Individual differences in cognitive ability and language experience are not modulating relative clause and verb bias effects in English: An extension of James et al. (2018)

A rich area of study in psycholinguistics over the past three decades is how people's cognitive abilities and linguistic background affect the way they process complex sentence structures[1,2]. However, much of the work in this area has used small samples and one measure per construct, which are not ideal for studying individual differences in sentence processing. James et al. (2018)[3] collected a large sample, used multiple measures per construct, and observed that contrary to previous work[1], individual differences in cognitive skills and language experience did not predict their participants' RC or verb bias effects in either online (i.e., response times [RTs]) or offline (i.e., accuracy) measures of sentence processing. Emphasizing the importance of psychometrics in studying individual differences in sentence processing, they hypothesized that their lack of individual difference results may be partly due to the difficulty of reliably measuring each person's RC and verb bias effect size. Alternatively, because their sample was largely from the university community (94% of their sample was under age 30), homogeneity in participants' backgrounds may have limited the variability in their syntactic processing, leading to homogenous RC and verb bias effects even in the presence of high variability in the individual difference measures.

We address these psychometric considerations in this ongoing replication and extension of James et al. (2018). We build on their study by: (1) recruiting a larger and more age-diverse sample from the general community in southern US to potentially capture greater variability in participants' syntactic processing and (2) increasing the number of items per condition (based on a sensitivity analysis) to measure people's syntactic effects reliably (Table 1).

211+ participants read 80 English sentences with a RC manipulation (40 SRC/ORC) and 80 sentences with a verb bias manipulation (40 DO/SC) using the moving window self-paced reading paradigm (Ex 1), and each sentence was followed by a comprehension question. They also completed the battery of individual difference measures used in James et al. (Table 2). Each measure was z-scored, and the z-scores for all measures of the same construct were averaged to arrive at a person's composite score for each individual difference construct.

We observed the expected RC effect: compared to SRCs, ORCs elicited longer RTs overall (localized in the RCs; β = 32.21 ms, $p < 0.001$; Fig 1) and lower accuracy for comprehension questions (β = -1.00 logits, $p < 0.001$; Fig 2). For the verb bias sentences, the ambiguous condition elicited longer RTs in the disambiguating region overall (β = 12.50 ms, p = 0.002) and equally between the DO- and SC-biased conditions (i.e., no ambiguity x bias interaction; β = -8.14 ms, p = 0.21; Fig 3) and there were no differences in comprehension accuracy between the conditions (β = -0.10 logits, p = 0.50; Fig 4). However, despite having recruited a more diverse sample, there was little evidence that the constructs we measured explained systematic differences in people's RC or verb bias effects: the only significant interaction we currently see is a Processing Speed x RC effect interaction, where people with faster processing speed show smaller RC effects in the RC (β = -18.87 ms, p = 0.04).

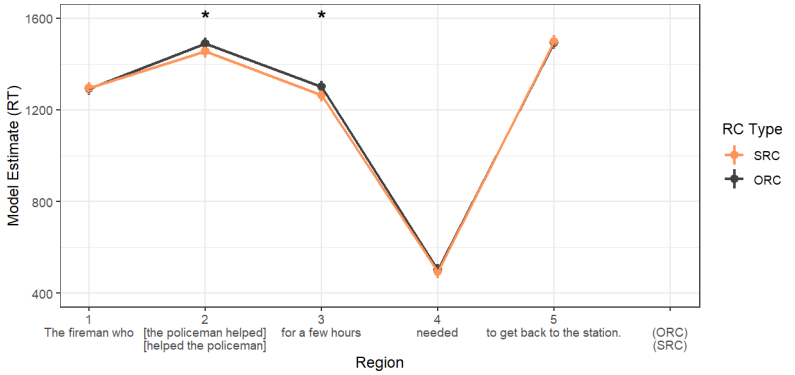
The current results are largely consistent with James et al.'s findings, suggesting either that the RC and verb bias effects do not vary enough—even in a more diverse sample—to be explained by the constructs measured in this study; or that the instruments used in this study do not capture the constructs that would explain individual differences in the RC and verb bias effects. Beyond these results, the current study highlights how recruiting a more diverse sample can provide more informative evidence in studies of individual differences in sentence processing.

