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The Influence of Retrieval Organization on the Formation and Persistence of Collective Memory

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Abstract of the Dissertation

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Cognitive research on human memory has primarily focused on how individuals form and maintain memories across time. However, less is known about how groups of people working together can create and maintain shared memories of the past. Such "collective memories" common to all people have been theorized to play a role in the emergence and persistence of a strong cultural identity within groups. Empirical research has been focused on understanding the processes behind the formation of such collective memories, but virtually none has investigated the structure of collective memory. This dissertation examined the extent to which the strength of individual and shared memory structure relates to the formation of collective memory and its persistence over time. Results indicate that both collective memory formation and its persistence over time are strongly tied to the amount of shared organization that develops among individuals, particularly among those who have collaborated with each other to reconstruct the past.

Dedication Page

This dissertation is dedicated to my parents, Michael and Lana Congleton.

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List of Abbreviations

IIII = Control Condition

(Retrieval Sequence: Individual – Individual – Individual – Individual)

ICII = Early Collaboration Condition

(Retrieval Sequence: Individual – Collaborative – Individual – Individual)

IICI = Late Collaboration Condition

(Retrieval Sequence: Individual – Individual – Collaborative – Individual)

ICCI = Multiple Collaboration Condition

(Retrieval Sequence: Individual – Collaborative – Collaborative – Individual)

ARC = Adjusted Ratio of Clustering

SOMA = Shared Organizational Metric Analysis

ANOVA = Analysis of Variance

ANCOVA = Analysis of Covariance

MSE = Mean Squared Error

CHAPTER 1

Introduction

The notion of collective memory has long occupied the interests of historians, anthropologists, sociologists, and even literary thinkers, and the definitions and implications of this construct across these disciplines have focused on different aspects of what collective memory might mean. In recent years, interest in collective memory has galvanized within psychological science as well, and here collective memory refers to the memories shared by individuals who have engaged in some form of conversational or collaborative recall of information or events from the past. The current dissertation adopts this definition and addresses key questions related to the role of memory organization in the formation and persistence of collective memory.

In psychological science, empirical research has been focused on understanding the processes behind the formation of collective memories. But virtually none has investigated the structure of collective memory. The central aim of this dissertation is to examine the extent to which the strength of individual memory structure, or *organization*, relates to the formation of collective memory and its persistence over time. This work will also examine the reciprocal process of how collective memory formation changes the structure of individual memory following its formation, especially by examining the way in which the structure of collective memory itself evolves. A venerable cognitive literature documents the fundamental importance of organization in individual memory performance, but there is presently a complete absence of

theoretical and empirical work on the role of organization in subserving the formation and persistence of collective memory. This dissertation aims to advance our empirical and theoretical understanding of these unexplored yet fundamental components of collective memory.

Collective Memory

Collective memory has been studied across numerous disciplines, ranging from sociology (Halbwachs, 1950/1980; Zerubavel, 2006) to anthropology (e.g., Cole, 2001) and history (e.g., Bodnar, 1992). Given the wide variety of approaches to studying collective memory, there is an equally wide range of definitions with no formal consensus. Coming from a psychological science perspective, Hirst and Manier (2008) argued that the central aspect of collective memory is its relation to group identity, and in the process of reviewing the nature of collective memory the authors attempted to form a bridge between the ideas of social scientists and the empirical work done by psychologists. Researchers' interest in bridging gaps between predominantly philosophical and more empirical approaches has led to an interdisciplinary nature of the study of collective memory, such as work done using research on socially distributed memory to inform philosophical debate about the nature of extended mind (Sutton, Harris, Keil, & Barnier, 2010).

Wertsch and Roediger (2008) discuss the nature of collective memory in a series of oppositions between the said term and other similar terms, and here too one can gain a functional psychological perspective on the disparate ideas. For example, they consider *collective memory*

in contrast to *collective remembering*, where collective memory refers more to an unchanging knowledge base common to all adherents of a group (see Dudai, 2002), while collective remembering refers more to the continuous interplay between individuals who compose a group and the group itself, where both entities are constantly influencing each other (again see Dudai, 2002). Wertsch and Roediger (2008) argue that more emphasis is needed on collective remembering and the continuous reconstructions of the past that occur rather than collective memory as a static body of knowledge.

Regarding the second pair of terms, the difference between *history* and *collective remembering*, Wertsch and Roediger (2008) argue that while both entities seek to provide representation of past events, their ultimate objectives differ. History seeks to provide an unbiased representation of the past while collective remembering is more subjective and tied to the creation and sustainment of a unified cultural identity for all adherents. To quote Wertsch and Roediger (2008): "History is willing to change a narrative in order to be loyal to facts, whereas collective remembering is willing to change information (even facts) in order to be loyal to a narrative."

