Reliance on semantic and structural heuristics across the lifespan

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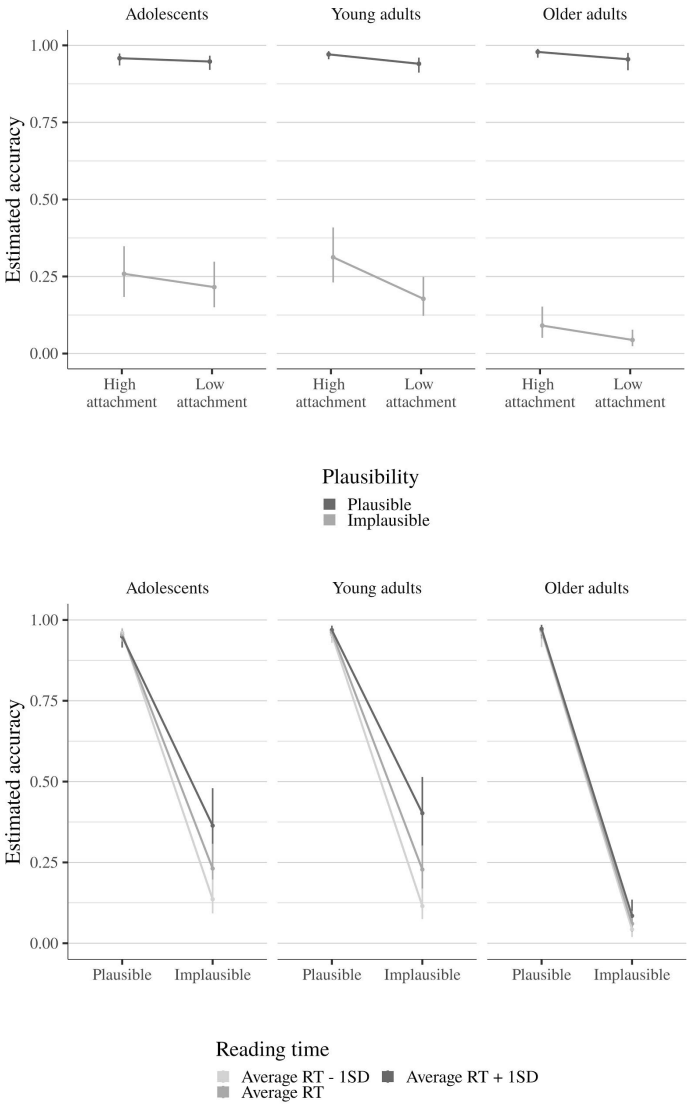
People sometimes misinterpret the sentences that they read. One possible reason suggested in the literature is a race between grammar-driven incremental bottom-up processing and "fast and frugal" top-down heuristic processing that serves to support fast-paced communication but sometimes results in incorrect representations. Heuristics can be semantic, relying on world knowledge and semantic relations between words [1], or structural, relying on structural economy [2]. According to the online equilibrium hypothesis of the good-enough processing theory [3], heuristic-based representations are computed faster than full syntactically-based representations. However, empirical studies have rarely evaluated this assumption directly, by analyzing the relationship between the accuracy of responses to comprehension questions (as an indicator of sentence representation accuracy) and reading speed.

Scattered experimental evidence preliminarily suggests that reliance on heuristics may change from greater reliance on syntactic information in younger people to greater reliance on semantic information in older people. Several studies showed that 7-to-12-year-old children relied on syntactic information and structural heuristics while disregarding semantic plausibility information [4]. At the same time, older adults were shown to rely more on semantic than syntactic information [5].

To test whether reliance on semantic and structural heuristics changes with age and whether heuristic processing is indeed faster than algorithmic processing, we tested three groups of Russian-speaking participants: 137 adolescents (87 female; age range 13-17 years, M=15), 135 young adults (99 female; age range 20–40 years, M=25), and 77 older adults (57 female; age range 55–91 years, M=64). The participants read 56 high- vs. low-attachment sentences that were marked by case inflection, and all stimuli sentences were therefore completely unambiguous (Russian speakers show bias to high-attachment interpretations even in unambiguous sentences, see [6]). The sentences were either semantically plausible or implausible, i.e., the syntactic structure either matched or contradicted the typical semantic relations, see Example 1 (all materials are available online https://osf.io/4f2px/). Sentences were presented in a non-cumulative self-paced reading paradigm and were followed by a two-alternative comprehension question targeting the attachment site of the relative clause.

To assess the reliance on heuristics, we analyzed question response accuracies using Bayesian mixed-effects logistic regression, see the model structure below. As expected, we found that young adults made more errors in the dispreferred implausible and low-attachment conditions. Older adults had lower accuracy than young adults across the board and showed a greater decrease in accuracy in implausible sentences, thus demonstrating increased reliance on semantic heuristics. Adolescents did not differ from young adults in overall accuracy, but had similar accuracy in high- and low-attachment conditions, thus demonstrating the lack of reliance on the structural heuristic of high attachment. We found that when participants read sentences faster, their accuracy decreased. However, specifically in implausible sentences, faster reading times were associated with an additional decrease in accuracy indicating that semantic heuristic processing was faster than incremental bottom-up processing.

To summarize, we showed heuristic mechanisms appear already in adolescence and then keep maturating across the adult lifespan, via emerging reliance on structural heuristics in adulthood and increasing reliance on semantic heuristics in older age. We also for the first time showed that heuristic processing is indeed faster than incremental processing, as predicted by the good-enough processing model.



Example 1:

High attachment, plausible

Rimma dressed the child-ACC of the writer-GEN, who was babbling-ACC incomprehensibly.

Question: Who was babbling incomprehensibly? **Child** / Writer

Low attachment, plausible

Rimma dressed the child-ACC of the writer-GEN, who published-GEN a popular novel.

Question: Who published an interesting novel? Child / **Writer**

High attachment, implausible

Rimma dressed the child-ACC of the writer-GEN, who published-ACC a popular novel.

Question: Who published an interesting novel? **Child** / Writer

Low attachment, implausible

Rimma dressed the child-ACC of the writer-GEN, who was babbling-GEN incomprehensibly.

Question: Who was babbling incomprehensibly? Child / **Writer**

The model structure:

accuracy ~ age(plausibility + attachment) + RT*(age + plausibility + attachment) + plausibility:RT:age + (1 + age*(plausibility + attachment) + RT*(age + plausibility + attachment) + plausibility:RT:age || ItemID) + (1 + plausibility + attachment || ParticipantID)*.

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[4] Joseph, H. S. S.L., Liversedge, S.P., Blythe, H.I., White, S.J., Gathercole, S.E., & Rayner, K. (2008). Children's and adults' processing of anomaly and implausibility during reading: Evidence from eye movements. *Quarterly Journal of Experimental Psychology, 61(5)*, 708–723.

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