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Commentary

The Role of Cognitive Control in Language Comprehension: Commentary on Kuz et al. (2024)

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Abstract: This commentary examines a recent study that challenges the view that cognitive control supports the resolution of linguistic ambiguities. We critique the study's methodological limitations, particularly its reliance on self-paced reading, which lacks the sensitivity to detect the effects of cognitive control on language processing. Furthermore, we address theoretical issues with the proposal that visual attention, rather than cognitive control, explains prior findings from the visual-world paradigm. By highlighting the linking assumptions behind the visual-world paradigm, we argue that eye movement patterns reflect syntactic parsing decisions and cannot be explained by visual attention alone. Considering these factors and the broader body of evidence, we maintain that cognitive control remains a key mechanism in language comprehension, despite the alternative account presented in the target study.

Keywords: cognitive control; language processing; visual-world paradigm; eye-gaze patterns; ambiguity resolution; comprehension

Academic Editors: Jeanine Treffers-Daller and Anthony Pak-Hin Kong

Received: 25 June 2024
Revised: 18 March 2025
Accepted: 19 March 2025
Published: 25 March 2025

Citation: Novick, J. M., Teubner-Rhodes, S., & Kim, A. E. (2025). The Role of Cognitive Control in Language Comprehension: Commentary on Kuz et al. (2024). *Languages*, *10*(4), 59. https://doi.org/10.3390/languages10040059

1. Introduction

While processing language, listeners often encounter ambiguities in linguistic input that lead them to temporarily consider interpretations that deviate from the speaker's intended message. For example, in a sentence like *While Mary bathed the baby spit up on the bed*, listeners initially face two interpretations: the intended one (Mary bathed herself) and a temporarily plausible but ultimately incorrect one (Mary bathed the baby). A well-established view posits that cognitive control enables the quick resolution of these ambiguities by guiding processing toward the most plausible interpretation among multiple conflicting possibilities (Ness et al., 2025; Novick et al., 2005). However, a recent study by Kuz et al. (2024) challenges this notion by reporting reading-time studies that fail to reproduce previous findings on the influence of cognitive control in language processing. The authors propose an alternative account, suggesting that previous findings were due to artifacts in the original experimental designs, which used a visual-world paradigm. This commentary evaluates the authors' premise, their experimental observations, and the overall implications for our understanding of the role of cognitive control in language processing.

2. Brief Summary of Kuz et al.'s (2024) Study

Kuz et al. (2024) conducted four experiments where participants alternated between a cognitive control task (Stroop) and a sentence processing task (reading). The key question was whether sentence processing difficulty would be reduced following incongruent trials of the Stroop task. This pattern, known as "cross-task adaptation of cognitive control", has been observed in several prior studies using similar methods (e.g., Hsu et al., 2021; Hsu & Novick, 2016; Thothathiri et al., 2018). The basic conclusion from the prior findings is that the incongruent Stroop trials create representational conflict, which engages domain-general cognitive control mechanisms. This heightened control remains active for a short period, influencing subsequent language processing. The carryover effect suggests an overlap between language processing and the non-linguistic conflict resolution processes involved in the Stroop task, supporting the idea that cognitive control aids sentence processing.

The primary syntactic manipulation in Kuz et al.'s study involved an ambiguity between the past tense and past participle forms of a verb within a reduced relative clause:

1a. The sunburned boys fed the hot dogs got a stomach ache [Ambiguous]

1b. The sunburned boys who were fed the hot dogs got a stomach ache [Unambiguous]

In the ambiguous version, readers initially misinterpret "fed" as the main verb of the sentence, thinking that the boys had fed someone. This misinterpretation, known as a *garden-path error*, requires revision upon encountering the phrase "got a stomach ache", leading to the correct interpretation that someone else fed the boys. The unambiguous version includes a complementizer to prevent misinterpretation by signaling the start of the relative clause. In three experiments (Exp. 1–2, 4), participants pressed a button at their own pace to reveal each word of a sentence, while in the fourth experiment (Exp. 3), participants read the whole sentence at once.

In all four of Kuz et al.'s (2024) reading-time experiments, the processing difficulty associated with garden-path errors was not reduced after incongruent Stroop trials. Consequently, the authors conclude that there is no evidence supporting the impact of a domain-general cognitive control mechanism on syntactic ambiguity resolution. Their Bayes factor analyses provided strong evidence in favor of null effects.

Furthermore, Kuz et al. (2024) argue that previous findings on cognitive control in language processing (e.g., Hsu & Novick, 2016) are flawed because they relied on the visual-world paradigm. They assert that earlier studies have misinterpreted eye movement effects in this paradigm by assuming they reflect operations of language comprehension, when in fact, they reflect visual attention to objects in a scene.