As for the third pair of terms discussed by Wertsch and Roediger (2008), there has been debate about the nature of differences between *individual remembering* and *collective remembering*. Some researchers have argued that there can be no such thing as collective remembering if one defines the term in such a way as to imply an anthropomorphic "group" having a memory of its own (e.g., Bartlett, 1932). On the other hand, others have argued that all

memory is social in origin, and thus collective, because it is located in cultural institutions and directives rather than within an individual (e.g., Schudson, 1995).

In recent years psychological scientists have become increasingly interested in collective memory, and they have begun to operationally define the concept in order to capture it empirically. In order to encapsulate the idea that collective memories are formed as a result of individuals engaged in group recounting of the past, it has been defined as the overlap in individuals' memories after they have engaged in conversational recall (Cuc, Ozuru, Manier, & Hirst, 2006). A growing body of empirical evidence has begun to examine the various mechanisms involved in the formation of collective memories. For instance, researchers have examined the role of conversations in forming collective memories by measuring the overlap in the post-conversational recall of individuals compared to their pre-conversational recall. Interestingly it has been found that conversations do not inevitably give rise to collective memories. According to Cuc et al. (2006), in order for conversations to lead to the formation of collective memories, unshared pre-conversational recollections of each individual must enter into the conversation of the group, and these recollections must as a result contaminate the post-conversational recollections of the other group members (a process known as social contagion, to be discussed below; see Basden, Basden, & Henry, 2000; Gabbert, Memon, & Allan, 2003; Meade & Roediger, 2002; Roediger, Meade, & Bergman, 2001; Weldon, 2001; Wright, Self, & Justice, 2000). Consistent with this idea, studies have demonstrated that unshared pre-conversational recollections are more likely to enter into a conversation when a dominant narrator is present (Cuc et al., 2006), are more influenced by those who speak first than who

speak second (Gabbert, Memon, & Wright, 2006), and are surprisingly less influenced by expertise per se if a dominant speaker is present (Brown, Coman, & Hirst, 2009). Thus, the formation of collective memories via conversations is not an inevitable process but is dependent upon a variety of factors.

Researchers have further found that the extent to which this overlap in post-conversational recall occurs is a function of not only selective remembering of a set of information during the conversations, but also "silences" or non-recollections of some information; consequently, collective memory results from only remembering a subset of the total (see Marsh, 2007; Zerubavel, 2006). Such selective remembering and silences can influence the nature of forgetting. For example, Cuc, Koppel, and Hirst (2007) found that forgetting is indeed greater in a listener when a speaker to whom the listener is attending is silent about some (e.g., related) but not all (e.g., unrelated) of the study stimuli, a process known as *socially-shared retrieval induced forgetting* (SS-RIF) that is similar to the more traditional *within-individual retrieval induced forgetting* that has been extensively studied in the individual memory literature (WI-RIF; Anderson, 2003).

The Nature of Retrieval Organization

Despite the advances made in understanding some of the mechanisms involved in the formation of collective memories as they arise during and following conversations, there is a complete absence of empirical research on the influence of an individual's pre-conversational memory, particularly with regard to their pre-existing way of organizing the memory that they

bring with them to conversations with others. Memory organization has been traditionally conceptualized in terms of *retrieval organization,* or the degree to which participants systematically cluster information together during recall according to some strategy that will allow the information to be better remembered across time. For instance, such clustering is typically measured by assessing words from the same taxonomic category that are recalled together, or words that are recalled in the same temporal sequence in which the participants originally viewed the stimuli. Research in support of this idea has demonstrated that people tend to impose organization upon their recall when they have studied a list of conceptually-related stimuli (Bousfield, 1953; Bousfield, Cohen, & Whitmarsh, 1958). Even in the absence of an externally-imposed organization (such as elicited by categorized stimuli), participants are still likely to impose their own idiosyncratic organization on the study material, chunking information into higher-order conceptual units across time in a process known as *subjective organization* (Mulligan, 2002).

Once individuals have clustered these items together during an initial recall of the stimuli, the consequences of such elements being currently held in the focus of an individual's attention and reflected upon, either immediately as they are produced or shortly thereafter, are that such stimuli are "bound" together. As a result of this binding, the reactivation of one of the elements during later retrieval is likely to occur with cues concerning the activation of the other bound elements (Johnson, Raye, Mitchell, Greene, Cunningham, & Sanislow, 2005). In addition, it has been demonstrated that any mental process in which an individual is currently engaged (such as retrieval of information) that is similar to a past process in which the individual engaged (such as

a previous retrieval of the same information) can cue the reactivation of that past process (perhaps in the same manner in which that same reactivated information had been organized during the previous retrieval), a phenomenon known as *synergistic ecphory* (Tulving, 1984). Thus, chunks of information may develop because items become clustered next to each other via an imposition of externally-imposed organization or via an idiosyncratic organization that develops during an initial recall process or a combination of these processes. Regardless, one could argue that as a result of having higher-order chunks of information being formed out of the binding together of items, we tend to reproduce such chunks again during future retrieval sessions which possess similar mental activity with the initial retrieval session.

