Collaborative Recall and the Construction of Collective Memory Organization: The Impact of Group Structure

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Abstract

Collaborative recall synchronizes downstream individual retrieval processes, giving rise to *collective organization*. However, little is known about whether particular stimulus features (e.g., semantic relatedness) are necessary for constructing collective organization and how group dynamics (e.g., reconfiguration) moderates it. We leveraged novel quantitative measures (Congleton & Rajaram, 2014) and a rich dataset (Choi et al., 2014) to address, a) whether collective organization emerges even for semantically unrelated material and b) how group reconfiguration – changing partners from one recall to the next – influences collective organization. Participants studied unrelated words and completed three consecutive recalls in one of three conditions: Always recalling individually (III), collaborating with the same partners twice before recalling alone (CCI), or collaborating with different group members during two initial recalls, before recalling alone (CRI). Collective organization increased significantly following any collaboration (CCI or CRI), relative to “groups” who never collaborated (III). Interestingly, collaborating repeatedly with the same partners (CCI) did not increase collective organization compared to reconfigured groups, irrespective of the reference group structure (from Recall 1 or 2). Individuals, however, did tend to base their final individual retrieval on the most recent group recall. We discuss how the fundamental processes that underlie dynamic social interactions align the cognitive processes of many, laying the foundation for other collective phenomena, including shared biases, attitudes, and beliefs.

Keywords: collective memory, collective memory organization, retrieval dynamics, collaborative memory, socially-situated remembering

Collaborative Recall and the Construction of Collective Memory Organization: The Impact of Group Structure

When people reminisce together, they develop a similar representation of the past. These shared memories can develop through memories retrieved in a variety of settings such as café conversations with friends, dinner table banter with family, classroom discussions, workplace meetings, political discourse, and chats on social network platforms. How does such collaboration synchronize not only what people recall (collective memory content) but also how they organize these memories (collective memory structure)? These are fundamental questions for understanding how social interactions shape our memories, and how our memories shape us. In this article, we focus on the nature of collective memory structure.

Social construction of memories raises two possibilities about how conversational partners mold one another's memories and how this process constructs their collective memory narrative. First, collective memory of a group reflects intentional choices; group members keep or discard details in the service of developing and maintaining a shared perspective. Alternately, collaborative remembering recruits fundamental memory processes where narratives take shape irrespective of group members' intentions. We propose that both possibilities guide the construction of collective memory. With respect to the first possibility, groups with specific, shared leanings based on political, religious, or cultural beliefs are likely to discard details that do not fit their shared perspectives and settle on a cohesive, albeit selective, narrative that reinforces these leanings (Roediger et al., 2022; Wertsch et al., 2022; Yamashiro, 2022).

We explored the second possibility in this article: Recalling in groups leads people to remember and forget details of an event that do not just reflect intentional choices, but rather some fundamental properties of memory shaped by group recall. This possibility is consistent with the evidence that people report others' knowledge as their own, even in the absence of possessing that knowledge (Sloman & Rabb, 2016). This suggests that individuals have a propensity to align their cognitive frameworks with others. We focused on two basic features to explore the fundamental nature of memory alignment. First, we focused on collaborative remembering of unrelated information. In the spirit of Ebbinghaus (2013), using semantically unrelated target material largely strips information of relational properties and other features that can enable social and motivational biases to drive memory selection. As such, unrelated information facilitates discovery of basic memory principles involved in the construction of collective memory narratives. Second, we explored the impact of different group configurations, with groups constructed in the lab and composed of strangers. The key manipulation of group configuration involved having people collaboratively recall with the same partners repeatedly or with different partners across recall attempts, mimicking the varying social networks we inhabit in the real world. This allowed us to assess at a fine-grained level how collaboration within such networks helps shape and construct group cognitive products.

The theoretical importance of assessing collective memory organization is rooted in over a century of human memory research on robust retrieval patterns in individuals (Kahana et al., 2022). Yet how retrieval organization is shaped by previous collaborations and group membership remains mostly unknown. This puzzle about the structure of memory is particularly important to solve given that cognition is socially situated. In individual recall, specific organizational patterns are known to protect memory over time (Congleton & Rajaram, 2012; Miller, 1956; Mulligan, 2005; Puff, 1979; Zaromb & Roediger, 2010). Construction of shared retrieval organization then has implications for shaping – and synchronizing – group members' memories and shared cues long after they have left the group (Andersson & Rönnberg, 1997;

Congleton & Rajaram 2014). Such potential consequences of collective memory organization have far-reaching implications. Consider formal education – classrooms and textbooks, shared by groups of students, provide a common experience that may contribute to homogenized representations (Congleton & Rajaram, 2014). Might this inhibit divergent solutions to complex problems, or influence how novel ideas develop? In a different domain, reports of a national-level propensity to converge on a common narrative for such consequential events as WWII (e.g., narrative organization; Abel et al., 2019; Wertsch, 2008) may explain fractionated views of history through processes of memory. This range of implications motivated the present analysis.

Measuring Collective Memory: The Collaborative Memory Paradigm

Our study capitalized on a cognitive-experimental framework to assess the basic processes of group remembering and the emergence of collective memory in the laboratory (Basden et al. 1997; Rajaram & Pereira-Pasarin, 2010; Weldon & Bellinger, 1997). A typical collaborative memory experiment starts with a study phase, usually completed individually. Next, tasks vary depending on the condition. In *Collaborative* conditions, participants complete one or more collaborative recall phases, generally in groups consisting of two to four partners, with groups of three (triads) being the most common (Marion & Thorley, 2016). In the *Nominal* (control) condition, participants complete one or more individual recall phases. Nominal groups, or groups in name only, are then formed by combining the nonredundant responses from the same number of participants involved in collaborative groups. To assess the downstream impacts of collaboration (including collective memory), studies include one or more post-collaborative, individual recall phases (Choi et al., 2014, 2017; Congleton & Rajaram, 2014). This basic experimental design has proven incredibly flexible, accommodating various study materials (see Rajaram & Pereira-Pasarin, 2010), group sizes (Marion & Thorley, 2016), collaboration dynamics (Choi et al., 2014, 2017), and digital platforms (Greeley et al., 2022), all the while providing considerable experimental control.

Widely replicated findings show a counterintuitive phenomenon about group recall – individuals recall less than their potential when collaborating with others, exhibiting *collaborative inhibition* in group recall (Basden et al., 1997; Rajaram & Pereira-Pasarin, 2010; Weldon & Bellinger, 1997; for a meta-analytic review, see Marion & Thorley, 2016). Although diffusion of responsibility (Latanè & Nida, 1981) seems an obvious reason for this reduction, evidence instead suggests that individual retrieval strategies are disrupted during collaboration (Basden, et al., 1997; Weldon et al., 2000; also see Barber et al., 2015). Interestingly, in later individual recall, former collaborators usually recall more than participants who never collaborated (Blumen & Rajaram, 2008; Weldon & Bellinger, 1997). Most relevant to the current study is the emergence of *collective memory*: Former collaborators recall more of the same material than those who never collaborated, in good measure because of the collaborative processes just described (Barber et al., 2012; Choi et al., 2014, 2017; Congleton & Rajaram, 2014; Cuc et al., 2006).

