The organization of memory for conversation

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Background: Successful language use depends on representations of the discourse history including representations of the current topic of conversation and what information has already been shared. These representations are held in memory and support basic linguistic processes including audience design[1] and pronoun resolution[2]. Surprisingly, then, is the growing body of evidence that the ability to accurately recall the ideas expressed in a conversation is limited[3] (e.g., 0-40% of a conversation can be accurately recalled after even brief delays), and asymmetric[4] (better recall of what one said vs. heard). While this work reveals insights into the quantity of information that can be recalled, it ignores how that information is organized in memory. The organization of memory guides what and when information is recalled and is evidenced by *temporal contiguity*[5] wherein the *order* in which information is recalled tends to follow the *order* in which it was experienced. Previously unknown, however, is how a semantically rich and interactive experience such as conversation might be organized in memory. Here we demonstrate for the first time evidence of temporal contiguity in conversational recall, as well as evidence of organization by topic and speaker. We speculate this previously undocumented organization of memory for language shapes the many language processes that depend on memory for the discourse history.

Method and Analysis: Pairs of participants (Ps, N=78) were given 6 conversation-starter topics and conversed unscripted for 15 min in English about these topics. After a 20 min filled delay, Ps recalled the conversation alone in detail for 15 min. Ps recalled the conversation again after ~4 and ~10 days. Conversations and recalls were compared on what was recalled (gist criterion for recall of idea units, IUs, per standard conventions[3]), and in what order. We then computed lag-Conditional Response Probabilities (lag-CRP)[6] to measure if Ps recall the ideas in the order they occurred in conversation (e.g., ideas 1,2,3 recalled 1,2,3), or instead if the recall skips forward (e.g., ideas 1,2,4) or backwards (e.g., 4,2,3). Lag-CRP quantifies the probability of making a given lag transition in recall (e.g., recalling idea 2, 4 is a lag +2; recalling 4,2 is lag -2) conditional on whether that lag transition was possible. In word list recall, temporal contiguity is characterized by peaks at lag +1 (once a word is recalled, the *next most likely* word recalled is the next one in the list) and -1. We quantify lag-CRP for each recall period (20m, 4d, 10d), and test if *topic* and *speaker* structure recall beyond temporal organization.

Results: Analysis of lag-CRP (**Fig 1**) revealed significantly more +1 transitions at the 1st vs. 2nd recall ($t(61) = 2.74, p = .008$) and 1st vs. 3rd recall ($t(61) = 2.78, p = .007$). Analysis of within (vs. between) category lag-CRP compares recall transitions made within (vs. between) the same category tests relative temporal organization as participants transition both within and between items that belong to the same (within) or different (between) categories. For this work we test topic and speaker as categories (**Fig 2**). For example, if A and B had a back-and-forth exchange over the 1st 6 ideas in dialog (e.g., 1A, 2A, 3B, 4B, 5A, 6B), if A recalled ideas 1A, 2A, 5A, the transitions would be +1 (idea 1->2) and +3 (2->5) in the overall analysis but a +1 and +1 in the within-speaker analysis. The analysis of speaker tests if Ps utilize temporal context to organize recalls as they recall IUs from one speaker (within) or IUs across speakers (between). Here we find non-zero slopes in each direction for both within and between-speaker lag-CRP indicating more extreme lag values are less likely to be made (all $p < .001$). The analysis of topic tests if Ps use temporal context as they recall IUs from the same topic (within) or from different topics (between). We find all nonzero slopes ($p < .001$) except for the negative between-topic lag values ($p = .414$). Thus, Ps ignore temporal context when transitioning back in time during recall to a *prior* topic but do utilize temporal context when recalling IUs from the same topic or moving to *forward* topics.

Discussion: We demonstrate clear evidence of temporal-, speaker-, and topic-based organization in memory for conversation. These novel findings lead to a cascade of new questions regarding how this organizational structure guides the way representations of the discourse history influence language use. We speculate representations of the discourse history will more strongly influence language when there is parallelism in temporal and topical structure between past instances of language use and the way language is used in the moment.