Research from the individual memory literature has shown that information that is better organized survives longer across time (Mulligan, 2005; Puff, 1979; Zaromb & Roediger, 2010; Congleton & Rajaram, 2012; Luhmann, Congleton, Zhou, & Rajaram, 2012). This outcome suggests that highly organized memories are less likely to be disrupted in collaborative, conversational situations. Conversely, the more ways in which it is possible to organize a set of information, the greater the probability that individuals engaged in conversation will possess divergent organizations in terms of how they have idiosyncratically organized the material. As a result of such divergence, people who possess different organizations coming into a collaborative, conversational situation actually will hinder one another in their ability to reconstruct the material, increasing the likelihood of less information being produced (and thus, more information being "silent") compared to if all of the participants shared the same organization coming into the conversation (e.g., Basden, Basden, Bryner, & Thomas, 1997).

Thus it is important to study the influence of idiosyncratic retrieval organization, as it may have an effect not only on the formation of collective memories (as intimated by its subsequent effects on conversational output in terms of recollections and silences), but also on the persistence of collective memory.

The persistence of collective memory refers to the continued collective retrieval of the information during each subsequent retrieval opportunity. Thus, the memory continues to "persist" across time if all group members who previously collaborated retrieve it during every subsequent retrieval opportunity. The proposed influence of retrieval organization on collective memory persistence follows from the fact that it has already been implicated in the persistence of individual memory, and that previous research has demonstrated that the two forms of memory (individual and group) often share many of the same underlying principles (Weldon & Bellinger, 1997). Given the critical role retrieval organization plays in shaping the collaborative process both in immediate recall and after some delay between learning and recall (Congleton & Rajaram, 2011), the time is ripe for testing its role in the formation and persistence of collective memory. This influence of retrieval organization will be examined empirically in this dissertation by means of a paradigm designed to look at what happens when people collaborate together to recall information or events from the past: *the collaborative memory paradigm*. The specific questions to be addressed in this dissertation will be described in later sections. The next section will describe the collaborative memory paradigm that will be used to test these questions empirically and illustrate the proposed mechanisms that come into play during collaboration, which have implications for collective memory formation.

Collaborative Memory

Arising from a cognitive psychological tradition, collaborative memory research is a relatively recent approach to studying group memory processes (Weldon, 2001; Weldon & Bellinger, 1997). This research has focused on investigations about the nature of group recall and the consequences of such collaborative retrieval on the changes in individual group members' memories (see Rajaram & Pereira-Pasarin, 2010 for an overview). This paradigm readily lends itself to examining not only the nature of group recall but also the consequences of such group retrieval (or group encoding) on the formation of collective memory (see the next section for details).

Early work on collaboration demonstrated that while collaborative groups recall more than individuals working alone, the groups tend to recall less than if the individuals comprising that group had worked individually and had their non-redundant responses pooled, forming a post-hoc group known as a nominal group. This phenomenon whereby collaborative groups recall less than their nominal counterparts is known as *collaborative inhibition* (Weldon & Bellinger, 1997). Although social loafing (Latane, Williams, & Harkins, 1979), or diffusion of responsibility, in contributing the learned information during group recall seems like a plausible explanation of this outcome, extant research has failed to support this interpretation (Weldon, Blair, & Huebsch, 2000). The prevailing theory of collaborative inhibition is that it is caused by the disruption of each individual participant's way of organizing the study materials during recall (i.e., retrieval organization). In essence, each participant forms their own idiosyncratic organization of the study materials prior to collaboration. However, during collaboration the

output of one participant attempting to reproduce their own organization may actually disrupt the ability of the other participants to successfully reproduce their own organizations. This process of retrieval disruption reduces each individual member's recall output which in turn reduces the total output of the group to less than its full potential, as indexed by lower recall of collaborative groups compared to the recall of nominal groups (Basden et al., 1997).

Much research has examined the influence of collaboration on the later recall of individuals who previously collaborated, known as post-collaborative individual recall (e.g., Barber & Rajaram, 2011; Barber, Rajaram, & Fox, in press; Basden, Basden, & Henry, 2000; Basden, Reysen, & Basden, 2002; Blumen & Rajaram, 2008, 2009; Congleton & Rajaram, 2011; Thorley & Dewhurst, 2007). How the collaboration process during group recall shapes the post-collaborative recall may depend on the operation of several factors during collaboration, and some of which, as we will see below, may be as such involved in the mediation of collective memory formation (see Rajaram & Pereira-Pasarin, 2010). Figure 1 illustrates the framework that summarizes these mechanisms (taken from Rajaram & Pereira-Pasarin, 2010), and the operation of each is described briefly below.

The first mechanism is *retrieval strategy disruption* that was discussed above, where the output of participants during collaboration acts analogous to the presentation of *part-set cues* and leads to inhibition of the non-presented responses (D.R. Basden & Basden, 1995; D.R. Basden, Basden, & Galloway, 1977; Roediger & Neely, 1982). Part-set cueing refers to presenting a subset of the total stimuli to the participants during recall and asking them to produce the non-presented material. Research has found that presenting this subset of information leads to less

recall output compared to not presenting any of the material (e.g., D.R. Basden & Basden, 1995). The presentation of part-set cues or conversational output in the case of collaboration leads to disruption of participants' organizational retrieval strategies that were formed pre-collaboratively, and thus leads to less effective retrieval for each participant.

