<.001 for the similarity by syntax interaction (see Figure 2); As predicted by Hypothesis 2: When the two NPs were dissimilar, readers were more likely to regress out of the post-critical region (i.e., matrix verb) following an OR clause, F(1, 70)=26.27, p<.001, compensating for the initial shallow representation of the more complex syntactic structure (see Figure 3).

CONCLUSIONS

* There was little age-difference in online eye-movement measures of syntactic processing. Consistent with the similarity-based interference hypothesis, both younger and older adults spent more time integrating the OR structure when the NPs embedded in the sentence sharing semantic features, attempting to build up a *coherent* text representation.

* When the two NPs were dissimilar, readers initially formed a *shallow* or *good-enough* representation of the more difficult syntactic structure (i.e., OR clause), causing the spill-over effect at the post-critical region.

* Older readers' comprehension was especially depressed by the combination of syntactic complexity (OR) and semantic similarity, suggesting that age differences in understanding complex syntax may result in part from a difficulty in controlling interference in WM.

* RPD on the critical relative clause region were longer for conceptually similar clauses than for conceptually dissimilar clauses, F(1,70)=78.04, p<.001. OR clauses took more time to integrate compared to SR clauses, F(1, 70)=9.74, p<.01, but only when NPs were conceptually similar, F(1,70)=34.86, p<.001, for the syntax by similarity interaction. RPDs were longer for the older adults relative to the young, F(1,70)=6.19, p<.05, but the syntax by similarity interaction did not vary with age (see Figure 4).
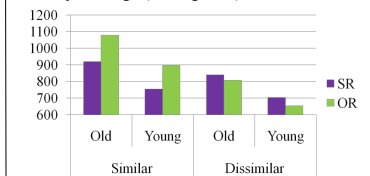

Figure 4. RPD at the critical region as a function of Age, Syntax and Conceptual Similarity (in *ms*)

* Comprehension accuracy was higher for the younger adults, F(1,70)=25.98, p<.001; for sentences containing dissimilar concepts, F(1,70)=5.03, p<.05; and for sentences embedded in simpler syntactic structure (i.e., SR clause), F(1,70)=9.92, p<.01. When the two NPs in the sentence belonged to the same semantic category, older adults' understanding of sentence meaning was disproportionally compromised by the more difficult syntactic structure (i.e., OR clause) compared to that of the young, F(1,70)=4.21, p<.05 for the age by syntax interaction. However this interaction was not reliable when the two concepts contained in the sentence were dissimilar, F<1 (see Figure 5). Paired t-tests indicated comprehension for OR clauses was significantly worse than that for SR clauses only when older adults read relative clauses containing two similar NPs, t(35)=2.97, p<.01.
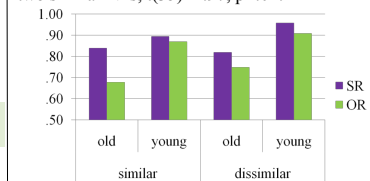

Figure 5. Comprehension Accuracy as a function of Age, Syntax and Conceptual Similarity

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