Preserved language comprehension with age and its relationship to cognitive control

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Introduction

While several cognitive abilities decline with age, particularly those dependent on cognitive control (Hasher & Zacks, 1979), language comprehension is remarkably preserved (Tyler et al., 2010).

Successful language comprehension requires the integration of the syntactic and semantic properties of each word into the online development of a sentential representation. This representation places constraints on, or predicts, the incoming speech input.

Taken together, these findings suggest that syntactic and semantic prediction are relatively automatic processes, honed through years of experience and requiring little top-down control.

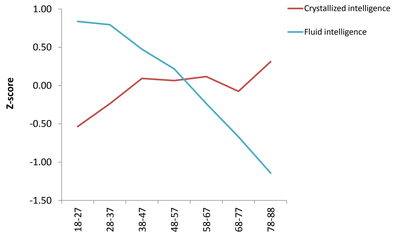
The present study aimed to test this hypothesis, asking 1) whether age differentially affects the prediction of syntactic structure and semantic meaning and 2) whether these abilities relate to individual differences in cognitive control (as measured by fluid intelligence).

Further, in order to probe how these abilities are preserved in the context of structural loss, we used voxel-based morphometry (VBM) to determine how syntactic and semantic prediction relate to grey matter integrity across the lifespan.

Method

participants

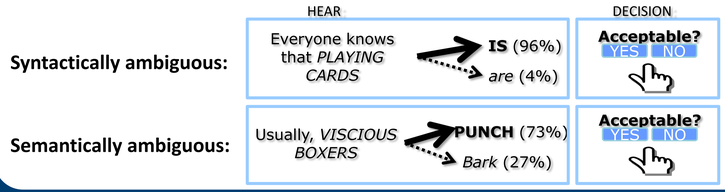
A population-based sample (N = 604; 18-88 years, *M* = 54.8, *SD* = 18.5) was recruited as part of the Cambridge Centre for Ageing & Neuroscience (Cam-CAN) project



cognitive measures

1) **Cattell culture fair:** test of fluid intelligence
2) **Spot-the-word:** test of crystallized intelligence (used as a control variable)
3) **Language Comprehension**: participants listen to sentences containing an ambiguous phrase

• ambiguity followed by a disambiguating verb of varying levels of **predictability** (based on previous norms)
• for each participant, we calculated the correlation between predictability of the continuation verb and 1) their decision to accept or reject and 2) the time taken to make that decision (RT)



imaging methods

VBM of segmented grey matter images to determine regions relating to syntactic and semantic prediction ability

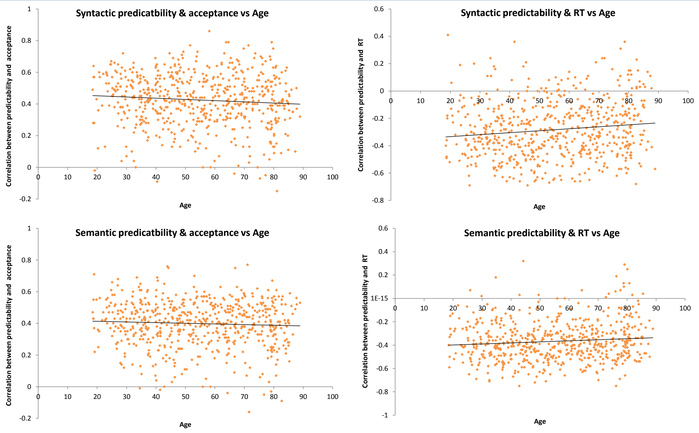
Results

prediction effects

Overall, more predictable continuations were accepted more often and responded to more quickly than less predictable continuations

age effects

No significant effect of age on syntactic or semantic prediction, in that predictability of the continuation word had a similar effect on acceptance and RTs across the lifespan



Results

cognitive control & syntax

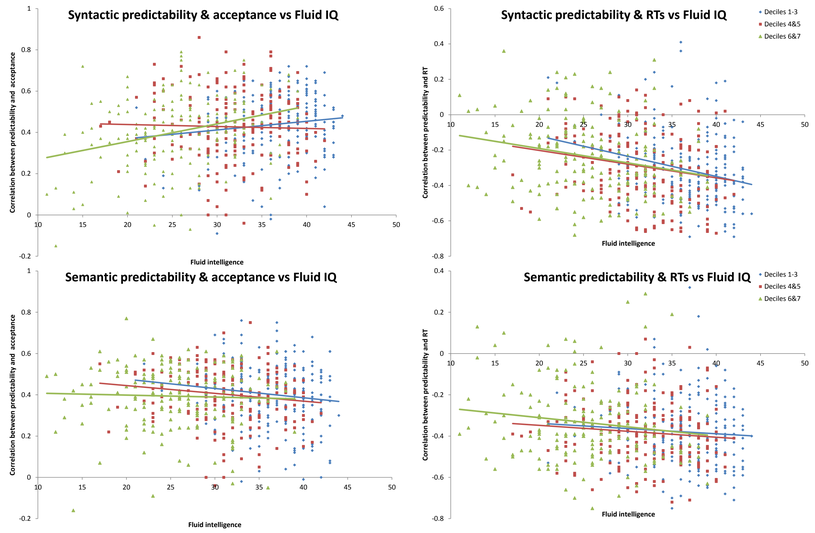
Fluid IQ was not related to the effect of predictability on acceptance (except in the oldest group).

However, RTs were more affected by the predictability of the continuation word in those with higher fluid IQ across the lifespan.

semantics

Fluid IQ was also not related to the effect of predictability on acceptance for semantic items.

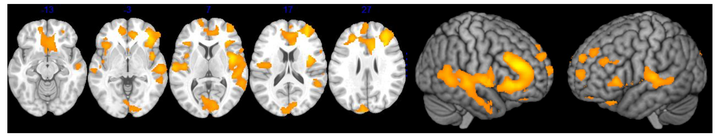
But RTs again were more affected by predictability in those with higher fluid IQ.



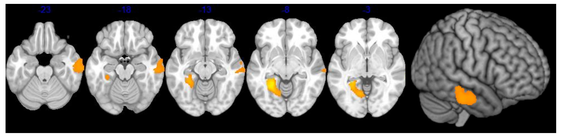
Relationship to Grey Matter

syntactic prediction

Stronger syntactic prediction (as measured by RTs) relates to greater grey matter integrity in frontal control regions and bilateral middle and superior temporal cortices.



Voxel-level threshold: $p < 0.001$. Clusters corrected for multiple comparisons.



Voxel-level threshold: $p < 0.001$. Clusters corrected for multiple comparisons.

semantic prediction

Stronger semantic prediction (as measured by RTs) relates to greater grey matter integrity in the left medial temporal lobe and right middle temporal gyrus.

Conclusions

Despite general declines in controlled processing with age, older and younger adults showed similar prediction for upcoming syntactic structure and semantic meaning, lending support to the view that these are relatively automatic processes.

Further support for this view comes from the null effect of fluid intelligence on acceptability decisions: people of varying abilities made similar decisions based on the predictability of the continuation word.

However, our RT measure was sensitive to individual differences in cognitive control. Follow-up analyses suggest that this was due to people with higher cognitive control being faster for dominant continuations, and similarly slowed by subordinate ones. Greater control may allow for faster selection and integration of sentential constraints, leading to faster responding when expected outcomes occur, but exaggerated slowing when they do not.

Our grey matter results suggest that successful syntactic prediction depends on frontal control and syntax-processing regions, whereas prediction of semantic representations relies on regions relevant to semantic knowledge.

References

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