Collective Memory: A Cognitive Perspective

Collective memory has been defined differently across disciplines (Olick, 1999; Wertsch & Roediger, 2008), but core features connect definitions. The academic consideration of collective memory can be traced back to Halbwachs (1992), who framed collective memory as socially (re)constructed, existing outside of individual agents. While individuals do the remembering, collective memory is relevant to the group and manifest in commemorations, archives, religious practices, museums, and memorials (Beim, 2007). Different groups (e.g., families, nations) have different collective memories, often tied to group identity (Wertsch & Roediger, 2008).

Within cognitive psychology, collective memory is typically operationalized as the amount of information that is remembered or forgotten by all, or most, members of a group (Choi et al., 2014, 2017; Congleton & Rajaram, 2014; Hirst & Manier, 2008; Wertsch & Roediger, 2008). This conceptualization affords laboratory-based, experimental study and formal comparisons between groups. For example, Congleton and Rajaram (2014) found that, after participants collaborated to recall categorized word lists, they recalled more of the same material than Nominal "groups" that never collaborated – even up to a week after collaborating. Similar effects occur with more naturalistic stimuli (Cuc et al., 2006), and with recall of U.S. presidents (Roediger & Abel, 2015; Roediger & DeSoto, 2016), the recall of U.S. cities (Greeley et al., 2022), and in the comparison of national memories, for example, when recalling World War II events (Roediger et al., 2019).

Retrieval Organization: Scaling from Individual to Collective

Individual Retrieval Organization

Retrieval organization, sometimes retrieval dynamics, refers broadly to the order in which individuals recall information (Bousfield, 1953; Bousfield & Bousfield, 1966; Tulving, 1966). The way people structure, sequence, cluster, and otherwise organize their recall has been a central issue in the study of human memory (Ebbinghaus, 2013; Murdock, 1985; Slamecka, 1985). Common organizational patterns include the clustering of semantically related responses (*semantic contiguity*; Bousfield & Sedgewick, 1944; Manning & Kahana, 2012) and recalling items in clusters that appeared close together at study (*temporal contiguity*; Kahana, 1996;

Healey et al., 2019). Likewise, items across repeated recalls may appear adjacently, reflecting *subjective organization* (Sternberg & Tulving, 1977; Tulving, 1962).

We focused on subjective organization as we were interested in assessing the structural similarity of recall outputs across group members and selected the *pair frequency* (henceforth *PF*) metric to capture such similarity (Sternberg & Tulving, 1977). Focusing on intra-subject recall stability across repeated retrieval attempts, PF considers the number of *observed* forward or backward word transitions common to two recalls (e.g., Recall 1 and 2) against the *expected* number of such transitions. When computing PF, the expected number of common transitions is a function of a) the number of items recalled in each retrieval attempt and b) the number of items common to both retrieval attempts. Because PF is the difference between the number of observed and expected common transitions, “chance” PF hovers around 0 while higher scores indicate more stability (i.e., subjective organization) from one recall to the next. Computational details can be found in the **Supplementary Materials**.

Collective Retrieval Organization

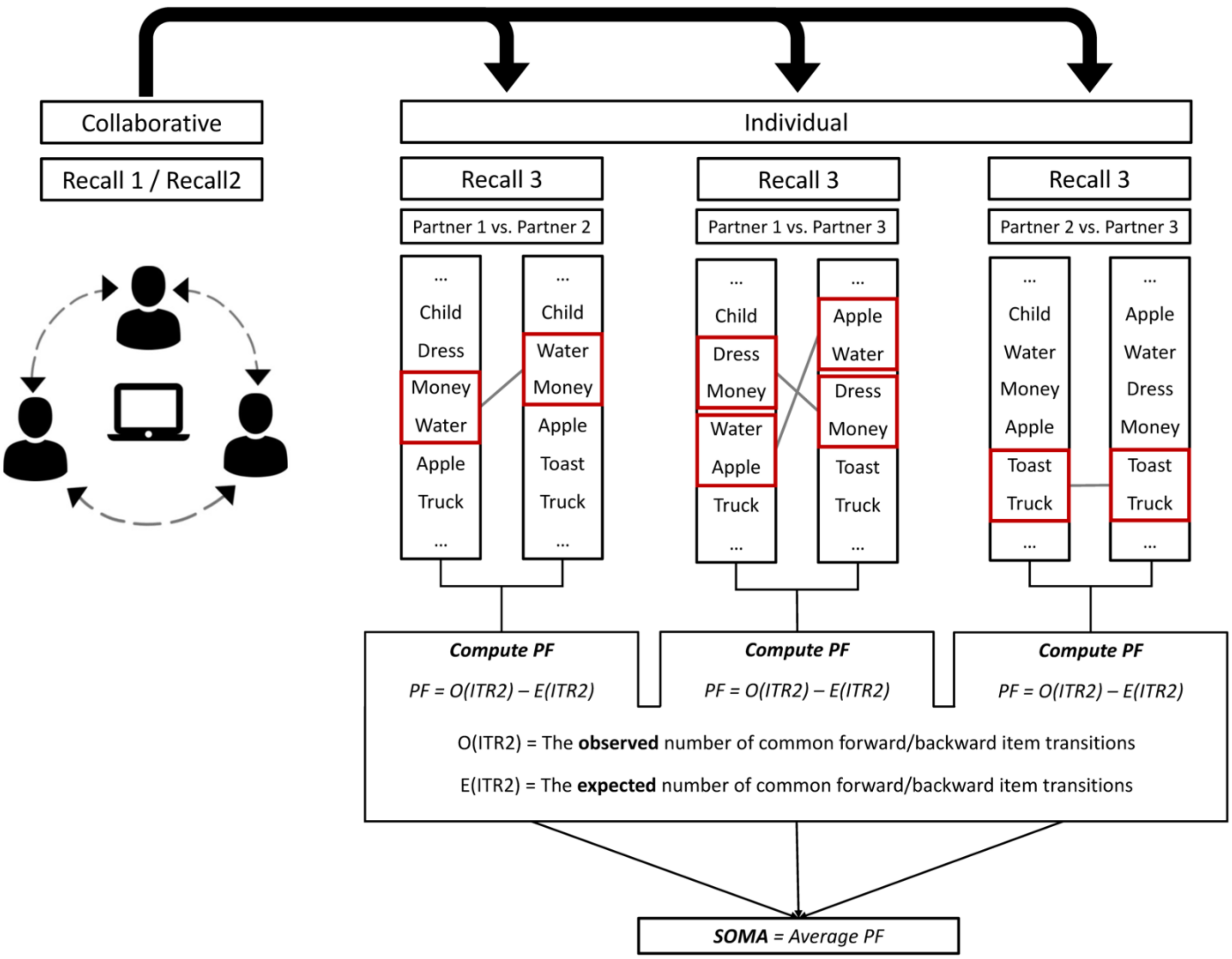
The idea that different individuals may converge on similar representations is not new. Bartlett’s (1932) notion of schema invokes common structure and patterns, characterizing memory as a reconstructive process molded by prior knowledge, experience, and culture (Wagoner, 2013). Likewise, collective memory research that focuses on overlapping content has gained traction (e.g., Choi et al., 2014, 2017; Cuc et al., 2006; Harris et al., 2008). But explicitly considering *inter-subject* retrieval structure similarity, using the analytical tools from research on individual retrieval organization, is a relatively new approach (Congleton and Rajaram, 2014; Greeley et al., 2022).