A second cognitive mechanism involved in collaboration is known as *rebound*, which refers to items that a participant recalled initially, but which did not appear during the group collaboration, reappearing on a person's final individual recall (Finlay, Hitch, & Meudell, 2000; Weldon & Bellinger, 1997). The process of rebounding occurs presumably because participants are able to recapture/reproduce their idiosyncratic retrieval organization in the absence of collaborative output disrupting their ability to use the organization.

A third cognitive mechanism is known as *blocking and/or forgetting*, where some items not recalled during collaboration can actually be forgotten or fail to be recalled without rebounding during a post-collaborative individual recall. Blocking is a common mechanism that occurs in collaboration, induced by participants being forced to wait to recall their items while their partners' recall their own (Diehl & Stroebe, 1987; Finlay et al., 2000). The process of forgetting in a conversational paradigm has been extensively described in the SS-RIF phenomenon discussed earlier (Cuc et al., 2007; Coman et al., 2009).

A fourth mechanism involved in the process of collaboration is the *social contagion errors* that can arise during, or as a result of, collaboration. Social contagion refers to the process by which memories spread within a group and it has been found that shared memories increase within a group as the contagion spreads among the group members. Research on the

spread of false information has determined that non-studied (i.e., false) information recalled by group members often makes its way into the post-collaborative final recall of the other individuals who comprised the group (e.g., B.H. Basden, Reysen, & Basden, 2002; French, Gary,& Mori, 2008; Gabbert, Memon, & Wright, 2006; Meade & Roediger, 2002; Reysen, 2003, 2005; Roediger, Meade, & Bergman, 2001).

Social contagion as a subcomponent of collaboration is in direct contrast with a fifth cognitive mechanism known as *error pruning*, where the process of listening to one's collaborating partners recall information can prevent the emergence of errors in recall that one might otherwise make during later individual recall (Barber, Rajaram, & Aron, 2010; Ross, Spencer, Lindardatos, Lam, & Perunovic, 2004; Ross, Spencer, Blatz, & Restorick, 2008).

The sixth component mechanism that occurs during collaboration is known as *re-exposure*, where the act of collaboration re-exposes participants to information recalled by their fellow partners that they themselves might not have recalled otherwise (Blumen & Rajaram, 2008; Weldon & Bellinger, 1997). These benefits are detected on post-collaborative individual recall, where many studies have found that memory increases if collaboration comes before an individual recall, such that there is a positive cascade on recall across time (Blumen & Rajaram, 2008, 2009; B.H. Basden et al., 2000; Congleton & Rajaram, 2011; Thorley & Dewhurst, 2007; Weldon & Bellinger, 1997; however, see Finlay et al., 2000).

And finally, there is the seventh component mechanism on collaboration known as *relearning through retrieval*. Collaboration allows participants the opportunity to study and rehearse information during recall output. It is well known in the individual memory literature

that repeatedly retrieving information improves long-term retention via relearning through retrieval (Karpicke & Roedgier, 2008; Roediger & Karpicke, 2006), while collaboration can lead to both relearning through retrieval and the process of re-exposure as discussed above.

The various mechanisms outlined above will be evaluated in the present dissertation only to the extent that they influence the formation of collective memory and the other questions the dissertation addresses.

Linking Collaborative Recall Processes to Collective Memory Formation

Research has demonstrated the above principles involved in collaborative recall in empirical studies. In Blumen & Rajaram (2008) it was discovered that participants who collaborated in the recall of a list of words had greater overlap in their post-collaborative individual recall (i.e., more overlapping or shared memories) because there was an increase in redundant responses in nominal groups. This increase in overlap lowered the nominal group output (calculated from the post-collaborative, individual recall outputs) and thus wiped out collaborative inhibition. Henkel and Rajaram (2011) recently also showed that collective memory formation is unaffected by the process of normal aging, such that post-collaborative recall of individuals shows an equivalent increase in memory overlap compared to pre-collaborative, individual recall in both young and older adults.

More recently, it has been empirically demonstrated that there is a difference in the influence of collaboration on the amount of collective memories formed depending on whether collaboration occurs at encoding or at retrieval (Barber, Rajaram, & Fox, in press).

Collaboration led to a greater formation of collective memories (greater overlap among post-collaborative memories) when participants collaborated during retrieval. These results suggests that collective memory formation may be tied to the cognitive mechanisms and processes occurring when participants are attempting to work together to recall memories that they had individually formed and idiosyncratically organized (e.g., such as the mechanism of retrieval disruption). Thus, collective memories can be born out of the influence and confluence of the subcomponent processes of collaborative recall (Rajaram & Pereira-Pasarin, 2010).