3. Methodological Limitations

Before addressing the theoretical implications of Kuz et al.'s (2024) findings, we raise several methodological concerns about their results. Specifically, there are four critical issues in the study that, although they may seem minor, nonetheless limit the conclusions they support: (1) the low sensitivity of the self-paced reading paradigm; (2) participants' development of syntactic expectations; (3) the inclusion of sentences with incorrect responses to comprehension questions in their analysis of reading times; and (4) the use of certain methods and analyses known to limit adaptation effects.

3.1. Sensitivity Concerns with Self-Paced Reading

The self-paced reading method (Just et al., 1982) is widely considered a blunt tool, making null results obtained with this method difficult to interpret. Self-paced reading does not allow readers to return to earlier sentence regions to gather more information, a key aspect of naturalistic reading that is crucial for revision when an initial parse is incorrect (Sturt, 2007; cf. Christianson et al., 2024). Another limitation of the self-paced reading paradigm is the variability in time between trials, which can depend on participants' reading speed and familiarity with the task setup. Longer pauses between trials—particularly between ambiguous sentences and Stroop tasks—may allow cognitive control engagement to fade, reducing the chance of observing adaptation effects. To prevent this, timing should be kept consistent across participants, but Kuz et al. (2024) do not appear to control for this factor.

In one of their four experiments, Kuz et al. (2024) measured whole-sentence reading times, which is even more coarse-grained than standard word-by-word self-paced reading. This measure provides little information about where changes in reading times occur within a sentence—for instance, speedups in one part of a sentence may obscure slowdowns in another part—and is generally a poor choice for assessing the dynamics of real-time language processing. Overall, the coarse-grained reading-time measures used by Kuz et al. lack the sensitivity needed to rigorously test the hypothesis that garden-path effects are modulated by cognitive control engagement.

In contrast, prior work using eye tracking during reading—a more sensitive alternative to self-paced reading—has provided evidence that cognitive control affects recovery from initial sentence misanalysis, in the form of re-reading patterns that are reduced under conditions of upregulated control, which occur in specific sentence regions where conflict arises (Hussey et al., 2017; Novick et al., 2014; see also Hussey et al., 2015).

3.2. Development of Syntactic Expectations

Kuz et al. (2024) observe syntactic adaptation, noting reduced ambiguity effects as participants encounter more critical trials throughout the experiment. They acknowledge that the "RC-MC ambiguous verb was resolved towards the RC interpretation 100% of the time" (p. 34), which is substantially more frequent than its occurrence in natural language input. This syntactic adaptation can be reasonably attributed to changes in structural expectations, with participants updating the likelihood of particular syntactic structures based on their frequency in the current context. If participants rely heavily on these structural expectations, it may block conflict monitoring—the process of detecting conflict and increasing cognitive control accordingly (Botvinick et al., 2001). Cognitive control-driven adaptation at the trial level depends on participants' engagement in conflict monitoring, which is influenced by task demands. Some researchers propose that individuals might opt for easier associative learning strategies when available instead of engaging in conflict monitoring (Bugg, 2014; Teubner-Rhodes et al., 2024). Allowing participants to anticipate that critical sentences always used a specific construction might have discouraged them from engaging in conflict monitoring, resulting in null effects of cognitive control on sentence parsing. One potential solution to this issue is to include sentences in the stimulus materials that resolve the RC-MC ambiguity in favor of the more frequent transitive parse.

3.3. Sentences with Incorrect Responses to Comprehension Questions

A minor concern in the study by Kuz et al. (2024) is the inclusion of data from sentences where participants answered comprehension questions incorrectly. This inclusion raises potential issues because prior research suggests that incorrect responses often indicate a failure to fully recover from a syntactic misanalysis (Christianson et al., 2001). The inability to correct the initial misinterpretation may suggest either that the reader did not detect the conflict or did not deploy the necessary processing resources to resolve it. In either case, there would be no effect of cognitive control. As reading times for correctly and incorrectly answered sentences reflect different cognitive processes, it is advisable to analyze them separately.

3.4. Analysis Methods That Limit Adaptation Effects

Adaptation effects are known to be highly sensitive to task parameters. For example, these effects are diminished or eliminated when longer response deadlines are used, as shown by Dunaway and Weissman (2025), a condition similar to that used in Kuz et al. (2024)'s experiments. This aligns with evidence suggesting that only faster responses reliably indicate engagement of cognitive control (Moretti et al., 2025).