Congleton & Rajaram (2014), to our knowledge, were the first to formally quantify and examine the emergence of collective organization following collaborative recall. They leveraged the PF metric, applying it *across members of a group*, and developed a novel application - the Shared Organization Metric Analysis (*SOMA)*. Whereas PF was designed to assess intra-subject retrieval stability, SOMA applies the same computation in an inter-subject fashion, across each pair of participants within a group. For example, consider a collaborative group that worked together at Recall 1 and Recall 2 before recalling alone at Recall 3. Calculating SOMA would involve targeting the individual Recall 3 outputs; first, PF would be computed *between* each pair of partners (e.g., Participant 1 and 2, Participant 1 and 3, and Participant 2 and 3), then SOMA is given by averaging the three PF scores. A schematic of this approach is included in **Figure 1**, and computational details are included in the **Supplementary Materials**. Like PF, higher SOMA scores indicate a greater level of collective retrieval organization.

This approach, to explore how collaboration synchronizes retrieval, shows that not only do former collaborators recall more of the same material than those that never collaborated, they recall that material in a similar way (Congleton & Rajaram, 2014). Moreover, this synchronization is not limited to in-person groups – a single, fully online, chat-based group recall is enough to induce post-collaborative collective retrieval organization (Greeley et al., 2022). While this converging evidence suggests that collaboration can synchronize retrieval, contributing to collective organization, little is known about the impact of different group dynamics (e.g., reconfiguration) or stimulus features.

Figure 1

Procedure for Computing SOMA



Note. PF = Pair Frequency; SOMA = Shared Organization Metric Analysis. The basic procedure for computing SOMA for a single hypothetical group based on each participant's individual Recall 3 recall output. Whereas PF is typically employed to assess intra-subject organizational stability across retrieval attempts, here it is applied across participants within a single retrieval attempt. For each pair of participants, PF is the difference between the observed and expected number of common forward/backward item transitions (highlighted with red boxes). SOMA for the group is computed by averaging the pairwise PF scores and can be interpreted similarly to PF; chance hovers around 0 while higher scores indicate greater levels of collective retrieval organization.

Present Study

Two goals guided the present study. First, we assessed the downstream impact of group configuration on the development of collective organization. Specifically, we examined whether collaboration with the same or different partners across recall attempts contributes to different post-collaborative, collective organization. Given how common it is to move in and out of different groups (e.g., student groups, a string of meetings), understanding whether different collaborative dynamics shape post-collective organization in different ways has implications for how group affiliations shape memory.

Second, as a more general goal, we assessed the emergence of collective organization for unrelated information. Previous research assessing collective organization has used categorized word lists (Congleton & Rajaram, 2014; Greeley, et al., 2022). While these studies used appropriate Nominal controls, semantically related material may lend itself to a particular organization (e.g., within-category contiguity [clusters] are likely). Use of unrelated nouns sets a "higher bar" for collective organization; without any inherent structure to the stimuli, there are more plausible ways one could structure retrieval, so collaboration must have an outsized impact on subsequent individual retrieval for a collective pattern to emerge. The Choi et al. (2014) study was perfectly suited to address these novel goals.

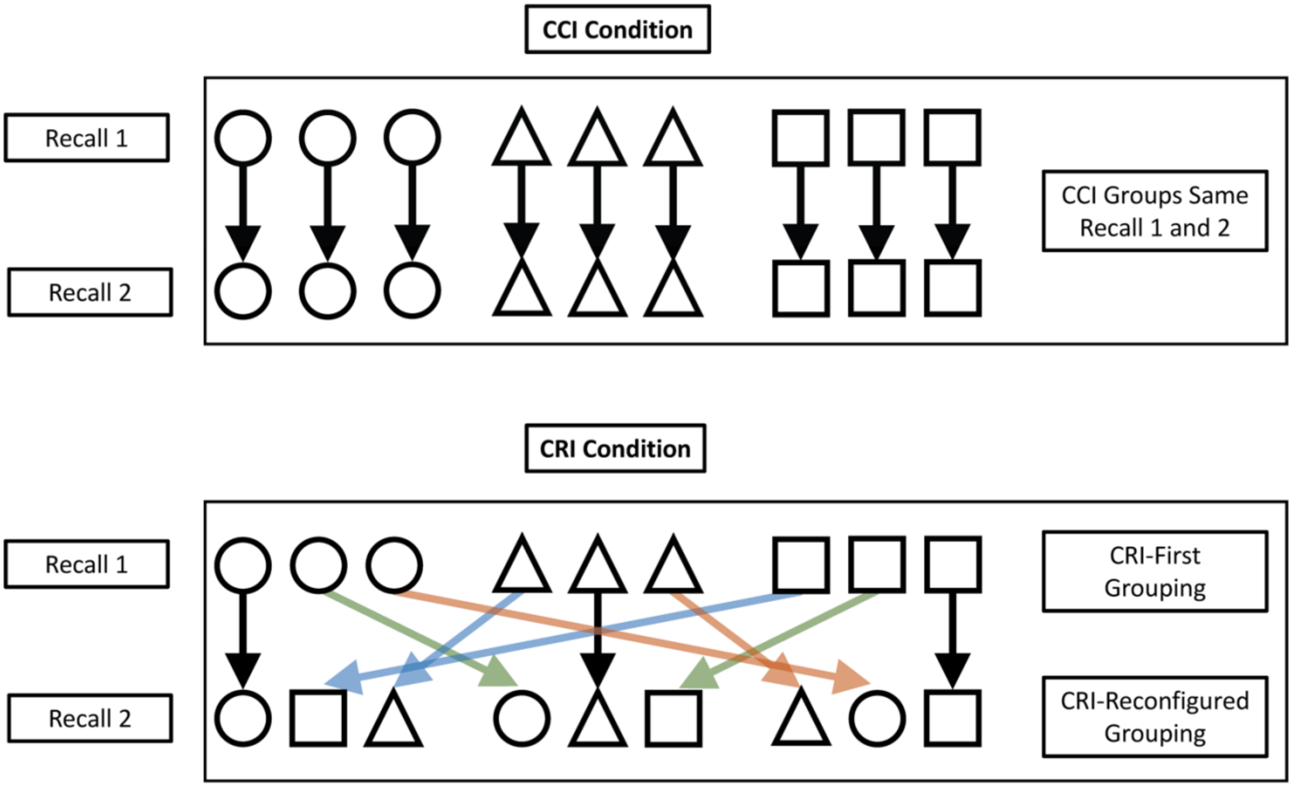
Method

The data we analyze come from Choi et al. (2014). A condensed methodology follows, with details available in that article and in the **Supplemental Materials** for this study.