The results of Barber et al. (in press) demonstrating the propensity of collective memory formation as a result of collaboration during retrieval as opposed to encoding beg the question as to the influence of retrieval organization on the various subcomponent mechanisms of collaboration (particularly retrieval disruption). Given that collaboration during retrieval leads to greater collective memory formation, this likely occurs because of the mechanism of retrieval disruption of each participant's way of idiosyncratically organizing the material. As a result of having their original way of organizing the material disrupted, participants are left with no choice but to adopt the organization and recall output produced during collaboration when it comes time for them to recall individually post-collaboratively. This process could entail not only retaining from one's own memory the items that gained entry into collaborative discussion, but also incorporating others' recalled items that were not in one's own memory (social contagion), eliminating one's own memories if these did not enter collaborative discussion (forgetting), and correcting one's erroneous output through others' feedback (error pruning). At the same time, the results of Barber et al. (in press) also question these mechanisms' reciprocal

influence on retrieval organization, and how all of these cognitive mechanisms influence the very formation of collective memories. In other words, retrieval disruption not only leads to the formation of more collective memories, but it also forces participants to adopt the organization of the group (as their own organization was disrupted during collaboration, and as they pruned from or incorporated various items into their own recall structures). As a result, it is very likely that the participants will share not only the same overlapping information (i.e., collective memories) but also the same overlapping organization of that information that newly developed during collaboration (i.e., *shared or collective organization*, or the structure of collective memories). We predict that one of the factors involved in the formation and persistence of collective memories across time is how well a shared organization among all collaborators may be formed through the process of collaboration.

In brief, the present dissertation is designed to investigate whether the extent to which people are already entrenched in their own idiosyncratic organization of the past affects the formation and persistence of collective memories. It is also designed to examine the evolution in the overall structure of collective memories by examining the influence of pre-existing idiosyncratic organization brought to collaborative recall sessions by the participants on the formation of collective memories. In addition, the dissertation will investigate the reciprocal process of how the act of collaborating influences the post-collaborative idiosyncratic organization of the participants. Given that collaboration can influence the amount of recall produced by participants post-collaboratively (Congleton & Rajaram, 2011; Blumen & Rajaram, 2008), it follows that collaboration can also influence the way in which such information is

individually organized following collaboration. In addition, this dissertation will investigate how the act of collaboration instantiates a group-level organization of the study materials formed out of the simultaneous recall of idiosyncratic organization produced by each collaborating member. Thus, the study can examine if the group-level organization, formed out of the synthesis of divergent idiosyncratic organizations brought to collaboration by each participant, will also influence the formation of collective memories.

Shortly we will describe the specific questions tested in this dissertation. The role of the various mechanisms implicated in the process of collaboration, will be discussed in the context of these questions as appropriate. However, many of the details discussed in the questions below are presaged on the nature of the selected methodology for this dissertation. Therefore, the next section will present a brief overview of the details of the methodology for the conditions to facilitate the presentation of the specific hypotheses.

Preview of Methodology

The participants first studied a list of randomly sequenced, categorized word stimuli. They performed this study task individually, and then performed a following distractor task also individually. During the test phase, all participants in the first session recalled the studied items individually, i.e., performed an individual recall task. This task served as the baseline recall for calculating the pre-collaborative recall and overlap in recall. The experimental manipulations began after this task in the second retrieval session of the experiment. Participants were randomly assigned to one of four conditions, and each condition consisted of a series of retrieval

sequences. In the Control condition, participants engaged in three sequential individual recalls (I-III). In the Early Collaboration condition, participants first recalled collaboratively, before recalling individually two more times (I-CII). In the Late Collaboration condition, participants recalled individually once, then they recalled collaboratively, before recalling individually one final time (I-ICI). In the Multiple Collaboration condition, participants recalled collaboratively twice, before recalling individually once more (I-CCI). Note that the first recall and the last recall in these sequences always consisted of individual recall, and thus provided a clear way to measure the changes in the overlap of recall among group members between their pre-collaborative recall performance to their post-collaborative performance, where the intervening recalls provided different experiences with respect to the timing and extent of the collaboration experience. These tests provided data for examining the formation of collective memory. All participants then left the lab and returned exactly one week later to take a final individual recall test along with completing several other experimental tasks that will be described in more detail below. The one-week test provided data for examining the persistence of collective memory.

From this point onward, any mention of the conditions will include the notation denoted in parentheses above, but the first recall will be omitted because it is always individual. Thus, the Control condition will be denoted as III, Early Collaboration as CII, Late Collaboration as ICI, and Multiple Collaboration as CCI.