Another factor influencing adaptation effects is the inclusion of trials that follow errors in analyses, a practice adopted by Kuz et al. (2024). This approach can obscure adaptation effects due to post-error slowing (see Braem et al., 2019 for review of best practices; Danielmeier et al., 2011; Notebaert et al., 2009). These methodological choices may have contributed to their failure to find evidence of cross-task adaptation of cognitive control. Rather than suggesting distinct cognitive control mechanisms for tasks like Stroop and syntactic ambiguity resolution, their results may indicate the limits of adaptation effects.

In summary, the study by Kuz et al. (2024) has multiple methodological weaknesses that limit its ability to rigorously test the hypothesis that cognitive control modulates garden-path effects.

4. Theoretical Limitations

The role of domain-general cognitive control in language processing—particularly in ambiguity resolution—remains an active and ongoing area of debate (e.g., Fedorenko et al., 2024; Ness et al., 2025). Kuz et al. (2024) offer an important contribution to this dialogue. While we critique their theoretical account and methods, we recognize that their work reflects one perspective within a larger, unresolved discussion. Our focus is on evaluating their specific claims and identifying the methodological factors that may constrain their conclusions.

Our primary critique of the conclusions drawn by Kuz et al. (2024) concerns their theoretical account, which fails to address important aspects of the original findings. The Kuz et al. (2024) paper responds to a specific type of previously observed cross-task adaptation effect, where language processing operations are measured using the visual-world paradigm (Novick et al., 2008; Spivey et al., 2002; Tanenhaus et al., 1995). In this paradigm, listeners follow spoken commands like "Put the apple on the napkin onto the box", while their eye-gaze is tracked to objects in a visual workspace accompanying the instruction (e.g., a scene with an apple on a napkin, a pencil, an empty napkin, and a box; see Figure 1). The phrase "on the napkin" is initially ambiguous, potentially specifying the apple's goal (where it should go) or serving as a modifier (conveying the apple's current location). Listeners initially interpret "on the napkin" as indicating a goal (they look at the empty napkin in the display) and then switch to interpreting it as a modifier once "onto the box", which specifies the correct goal, is heard (they look away from the empty napkin, toward the apple, and then the box). These eye-gaze patterns indicate a revision of an initial misanalysis. The misanalyses do not occur when the sentence is unambiguous (e.g., "Put the apple that's on the napkin. . ."), forcing the modifier interpretation of "on the napkin". In this case, listeners increase their gaze to the apple and the napkin underneath it, with minimal consideration of the other (empty) napkin in the scene (Novick et al., 2008; Spivey et al., 2002; Trueswell et al., 1999).

After incongruent Stroop trials, the eye movement signature of revising the incorrect interpretation in the ambiguous condition occurs nearly a half-second earlier than following congruent trials. The idea is that representational conflict during an incongruent Stroop trial increases cognitive control engagement, which then speeds ambiguity resolution during the subsequent language processing trial (e.g., Hsu & Novick, 2016; Hsu et al., 2021; see also Navarro-Torres et al., 2019; Thothathiri et al., 2018). Crucially, there is no impact of Stroop on eye-gaze patterns in the unambiguous condition, as there is no conflict to resolve.

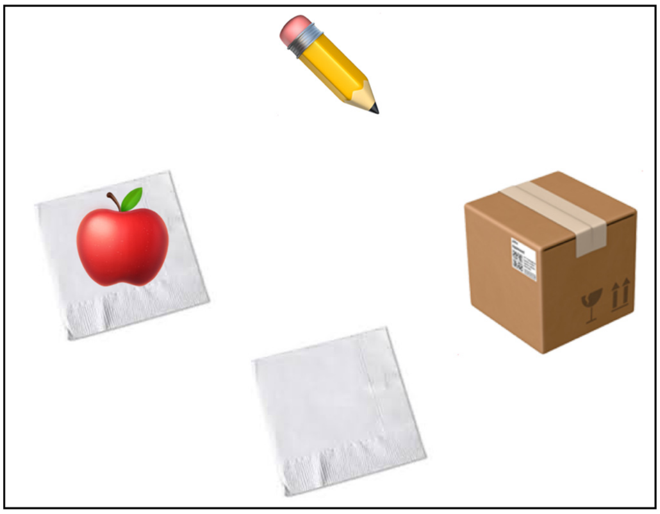

Figure 1. Example scene accompanying the instruction "Put the apple on the napkin onto the box" in the visual-world paradigm.