Participants (*N*=162) were randomly assigned to one of three conditions (*N*=54 each, or 18 triads composed of strangers) where the primary manipulation was retrieval sequence. At study, participants individually provided pleasantness ratings (1-5) to a list of 46 unrelated nouns (plus four buffers). At retrieval, participants recalled the words, individually or in groups, in any order they preferred. In the III (individual-individual-individual) condition, participants completed three sequential free recalls, always working alone. In the CCI (collaborative-collaborative-individual) condition, participants completed two collaborative free recalls *with the same partners at Recall 1 and Recall 2,* before completing a final individual free recall. In the CRI (collaborative-reconfigured-individual) condition, participants completed two collaborative recalls *with different partners at Recall 1 and Recall 2,* before completing a final individual free recall. In the CCI and CRI conditions, participants could discuss, contribute, and settle on responses freely (free-for-all collaboration). **Figure 2** presents a schematic of the group recall conditions.

Figure 2

Group structure of CCI and CRI groups in Recall 1 and 2



Note. CCI = Collaborative-Collaborative-Individual; CRI = Collaborative-Reconfigured-Individual; Procedure for Recall 1 and 2, adapted from Choi et al. (2014). CCI participants (left) collaborated with the same partners to recall words twice before working alone. CRI participants (right) collaborated with different partners at Recall 1 (CRI-First group members) and Recall 2 (CRI-Reconfigured) to recall words before working alone. III participants (Nominal groups; not shown) always worked alone to perform the recall tasks.

Analytical Approach & Hypotheses

We capitalized on the quantitative tools developed by Congleton & Rajaram (2014), namely SOMA, to assess collective organization, as well as a modified version of their Origin Analysis to probe the post-collaborative accumulation of organization.

SOMA: Collective Retrieval Organization

As shown in **Figure 1**, SOMA is calculated using post-collaborative, individual recall outputs. To recapitulate, closely tied to PF (Sternberg & Tulving, 1977), SOMA considers the observed and expected number of common forward/backward word transitions between recall outputs generated by different people. While PF quantifies intra-subject retrieval stability *across recall attempts*, SOMA applies the same calculations *across participants*, quantifying inter-subject retrieval stability. Specifically, PF is computed between each pair of participants, and SOMA by averaging across between-participant PF values. SOMA scores near 0 indicate a “chance” level of shared organization; the observed number of common transitions, on average, is approximately equal to the number of expected transitions. As SOMA increases, it indicates that members of a group have converged on a similar group-level retrieval strategy. See **Figure 1** for a schematic of how this is computed and, for computational details, see the **Supplementary Materials**.

We sought to advance our understanding of collective memory organization by applying SOMA to different group configurations. Beyond assessing SOMA at Recall 3 for III “groups” and CCI groups, we assessed collective organization in the CRI condition two ways: based on the first grouping (Recall 1; CRI-First) and on the reconfigured grouping (Recall 2; CRI-Reconfigured).

Origin Analysis: Imprints of the Past

To assess the impact of group configuration from another perspective, we calculated the accumulation of retrieval organization, that is, the extent to which a final individual recall can be traced back to each of the prior collaborations. Choi et al. (2014) addressed this question by applying PF to assess concurrence in retrieval organization between prior collaborative recall and final individual recall. Here we apply the Origin Analysis (Congleton & Rajaram, 2014) as this approach allows us to dynamically track the emergence and maintenance of word transitions through a series of individual and collaborative recall attempts.

The Origin Analysis is similar to SOMA such that a key step is the assessment of common item transitions (see **Figure 1**). Unlike SOMA, the Origin Analysis considers the number of item transitions that are shared between each individual recall and their previous *collaborative group* recall outputs (Recall 1 and 2). Here, for CCI and CRI participants, we were specifically interested in the number of common *nonredundant* transitions that were retained at Recall 3 – across recall combinations (i.e., Recall 1-3 and Recall 2-3). This indexes organizational dependency; higher counts indicate that more item transitions can be traced back to previous collaborations. For more detail on this computation, see the **Supplementary Materials**. By not normalizing counts (as in PF), we can assess the *accumulation* of dependence. If any organization is retained from *both* collaborative Recall 1 and Recall 2, CRI participants should accumulate more nonredundant common word transitions with previous collaborative recall phases than CCI participants. That is, while CCI participants have more opportunities to “settle” on a particular strategy, CRI participants interact with a broader network of partners, and thus have more opportunities for accumulating a higher aggregate of dependent word transitions.

Hypotheses

All hypotheses centered on the always-individual Recall 3, and the outcome of interest across all comparisons was collective memory organization, indexed by SOMA (Congleton & Rajaram, 2014), with the Origin Analysis providing supplementary insights.

First, we hypothesized that individuals stemming from groups that collaborated repeatedly (CCI groups) would converge on more similar retrieval strategies (greater SOMA scores) than those that never collaborated (III Nominal "groups"). This prediction derives from evidence for collective organization in groups that collaborated once (Congleton & Rajaram, 2014; Greeley et al., 2022). Based on the same evidence, we also hypothesized that individuals stemming from groups that were re-configured (CRI) would converge on more similar retrieval strategies than those from III groups. We assessed this comparison both using the first group structure (CRI-First, from Recall 1), and the more recent, reconfigured group structure (CRI-Reconfigured, from Recall 2).

Finally, we hypothesized that CCI groups would have greater SOMA scores than CRI-First groups. The CCI participants have two collaborative sessions (with the same partners) to converge on a particular retrieval strategy, whereas CRI-First participants face reconfiguration, potentially disrupting convergence. For a comparison between CCI and CRI-Reconfigured groups, competing predictions emerge. On the one hand, findings from Congleton and Rajaram (2014) suggest that, compared to a single collaboration, collaborating repeatedly with the same partners contributes to greater post-collaborative SOMA. This pattern combined with the potential for retrieval disruption from switching partners in the CRI condition, suggests that CCI groups should have greater SOMA than *either* CRI grouping. On the other hand, the Origin Analysis reported by Congleton and Rajaram (2014), as well as the PF results from Choi et al. (2014), show that the *most recent* collaborative recall has the strongest influence on subsequent individual organization, and these patterns suggest that CCI and CRI-Reconfigured groups should produce similar levels of collective organization. These alternate possibilities led to specific competing hypotheses – either CCI groups would have greater SOMA than CRI-R groups or there would be little difference.

Results

First, regarding the current sample size, prior research assessing SOMA has pointed to large differences between collaborative groups and Nominal control groups. Congleton & Rajaram (2014), with a sample size of 12 groups per condition, compared groups that collaborated repeatedly to Nominal groups, and reported a very large effect (d = 1.86). Likewise, Greeley et al. (2022), with a sample size of 15-16 groups per condition, compared groups – in a fully online context – that collaborated once to Nominal groups that never collaborated, and also reported a large effect (d = 1.78). Based on this prior work, the Choi et al. (2014) sample size of 18 triads per condition was deemed sufficient to detect any effect of interest in the CCI condition. No prior work is available to assess SOMA following group reconfiguration. Therefore, our analyses provide the basis for future estimations of effect size.