Selection of Stimuli

As mentioned earlier, our stimuli consisted of categorized words. The selection of categorized words as stimuli was guided by a number of important reasons. One, these stimuli have been found to lend themselves to the calculation of retrieval organization scores (Roenker, Thompson, & Brown, 1971). Thus, the use of these stimuli will provide a quantitative measure of the relation among collaboration, retrieval organization, and collective memory formation. Two, while more naturalistic stimuli may consist of past narratives or stories, previous research has shown that individuals tend to impose organization upon conceptually-related stimuli (W.A. Bousfield, 1953). Thus, related words invoke organizational processes, and as the principles involved in the formation of organization around these categorized stimuli are well known, their use aided in our examination of the relationship of this well-established principle to a new and exciting area of memory research. Furthermore, any potential concerns that word stimuli (even those that are highly structured in conceptual terms) may be artificial, and that any results derived from them may not generalize, are further mitigated by the reports that that even in the absence of an externally-imposed organization participants impose their own subjective organization upon whatever stimuli they encounter (Gates, 1917; Tulving, 1962; Mulligan, 2002). Thus, categorized word stimuli combined the best of various options for present purposes; these stimuli possessed externally-imposed conceptual structure (like a narrative), lent themselves to the natural inclination of subjects to impose a subjective organization, and have been successfully used to quantitatively measure retrieval organization in recall.

Core Questions to be Addressed in the Present Dissertation

(1) **How does the strength of (a) an individual's pre-collaborative memory (i.e., idiosyncratic retrieval organization), as well as (b) the memory formed during group recounting (i.e., group retrieval organization), influence the *formation* of collective memories?** As was described above, it has been demonstrated that the formation of a large amount of collective memories is tied more to participants collaborating with each other during retrieval as compared to collaborating with each other during the initial encoding and learning of the study materials (Barber et al., in press). It is known that when groups of people collaborate with each other during retrieval, they do not recall as much as they are capable of recalling had they been working individually (Weldon & Bellinger, 1997). This outcome suggests that collaborating with others during recall interferes with the use of each participant's own idiosyncratic organization that was formed prior to collaboration, particularly if the participants have formed divergent ways of organizing the study materials (Basden et al., 1997), or if they have not "solidified" their organization via repeated retrieval prior to collaborating (Congleton & Rajaram, 2011, 2012; Luhmann, Congleton, Zhou, & Rajaram, 2012). *Solidification* is defined here as the number of opportunities one has to reproduce organization as a result of multiple recalls. The more times one successfully/accurately reproduces this organization (as is the case in successive, multiple individual or multiple collaborative recalls), the more solidified, and less susceptible to disruption, the organization becomes.

Consistent with the logic outlined above, recent findings show that repeatedly retrieving material prior to collaboration reduces or eliminates collaborative inhibition compared to

repeatedly studying material (Congleton & Rajaram, 2011). Similarly, it was also found that repeatedly retrieving material in general for both nominal and collaborative groups led to increased retrieval organization scores, tying together the idea of the successful solidifying of one's own idiosyncratic organization as a result of repeated retrieval opportunities with the outcome of being protected against the disrupted influence of others during collaboration. As a result of being protected from the negative effects of retrieval disruption during collaboration, each individual participant was then able to glean the most in terms of re-exposure effects from their collaborating partners, leading to improved post-collaborative individual recall (Congleton & Rajaram, 2011; also see Blumen & Rajaram, 2008). Thus it appears that the securing of one's idiosyncratic organization prior to collaboration affects key cognitive mechanisms involved in the collaborative process that influence both the group and the individuals post-collaboratively. However, neither study illuminated the nature of collective memory as a consequence of either prior retrieval organization or the process of collaboration. One can predict that given the relationship between the formation of collective memories and these cognitive mechanisms outlined earlier in the Introduction that variations in the strength of idiosyncratic organization will also play a role in the formation of collective memories as a result of organization's influence on cognitive mechanisms.

In cases where participants have not solidified their own idiosyncratic organization, collaboration disrupts the participants' ability to accurately reproduce the manner in which the participants clustered items together during the individual recall, such that group recall (and group organization) is formed out of the disrupted reproduction of each participants'

idiosyncratic organization (e.g., Basden et al., 1997). As a result of this disruption, there is an increased probability that during post-collaborative recall participants will abandon their now-disrupted idiosyncratic organization and adopt not only the output but also elements of the newly emerging output organization of the group. As a result of this adoption of group output and output organization, it is predicted that there will be more collective memories formed when collaboration occurs early in the process of recall. This is because all participants involved in the collaboration will be left with weakened idiosyncratic organization and thus are more likely to adopt the output produced during collaboration. As a result of this process, post-collaborative individual recall is expected to feature fewer items that were recalled pre-collaboratively but failed to be recalled during collaboration (because individuals were not able to successfully use their own idiosyncratic organization) and instead will feature items recalled during the collaboration, thus increasing the likelihood that the participants will share a large number of items on their post-collaborative recall (i.e., collective memory).