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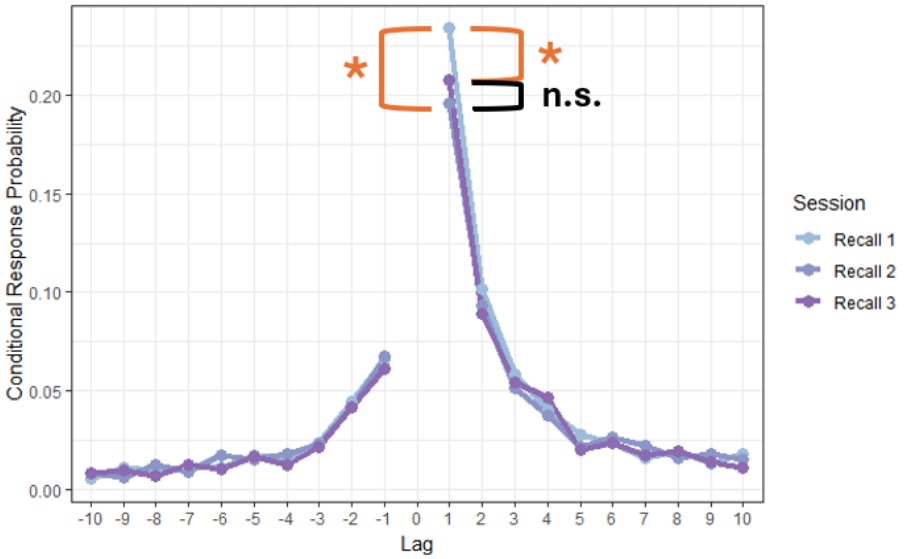

Figure 1. Temporal contiguity by session ($N = 62$, 31 groups), calculated based on Lag-CRP values separately for each recall session, truncated at lag distance +/-10. The CRP value at +1 is significantly greater at Recall 1 than Recall 2 ($p = .008$) and Recall 3 ($p = .007$) but Recalls 2 and 3 do not differ ($p = .855$).

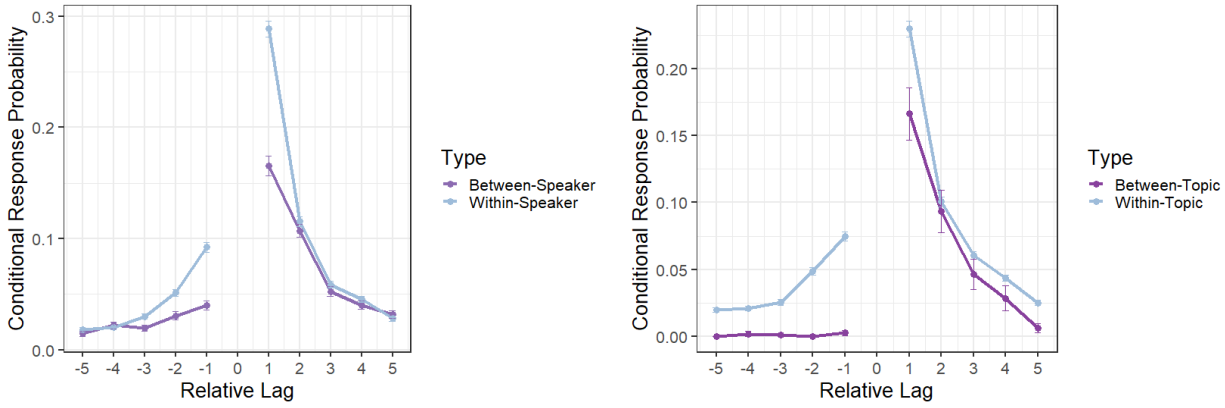

Figure 2. Temporal contiguity within and across topic and speaker ($N = 62$, 31 groups). Within and between lag-CRP values by topic and speaker, truncated at lag distance of +/-5. All single direction slopes are significant ($ps < .001$) except for the negative between-topic slope ($p = .414$).