For all analyses, alpha was set to .05 *a priori*. Across multiple specific comparisons, we controlled the false discovery rate (FDR) using the Benjamini-Hochberg (1995) method and used Cohen's d to assess effect size (Cohen, 1988). All statistical tests were directional as we had specific expectations regarding group differences. In the case of a null result, we computed a Bayes Factor (Rouder, et al., 2009). All analyses were performed using R 4.1.3 (R Core Team, 2022). As a reminder, the SOMA analyses were always applied to the recall outputs from the always-individual Recall 3, and the Origin Analysis considers for each individual the number of nonredundant common forward/backward item transitions between Recall 1-3 and Recall 2-3.

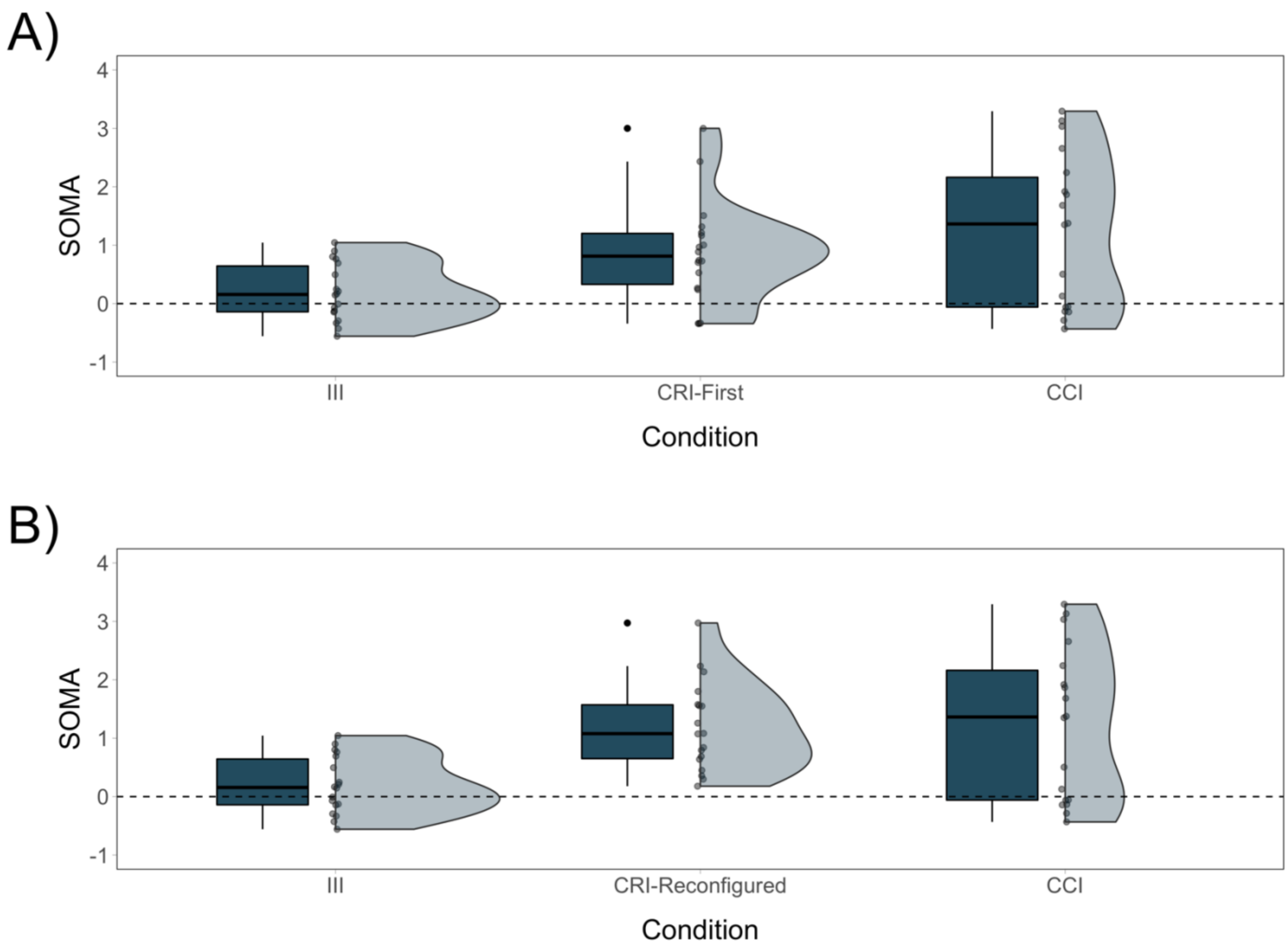
CRI-First Comparisons

Because CRI-First groups and CRI-Reconfigured groups cannot be compared formally due to dependency issues, we first compared III and CCI groups to CRI-First groups (SOMA based on who collaborated at Recall 1). We conducted a Welch omnibus ANOVA (due to violation of the assumption of homogeneity of variance; see **Supplementary Materials** for details) which was statistically significant, *WJ*(2, 29.6)=7.50, *p*=0.0023.

The follow-up, pairwise Welch t-tests were consistent with our hypotheses – CCI groups (*M*=1.23, *SD*=1.31, *N*=18) had greater SOMA scores than III groups (*M*=0.19, *SD*=0.49, *N* =18), *t*(21.64)=3.13, *p*=.0062, *d*=1.04, *d* 95% CI [0.32, 1.77]. Likewise, CRI-First groups (*M*=0.87, *SD*=0.88, *N*=18) had greater SOMA scores than III groups, *t*(26.58)=2.85, p=.0069, *d*=0.95, *d* 95% CI [0.24, 1.66]. In other words, the collaboration among CCI and CRI-First group members contributed to the construction of greater collective organization, relative to III Nominal "groups" that never collaborated. This outcome is depicted visually in **Figure 3** (distribution of SOMA scores across conditions) and **Figure 4** (effect sizes across comparisons). Interestingly, we did not observe a significant difference in SOMA scores between CCI groups and CRI-First groups, *t*(29.74)=0.96, *p*=.2167, *d*=0.32, *d* 95% CI [-0.36, 1.00]. A subsequent Bayes Factor analysis (Rouder et al., 2009) provided support for the null, BF_{10}=0.46.

Figure 3

Distribution of SOMA Scores Across III, CCI, and CRI Conditions



Note. SOMA = Shared Organization Metric Analysis; III = Individual-Individual-Individual; CRI = Collaborative-Reconfigured-Individual; CCI = Collaborative-Collaborative-Individual; SOMA score distributions across conditions. **A)** CRI-First data (based on the initial, Recall 1 group structure in the CRI condition). **B)** CRI-Reconfigured data (based on the reconfigured, Recall 2 group structure in the CRI condition). III and CCI data is the same in each panel since group configurations in those conditions were constant.