4.1. Kuz et al. Propose Facilitated Visual Object Processing over Syntactic Ambiguity Resolution

Kuz et al. (2024) argue that previous findings of cross-task adaptation with the visual-world paradigm could reflect enhanced post-interpretive visual attention, rather than enhanced cognitive control applied to linguistic representations. According to this perspective, Stroop trials can modulate visual attention, leading to more rapid convergence of eye fixations on the correct object (the box) after incongruent Stroop trials ("the transfer would be happening from the visual conflict in Stroop to the visual object conflict created by the visual world set-up", p. 33). For example, earlier looks to the correct goal (e.g., the box) might result from faster resolution of competition between the visual objects (the apple, the napkins, and the box), which vie for the participant's attention. Kuz et al.'s (2024) conclusions lean heavily on this argument, as it explains why they *did not* observe cross-task adaptation effects; their self-paced reading paradigm did not contain visual objects. The authors contend that previous observations of cross-task adaptation effects have misconstrued the eye movement patterns by attributing them to the operations of language processing (Hsu & Novick, 2016; Hsu et al., 2021; Ness et al., 2025).

We have two main objections to these conclusions. First, Kuz et al.'s interpretations of eye movement patterns and of the functional nature of the Stroop task deviate from standard theory and fail to account for the data. Second, the evidence for cognitive control in language processing extends well beyond the visual-world paradigm that Kuz et al. (2024) critique. As a result, their conclusions address only a small portion of the broader evidence showing that domain-general cognitive control influences language processing. Each objection is detailed in the following sections.

4.2. Kuz et al. (2024) Apply Non-Standard Interpretations of Both Eye Movements and the Stroop Task, Which Do Not Explain the Findings

One logical problem with Kuz et al.'s (2024) argument is that the eye-gaze effects observed in visual-world experiments cannot be explained by visual attention alone; the gaze effects are *driven by* language processing operations (Tanenhaus et al., 1995; Tanenhaus & Trueswell, 2006; Trueswell, 2008). The dependent measure in visual-world experiments, as described above, is the difference in gaze patterns due to a change in the sentence content, while the visual scene is held constant. For example, participants look more at the empty napkin in Figure 1 when the accompanying sentence is ambiguous than when it is unambiguous. This difference in looking patterns can be attributed to the fact that in the ambiguous sentence, "on the napkin" is interpreted as describing a destination for the apple as the phrase is unfolding in real time. The looking patterns cannot be due to some visual property of the empty napkin, because the visual scene associated with the two sentences is identical.

While visual attention is an important driver of eye movements, to explain the visual-world paradigm results we must have an account of how visual attention is modulated by linguistic operations. Kuz et al. argue that eye movement patterns can be explained entirely by modulations of visual attention. However, this perspective predicts that eye movement patterns would be the same for both ambiguous and unambiguous sentences, since the visual objects in the scene are identical. Additionally, their perspective predicts earlier eye movements to the target (e.g., the box) following incongruent Stroop trials for both ambiguous and unambiguous sentences, indicating faster resolution of competition between visual objects. But this is not the case, as we reviewed earlier: the eye movement patterns are driven by sentence parsing decisions, not just visual attention, and cognitive control engagement via Stroop impacts only the ambiguous sentences.

Kuz et al.'s conclusions are also difficult to justify based on the mechanisms underlying Stroop performance. They argue that previous cross-task adaptation effects occur in the visual-world paradigm because Stroop modulates visual attention to objects, which in turn affects eye movements to objects in the scene while participants listen to the following sentence. A problem with this perspective is that the Stroop task is not generally viewed as a task that engages visual attention to objects. Instead, the Stroop task requires participants to resolve conflict between two different *internal representations* of the same physical stimulus (the color of the font and the written word's meaning).

In fact, there is evidence that competition between objects for visual attention, as proposed by Kuz et al. (2024), is *not* the type of competition modulated by performance of the Stroop task. In a visual-world study investigating referential ambiguity, we found that when listeners hear sentence fragments like "She will eat the red . . .", in a context containing two red objects (e.g., a heart and a pear), they briefly consider both objects as possible referents, even though the heart only partially matches the description (e.g., it satisfies "red" but not "eat"). In this scenario, there is no strong theoretical argument for the necessity of cognitive control (Langlois et al., 2024). Substantial linguistic and contextual evidence supports one interpretation (pears are red and edible) with only weak competition from the alternative (two interpretations are not strongly supported and thus not in conflict; Ness et al., 2025). As we hypothesized, the Stroop manipulation did not affect eye-gaze patterns to red hearts and pears despite competition for reference. This strongly suggests that visual object competition is not the locus of the cross-task effects described earlier. The conclusion is not that cognitive control does not matter for comprehension (Langlois et al., 2024), but rather that visual object competition is not impacted by the Stroop manipulation.