In our design (III/CII/ICI/CCI), we can look to the Early (CII) and Late Collaboration (ICI) conditions to test these predictions. In these conditions, participants will either have one opportunity to produce their own idiosyncratic organization prior to collaboration, via their first recall which is individual for all participants, (Early Collaboration) or two opportunities (Late Collaboration), allowing for a comparison between those individuals who have not solidified their own organization versus those who have. Past research (e.g., Blumen & Rajaram, 2008; Weldon & Bellinger, 1997) has examined these sequences of collaboration but for a fewer number of recall sequences and, critically, only for study materials consisting of unrelated words.

The findings from those conditions are informative for present purposes in that individuals who collaborated twice (in a condition comparable to the present CCI) demonstrated a trend for improved retrieval organization scores compared to all other retrieval sequences. However, these findings fail to illuminate the present question because unrelated word stimuli do not lend themselves easily to robust measurements of organization in recall. Critically, both the early and later collaboration conditions in the present design will have the participants form divergent organizations, as they will be viewing a large list of words with large numbers of randomly sequenced exemplars from various categories, leading to increased potential ways of organizing such words (which is necessary for retrieval disruption to occur). The Early Collaboration condition will also have the added detriment of not allowing the participants to solidify their idiosyncratic organization of the study materials (via repeated retrieval) prior to collaboration to the same extent as possible for the participants in the Late Collaboration condition. As a result, we should see less adoption of the group organization in the Late Collaboration condition because the strengthened idiosyncratic organization will protect against retrieval disruption of idiosyncratic clusters, and we should see less formation of collective memories compared to the Early Collaboration condition. Here one possibility does exist for increased collective memory, and this comes from the opportunity to benefit from re-exposure to others' recall, as each group member would be in a position to produce more items (having their own idiosyncratic clusters relatively protected). However, the source of the increase in collective memory in this condition would arise largely from increased re-exposure, whereas in the Early Collaboration condition this increase will result from both the failure to recall one's own previously recalled items and

the increased reliance on recalling items shared during collaboration. The multiple analyses described in a later section will help identify these different origins of collective memory.

The Multiple Collaboration condition (CCI) should have the least amount of idiosyncratic organization left during post-collaborative recall (compared to pre-collaborative individual recall) due to a solidification of group organization across multiple recalls, and thus any pre-collaborative unshared information that is not produced during collaboration should be inhibited to a far greater extent in this condition (via the repeated adoption of the group output and organization due to inhibition of idiosyncratic organization reproduction). In turn, this is expected to bring about the highest overlap in recalled items, and thus facilitate collective memory formation to the greatest extent. If this is the case, it would mean that the formation of collective memories is actually tied to the adoption of group organization over idiosyncratic organization in circumstances where one's own organization is disrupted during recall (or is weak to begin with). One could interpret this in a broader sense to mean that if someone has not powerfully conceptualized their opinion or way of thinking about a particular set of information, ideas, or events, they will be more susceptible to the viewpoints or ways of thinking of others and will be more likely to adopt others' perspectives at the expense of their own.

Alternatively, perhaps we will find that the formation of collective memories across the Early and Late collaboration conditions will occur exactly as outlined above, but there may be no detectable differences in the retrieval organization that participants produce from their first individual recall to their last individual recall, or at least the pattern may not be quite as clear as the differences in the magnitude of collective memories across these conditions. In this case, it is

quite possible that the basic measure of retrieval organization that we will employ (adjusted ratio of clustering; Roenker et al., 1971) may actually not be sensitive to the more subtle changes occurring. For example, perhaps there is no difference in the amount of retrieval organization occurring between Early and Late Collaboration conditions because orphan items (i.e., non-clustered items) are being dropped, a process that would cause no noticeable difference in adjusted ratio of clustering scores. As a result of possibilities such as these, we will employ a wide variety of measures designed to be more sensitive to the changes in idiosyncratic and group organization and the fate of organization across time than is provided by such basic organizational measures as adjusted ratio of clustering scores.

(2) **How does the strength of an individual's pre-collaborative memory (i.e. idiosyncratic retrieval organization) influence the *persistence* of collective memory across time?** From the individual memory literature, it is known that organization is an important mechanism behind the persistence of individual memory across time, particularly if a person's organization has been solidified via multiple retrieval opportunities to reproduce the organization (Mulligan, 2005; Puff, 1979; Congleton & Rajaram, 2011, 2012; Zaromb & Roediger, 2010; Luhmann, Congleton, Zhou, & Rajaram, 2012). Based on this evidence, we reason that organization would be an important factor in the persistence of collective memory across time as well. We will examine the influence of, as well as the interplay between, the idiosyncratic organization produced by individuals recalling alone prior to collaborating as well as the group organization created during collaboration on the persistence of collective memory across time.

Nominal group comparisons in the Control condition with the group organization of the Multiple Collaboration condition should demonstrate that the participants of the Control condition will not have nearly as much overlap in their organizations on post-collaborative individual recall. This is because the participants in the Control condition will not collaborate at any time and thus they will each form and solidify their own idiosyncratic organization that is likely to be divergent because of the large study list (Basden et al., 1997). As a result, any overlapping memory items (i.e., collective memory) that they do possess will exist within their own idiosyncratic clusters (that will be different for each participant), and we predict that the shared information persists across time within these clusters to a shorter period of time than the information contained within the shared group organization that would be formed by participants in the Multiple Collaboration condition.