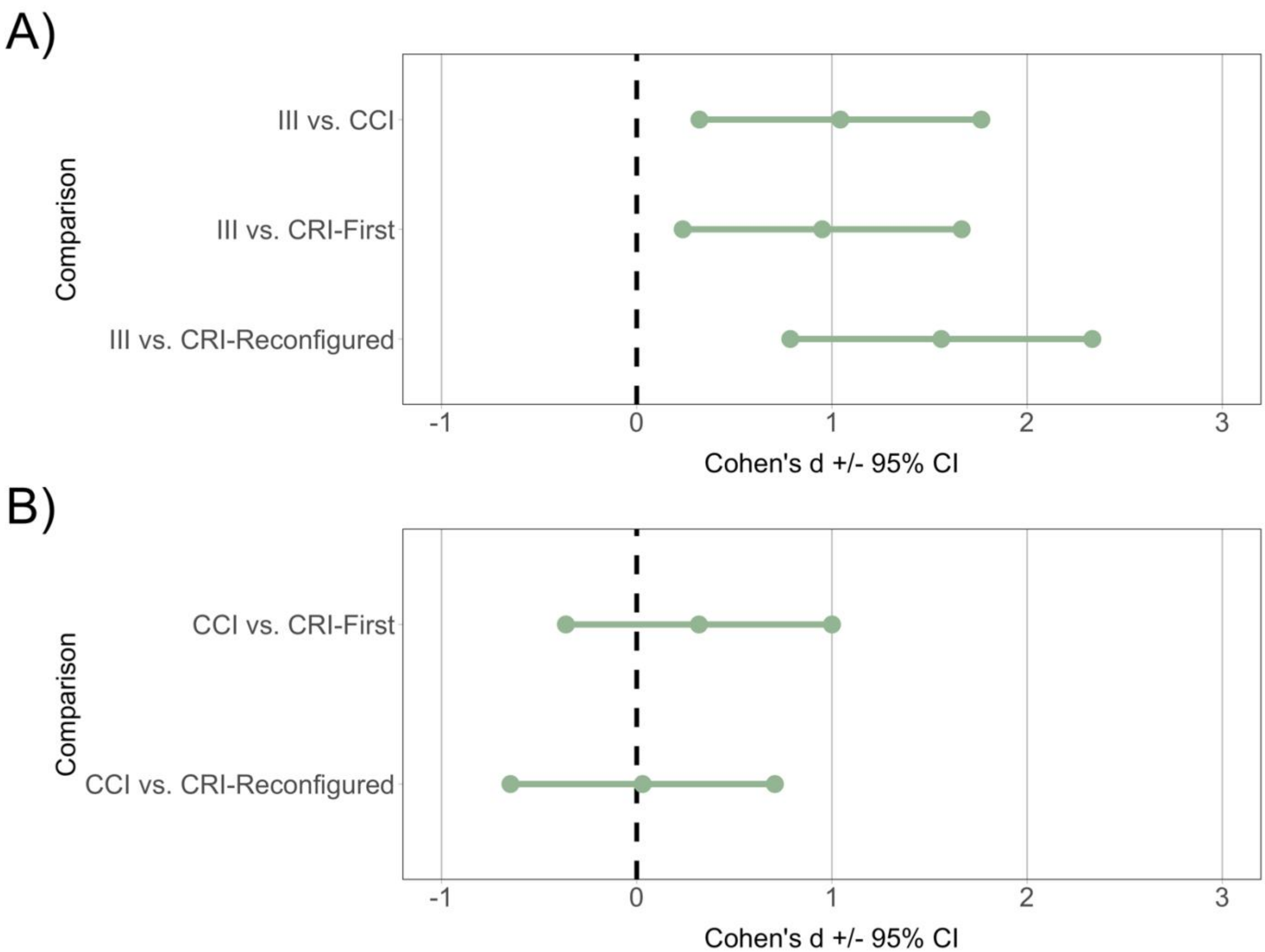
CRI-Reconfigured Comparisons

Moving to comparisons involving CRI-Reconfigured groups (SOMA based on who collaborated at Recall 2), we conducted another Welch ANOVA. This is partially redundant with the previous ANOVA (III and CCI data are the same), but we include the omnibus test for completeness. Expectedly, this test was statistically significant, $WJ(2, 30.33)=13.28$, $p < .0001$.

To test for specific condition differences, we conducted pairwise Welch t-tests and computed effect sizes (see **Figure 4**). Since the CCI vs. III comparison is unchanged from before, we only report the new tests involving the CRI-Reconfigured groups. Consistent with our hypotheses, the reconfigured CRI-Reconfigured groups (M=1.19, SD=0.76, N=18) had greater SOMA scores than III groups, $t(28.95)=4.68$, p=.0002, d=1.56, d 95% CI [0.79, 2.33]. This indicates that a single collaboration – even with new partners and potentially having to overcome the SOMA developed with previous partners – is enough to construct post-collaborative collective organization. This relationship is also evident in **Figures 3** and **4**. Interestingly, the CCI and CRI-Reconfigured groups did not differ significantly, $t(27.33)=0.091$, p=.4641, d=0.03, d 95% CI [-0.65, 0.71]. The subsequent Bayes Factor analysis indicated support for the null, BF_{10}=0.32. With respect to our competing hypotheses, this finding suggests that repeated collaboration does not necessarily contribute to more synchronized post-collaborative retrieval compared to changing groups – instead, collective memory organization may depend on the *most recent* collaboration.

Figure 4

Effect Sizes Across Pairwise SOMA Comparisons Between III, CCI, and CRI Groups



Note. III = Individual-Individual-Individual; CRI = Collaborative-Reconfigured-Individual; CCI = Collaborative-Collaborative-Individual; Effect sizes for each pairwise SOMA comparison. **A)** III “groups” – that never collaborated – compared to each collaborative group configuration. **B)** CCI groups – that collaborated with the same partners repeatedly – compared to both CRI group configurations. Any collaborative recall significantly contributed to collective organization relative to never collaborating, but there was no significant difference between CCI groups and either of the CRI configurations.