In short, Kuz et al.'s (2024) visual-object-centered view of the cross-task adaptation effects fails to accurately characterize the factors that drive eye movements in the visual-world paradigm and deviates from typical functional interpretations of the Stroop task. While it may be tempting to link Stroop to language processing via attention to visual objects, a more nuanced understanding suggests that this alignment does not correspond with either the widely posited functional characteristics of the Stroop task or the functional demands involved in the visual-world paradigm experiments.

4.3. Support for the Cognitive Control Theory Is Broad and Is Not Invalidated by a Single Study

Kuz et al. (2024) conclude that cognitive control is not involved in language processing by contesting the cross-task adaptation effects in the visual-world paradigm. This argument fails to acknowledge the strength and breadth of evidence supporting the pivotal role of cognitive control in language processing, which extends significantly beyond the studies that Kuz et al. (2024) critique. Our rationale for focusing on cognitive control is grounded in the view that the Stroop task engages cognitive control over internal representations, supported by multiple lines of evidence. First, sentence processing has been associated with cognitive control, particularly in resolving conflicting interpretations (as detailed in Ness et al., 2025; Novick et al., 2005). Second, neurobiological systems implicated in the Stroop task are also implicated in syntactic ambiguity resolution, indicating overlapping mechanisms (Hsu et al., 2017; January et al., 2009).

This overlap is further supported by studies using diverse methodologies that go beyond visual-world paradigms. For example, one study used event-related potentials (ERPs) to test how cognitive control affects the resolution of conflicting sentence meanings. Participants read sentences like "The bathroom floor was mopping yesterday", which creates a conflict between a syntactically licensed interpretation (floor as Agent) and a semantically plausible one (floor as Theme). These sentences led to a P600 ERP effect compared to "The bathroom floor was mopped", suggesting that readers engaged in morphosyntactic editing (changing "mopping" to "mopped") to accommodate the semantically attractive interpretation. Increased cognitive control, induced by Stroop, led to *greater* P600 ERP effects, indicating activation of the most plausible analysis of the input to resolve such conflicts (Ovans et al., 2022). Another study demonstrated that neural oscillatory EEG activity in the theta band (3–8 Hz), widely viewed as an index of cognitive control, is engaged during the processing of multiple sentence types that allow conflicting meanings (Ness et al., 2024). Importantly, neither study involved visual object processing during the language tasks.

Furthermore, individuals with brain damage affecting cognitive control (without discernible visual object processing deficits) struggle with language comprehension, particularly in ambiguous situations where they find it challenging to revise misinterpretations (Novick et al., 2009; Vuong & Martin, 2011). This finding complements evidence that the neurobiological systems recruited during the Stroop task are also involved in syntactic ambiguity resolution, suggesting a shared conflict resolution function (Hsu et al., 2017). Research also shows that cognitive control training can improve both the speed and accuracy with which comprehenders process sentences involving conflict, further supporting the role of domain-general control mechanisms in managing linguistic ambiguity (Hussey et al., 2017; Novick et al., 2014). These results highlight that the mechanisms driving cross-task adaptation effects are rooted in the brain's ability to manage conflict and ambiguity across different contexts. (Ness et al., 2025).

Overall, the extensive body of evidence supporting the role of cognitive control in language processing goes beyond the findings from the visual-world paradigm. While Kuz et al.'s (2024) critique offers an alternative perspective, it cannot undermine the broader, multi-faceted evidence that cognitive control is crucial for language comprehension.

5. Conclusions and Future Directions

In their efforts to extend prior work, Kuz et al. (2024) have conducted a series of high-powered studies that offer a valuable perspective, particularly by emphasizing methodological considerations for probing the effects of cognitive control in language comprehension. Their attention to methodological detail underscores the importance of considering the intricacies of experimental design when investigating the interplay between cognitive control and language processing. However, further exploration is necessary to fully understand the observed null effects. Moving forward, it will be important to determine why the modulation of cognitive control by Stroop does not affect sentence processing difficulty as measured by Kuz et al. (2024). Additionally, the evidence supporting a crucial role for cognitive control in language processing is broad and compelling, and the basic idea cannot be invalidated by a single set of null results.

Funding: This research was funded by the National Science Foundation, grant numbers 2020490 and 2020932. The APC is intended to be funded by startup money provided by Auburn University, and other university sources at the University of Maryland and the University of Colorado, Boulder.

Conflicts of Interest: The authors declare no conflicts of interest.

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