Table 1. Differences in study design from James et al. (2018)

	James et al. (2018)	Current Study
Subject sample size[1]	117	211+
% some college	95.12	96.32
Mean age (years)	20.94	38.10
SD age (years)	5.37	16.66
Item sample size (RC)	32 (16 per condition)	80 (40 per condition)
Item sample size (VB)	80 (40 per condition)	80 (40 per condition)

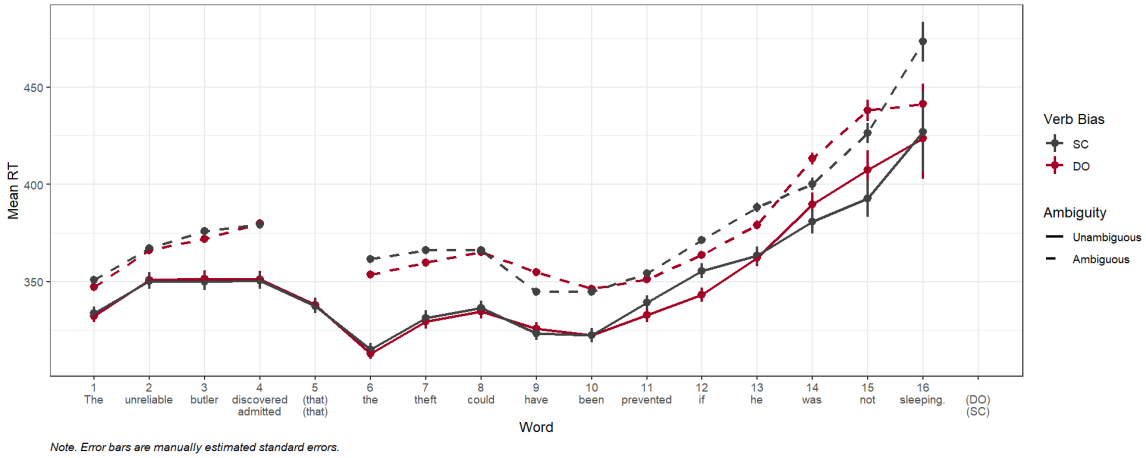
Table 2. Individual difference constructs and indicator tasks/measures. See James et al. (2018) for descriptions of each task.

Construct	Tasks
Attention control	Stroop, Flanker, Antisaccade
Language skills	Author Recognition Test, North American Adult Reading Test, Extended Vocabulary Range Test, Reading Time Estimate, Comparative Reading Habits
Processing speed	Letter Comparison, Pattern Comparison
Short-term memory	Forward Digit Span, Backward Digit Span
Phonological awareness	Blending Nonwords, Phoneme Reversal, Pseudoword Repetition
Verbal working memory	Reading Span, Operation Span, Listening Span



Note. Error bars are model-derived standard errors.

Figure 1. Overall RC effect on RTs. RTs for ORC were significantly longer at regions 2 and 3.



Note. Error bars are manually estimated standard errors.

Figure 2. Overall verb bias and ambiguity effects on RTs. Throughout the sentence, RTs were significantly longer for ambiguous sentences, but this ambiguity effect was not modulated by verb bias.

Example 1. Example RC and verb bias sentences.

The swimmer *who the rival insulted* in the final touched the wall first to claim the gold medal. (ORC)
The swimmer *who insulted the rival* in the final touched the wall first to claim the gold medal. (SRC)

The angry farmer *warned* (that) the trespassers would not be allowed onto his fields. (DO-biased)
The new receptionist *admitted* (that) her error should have been corrected sooner. (SC-biased)

References:
[1]Just & Carpenter (1992). *Psych Rev*, *99*, 122-149. [2]Kuperman & Van Dyke. (2011), *JML*, *68*. 42-73. [3]James et al. (2018), *JML*, *102*. 115-181.

Figure 3 (left). Overall RC and question type effects on comprehension accuracy. Accuracy was lower for ORC sentences, particularly for questions that target the RC vs. the main verb (i.e., RC x question type interaction).

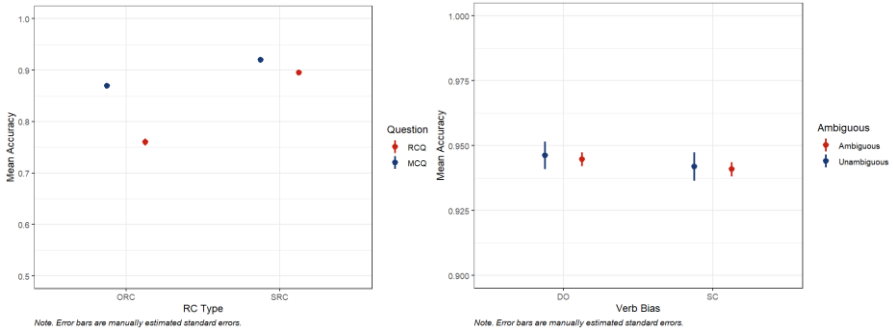


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Figure 4 (right). Overall verb bias and ambiguity effects on comprehension accuracy. There were no differences in comprehension accuracy among the 4 conditions.