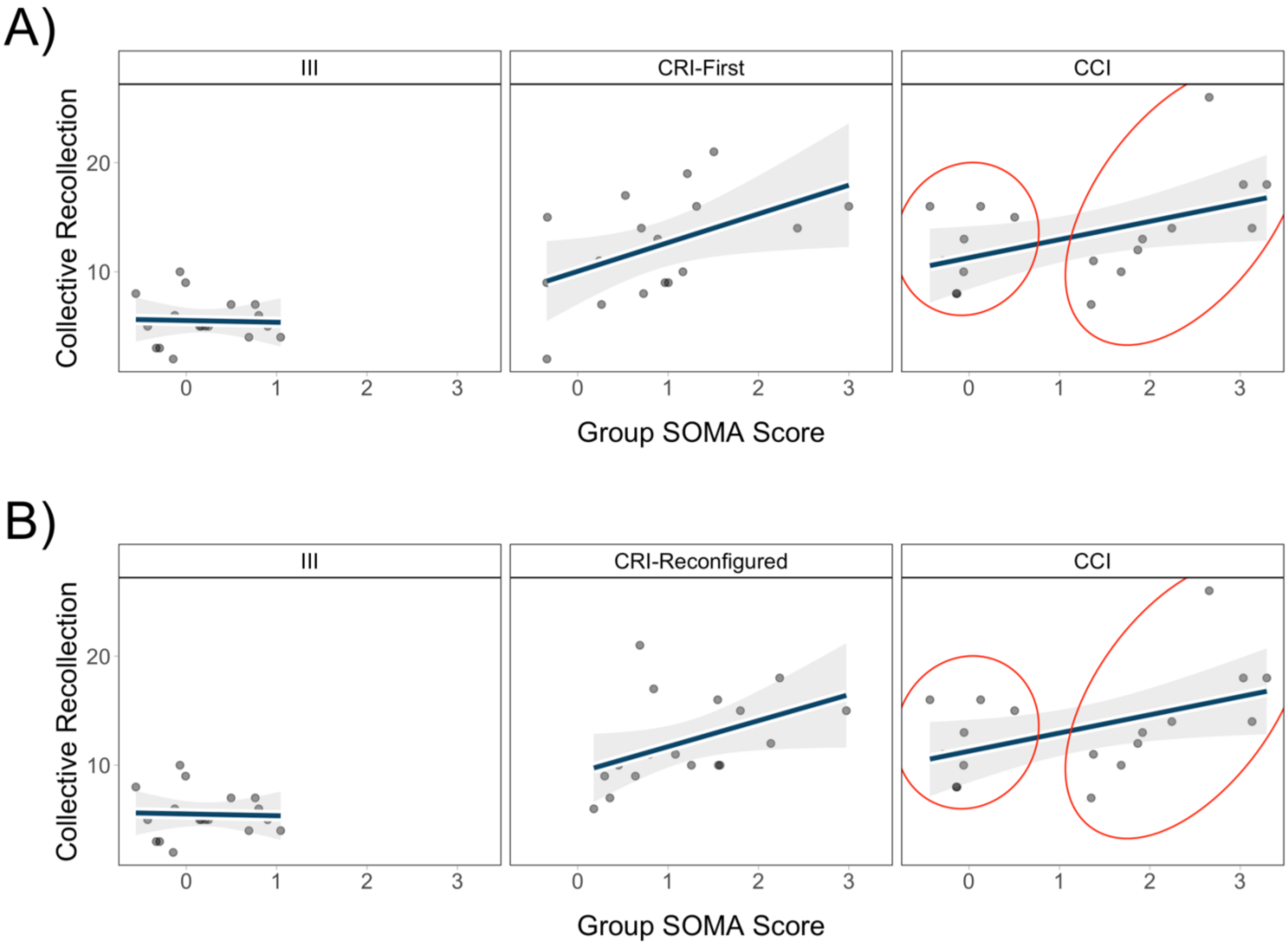
SOMA and Collective Recollection

Plotting all SOMA scores reveals some bimodality in the CCI condition (**Figure 3**). One explanation for this pattern is that some collaborative groups do not put forth the effort or cooperate in a way that promotes collective retrieval organization, and this lack of effort is more likely to reveal itself when the same people collaborate repeatedly. We posited that, if this was the case, other data in the CCI condition at Recall 3 could be bimodal. For example, groups with less collective organization (SOMA near 0) may also have fewer collective recollections (i.e., number of items recalled by all members of a group following collaboration; Stone et al., 2010). While SOMA should be positively associated with collective recollection in any collaborative condition – common transitions are more likely when there is more shared content – collective recollection should *not* be bimodal. If CCI partners are converging on remembering more of the same material than III groups *despite having SOMA scores near chance*, this suggests enough effort/cooperation was put forth to homogenize recalled content.

We interrogated this account with the current data by plotting collective recollection against SOMA for each condition at Recall 3 (**Figure 5**). First, we observe the expected positive relationship between collective recollection and SOMA in both collaborative conditions. More critically, while SOMA bimodality is clear in the CCI condition (highlighted with red ellipses), collective recollection is not bimodal and, as would be expected, is elevated relative to III groups. This provides some preliminary evidence against an effort or cooperation-based account of the SOMA bimodality in the CCI condition; groups can converge on remembering more of the same content without necessarily converging on more similar organizational strategies. We elaborate on this in the **Discussion**.

Figure 5

Collective Memory as a Function of SOMA Across III, CCI, and CRI Groups



Note. III = Individual-Individual-Individual; CRI = Collaborative-Reconfigured-Individual; CCI = Collaborative-Collaborative-Individual; Collective recollection (the number of targets recalled by all three members of a group) as a function of group SOMA scores. SOMA bimodality in the CCI condition highlighted with red circles. **A)** CRI-First data (based on the initial, Recall 1 group structure in the CRI condition). **B)** CRI-Reconfigured data (based on the reconfigured, Recall 2 group structure in the CRI condition). III and CCI data is the same in each panel since group configurations in those conditions were constant. Collective recollection in the CCI condition is not bimodal, despite SOMA bimodality.

Origin Analysis

Finally, we were interested in how individual retrieval organization at Recall 3 depended on prior collaborative recall phases. We applied a modified version of the Origin Analysis (Congleton & Rajaram, 2014) that considered – for each collaborative participant – their item transitions at Recall 3 that could be traced back to an earlier collaboration (e.g., to Recall 1 and 2). Across the Recall 1-3 and Recall 2-3 combinations, we computed the *cumulative number of nonredundant* forward/backward word transitions in common with previous collaborative recalls. At Recall 3, CRI participants (M=5.17, SD=2.31, N=54) tended to retain more nonredundant common item transitions with prior recalls than CCI participants (M=4.65, SD=2.24, N=54), however, the difference was not statistically significant (Poisson model: b=0.11, SE=0.09, p=.2241). Numerically, CRI participants retain approximately 11% more nonredundant common word transitions than CCI participants (Ratio: 1.11, 95% CI: 0.94, 1.32).

Discussion

In this study, we examined how collaborating with the same or different partners to recall unrelated material contributes to the construction of post-collaborative collective memory organization. CCI groups as well as both CRI configurations (based on Recall 1 and 2 groupings) reliably converged on more similar post-collaborative retrieval strategies than III Nominal "groups" that never collaborated. Thus, group recall synchronized post-collaborative retrieval organization even when the target material was unrelated, advancing prior research using categorized word lists (Congleton & Rajaram, 2014; Greeley et al., 2022). These novel findings speak to the power of collaboration; group recall has the capacity to synchronize *what* and *how* people recall even when there is little inherent structure to the recalled material.

A difference between collaboration conditions, that is, between CCI and CRI group configurations was not observed. This null finding alongside prior work (Choi et al., 2014; Congleton & Rajaram, 2014) suggests a pattern. Repeated collaboration may not synchronize post-collaborative retrieval over and above a single collaboration; instead, repeated recall within a group might help the group to “settle” on a strategy, whereas later individual retrieval may be driven by the *most recent* recall. Before discussing the impact of the most recent collaboration, we consider a final observation about comparable collective retrieval synergy between the CCI and CRI groups.

The CCI groups exhibited a somewhat bimodal SOMA distribution, suggesting that with repeated collaboration, some groups settle into SOMA whereas others resist it. What could account for this bimodality? Our exploratory visualization probed an effort/cooperation-based explanation and suggests that this cannot readily account for the observed pattern (**Figure 5**). While it is possible that converging on a greater degree of collective organization requires effort/cooperation over and above what is required for converging on remembering the same content, these patterns also suggest an alternative account. Consider CRI groups – those who may not settle into one version of SOMA in the first group configuration can find affinity into another version that they develop with different partners in the reconfigured groups. That is, collaborating with a diversity of partners offers more options for synchronizing retrieval organization, whereas collaboration with the same partners limits options; they either get in synch or they do not. This amounts to a *contagion-based* explanation of retrieval organization synchrony; the more partners one collaborates with, the more likely it is that other strategies get adopted. Testing this virality account is one avenue for future research.

A Collaborative Recency Effect

While *any* prior collaborative recall increased collective memory organization, working with the same versus different partners had no notable impact on post-collaborative retrieval synchrony, thus supporting our competing hypothesis that individual recall is driven substantially by the most recent collaboration. This account is consistent with Choi et al. (2014), who found that CRI participants tended to base their final individual recall more on the Recall 2 group output than CCI participants. Similarly, Congleton and Rajaram (2014) reported that, when recalling alone at Recall 4, participants who collaborated late in a recall sequence (at Recall 3; IICI) retained more overlapping forward/backward word transitions ("synergistic" clusters, p. 1578-1579) with their collaborative recall than those collaborating earlier (Recall 2; ICII). These findings, with the current results, point to an outsized influence of recent collaboration on subsequent individual retrieval organization.

The current data highlight the importance of collaborative recency following two recalls, but where are the boundary conditions for such an effect? For example, groups may collaborate many more times than twice, or collaborate in a chain-like fashion (Vlasceanu et al., 2020; Yamashiro & Hirst, 2020). After so many interactions, the group or broader network may converge on a very stable representation of the past, one that is relatively impervious to subsequent collaboration. Likewise, groups may retrieve and discuss highly structured material (e.g., personal narratives, news). With a more inherent structure, retrieval organization may synchronize quickly and be less amenable to modification in subsequent rounds of collaborative recall. Future work should leverage such variables to help parse, in more detail, the ways in which interactions, and sequences of interactions, synchronize retrieval organization. Our data show the unfolding process, where early in the sequence of repeated collaborations the most recent collaboration exerts more influence.

Broader Implications

Collective memory may form the bedrock on which other collective phenomena are built. We ask about the impact of formal education, then consider other intellectual endeavors, the construction of shared narratives, and the influence of social media and its social networks.

How might the highly structured activities in the classroom, and resulting synchrony in retrieval, influence the homogeneity versus diversity of learning (Congleton & Rajaram, 2014)? In this vein, our beliefs often go beyond what we have personally experienced; we depend on others to form beliefs (Hardwig, 1985) and use inferences about what others know to guide our own understanding (Rabb et al., 2021). Likewise, attitudes are often socially situated, constructed based on shared experience and background (Wyer & Albarracín, 2005).

In a similar vein, material recalled by partners in a series of interactions may influence not only what one remembers but what one *believes*. For example, selective retrieval of certain facts/myths by a public speaker, along with conversational recall, can modulate memory for specific facts/myths, leading participants to update their beliefs about these facts/myths in similar ways (Vlasceanu et al., 2020). With respect to the present study, the intricate interplay between memorial synchrony and synchronized beliefs may be critical. While collaboration in general seems to synchronize both what and how people recall, participants stemming from more diverse CRI groups retain more unique material and collectively forget less material than those stemming from insular CCI groups (Choi et al., 2014). Such memorial consequences suggest that belief synchronization may be *reduced* in a CRI or CRI-like condition, with profound implications in a range of domains such as echo chambers and belief in misinformation as a function of network insularity.

To what degree does collective organization, specifically, influence how cognition at this higher level is synchronized? Some level of structural similarity – a common cognitive reference – is important when pursuing complicated collective efforts such as mapping the human genome or visiting the moon. At the same time, synchrony is not enough; individuals within a broader network may be particularly well-suited for some tasks. A group attempting to solve an immensely complicated problem must find an equilibrium, the point at which knowledge and memory are synchronized enough to move toward goals, and where each individual retains enough of an idiosyncratic perspective to make novel contributions.

Power of Narrative

A narrative is a shared story, with a particular structure or template within which certain information is prioritized (Wertsch, 2008). Analysis of free recall sequences, while contrived, provides one window into such a structure, e.g., what is produced *first*, what is *associated*. If a collaborative group, or a particularly domineering member within a group, repeatedly relies to a particular strategy, that strategy may well be adopted by others. Synchronized retrieval of words not only reveals important theoretical properties of memory, it also has consequences in a practical sense. For example, what if a person or institution has a stake in instantiating a particular narrative? Take the case of how different news channels may opt for covering the hearings relating to the U.S. Capitol insurrection that took place on January 6th, 2021 (ongoing at the time of writing; Peters & Koblin, 2022). How will different coverage shape collective memory for, and collective understanding of, the historic insurrection? While millions tune into one channel, millions of others will tune into another. When discussion ensues, many will have a similar reference, but many will not. The point is that information flow influences what (and how) people discuss; as groups convene and collaboration unfolds, outside narratives may seep in. How the January 6th insurrection is collectively remembered may depend on how particular narratives are established, and subsequently, on the degree to which the public converges on certain representations.

Social Media & Network Size

The internet connects people to massive amounts of information, presenting new challenges and questions about human cognition and identity (Marsh & Rajaram, 2019; Risko, 2019; Wang, 2019). How might the internet, and all that it provides, shape collective memory and collective organization? Several findings related to collaborative recall, notably collective organization, have been replicated in fully online contexts (Greeley et al., 2022), paving a way to forge connections between the laboratory and the digital world. In this context, applying paradigms that involve a series of dyadic conversational recall phases across a network of people can speak to how network characteristics affect collective memory (Momennejad et al., 2018; Vlasceanu et al., 2020; Yamashiro & Hirst, 2020).

Two critical features of social media are reflected, in a basic form, in the data analyzed here for same versus varying group formations that inform the emergence collective memory and collective organization. First, the survival of a social media service requires engagement. If increasing engagement involves algorithmically showing users content that keeps them coming back, users risk becoming siloed in a proverbial echo chamber. Conversely, the size and scope of online social networks are unwieldy. Social media is not typically bound by geography or time, or by discourse topics that can swing from intense political discussions to cats, thus counteracting silos.

Concluding Note

Group recollection helps weave the tapestry of collective memory, synchronizing and structuring the representations of many. Considering collective memory at levels we evaluated in this paper provides a granular assessment of how collaboration synchronizes individual retrieval, helping to understand how collaborative remembering can leave a lasting mark on our beliefs, knowledge, and behavior.

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