In the Multiple Collaboration condition, group members should be more likely to adopt the organization of the group during their post-collaborative individual recall because of a lack of solidification of their own idiosyncratic organization during the main retrieval sequence (compared to the Control condition described above). Thus, these members will be more likely to disrupt one another's organization during collaboration, leading to a greater probability that all 3 group members will adopt the organization that emerges in the group at the expense of idiosyncratic organization to a certain extent and therefore share the same organization post-collaboratively. As a result of having adopted the group organization that was solidified across multiple collaborative retrievals, any collective memory items are predicted to persist across delay to a greater extent than if those collective memory items were actually contained with

idiosyncratic organizational clusters. This is because if a few members of the group have incorporated the collective memory items into their own pre-collaborative idiosyncratic organization (which may persist to a certain extent), after delay there would be an increased probability of at least one member losing the collective memory items because their own idiosyncratic organization would not be as strong due to a lack of solidification across multiple recalls compared to the collaborative group recall. In other words, idiosyncratic organizations may not be equivalently strong among the group members post-collaboratively, but the group organization that they did encounter should indeed be strong and collective memory items contained within group organizational clusters will persist longer.

CHAPTER 2

Methodology

Materials

The stimuli consisted of a list of 120 categorized words, with 8 categories and 15 exemplars per category, allowing for more potential ways in which the exemplars could be clustered together to avoid compensation in adjusted ratio of clustering (ARC) scores during repeated individual or collaborative recalls, as well as making it easier to separately identify idiosyncratic and group clusters during post-collaborative recall. The words were taken from the van Overschelde, Rawson, and Dunlosky (2004) word norms. We excluded the top 2-3 exemplars per category in order to prevent such items from dominating recall and retrieval organization patterns, which would make it more difficult to parse idiosyncratic from group organization during post-collaborative individual recall.

Participants

There were 12 triads of participants per condition across four conditions for a total of 144 participants.

Design and Procedure

The experiment consisted of four conditions: Control, Early Collaboration, Late Collaboration, and Multiple Collaboration. Table 1 presents the full design and sequential nature of the procedure described here. When the participants arrived in the lab for their first session

they were randomly assigned to one of those four conditions. At the beginning of the experiment, all participants were exposed to the study stimuli via a Power Point presentation. Afterwards, all participants completed a spatial distracter task for 7 minutes (i.e., maze completion). Following the completion of this task, all participants took an individual recall test, in which they were asked to write down on a blank sheet of paper as many of the study words they could produce. They had 7 minutes to produce as much as possible. They were told that whenever they heard a tone emitted by the computer, they should stop recalling and draw a horizontal line below the last item they produced (the tone sounded every minute). This minute-delineation mark allowed us to plot cumulative recall and organization curves (see Results section below). After completing the first individual recall (pre-collaborative recall), the procedure began to differ depending upon the condition.

Participants in the Control condition took three additional individual recall tests in a row following the same format given above. Collaborative groups were formed by randomly assigning three individuals into one group with the restrictions that they had not known each other before. Before beginning a collaborative session, the participants were asked to speak their subject numbers (e.g., 102, 203, etc.), along with a short sentence, aloud into a tape recorder that allowed us to have a record of what each participant recalled. Participants in the Early Collaboration condition were formed into a group of three members and were instructed that they would work together to recall as many items as possible. They were told that even though all three would be working together during recall, only one person (i.e., the scribe) would be

recording their answers on the sheet.[1] They were also apprised of the tone timer with instructions to draw a horizontal line as described above. As in the individual recall sessions, they also had 7 minutes to produce as much as they could. They were allowed to recall their words in a free-flowing format with no turn-taking structure, and they were told that if any disagreements arose between them about whether or not a particular word was actually studied it was up to them to arrive at a solution.[2] Afterwards, participants in the Early Collaboration condition were asked to recall individually two more times following the instructions outlined above. For the participants in the Late Collaboration condition, after the initial individual recall they were asked to recall individually once again following the same instructions outlined above. Afterwards, they were formed into a collaborative group and asked to recall according to the instructions outlined above. Finally, they recalled individually once more. For participants in the Multiple Collaboration condition, after initially recalling individually they were put into a collaborative group and asked to recall collaboratively two times in a row following the instructions outlined above. Afterwards, they recalled individually once more. Following the completion of these retrieval sequences, all participants were asked to leave the lab and return exactly one week later to complete the second part of the study. When the participants returned, they were asked to recall individually according to the instructions outlined above. Afterwards, all participants received a full written and verbal debriefing as to the goals of the experiment.

CHAPTER 3

Results

In the Introduction, I had predicted that the idiosyncratic organization produced by participants prior to collaboration (assessed via ARC for Recall 1), as well as the group-level organization produced during collaboration (also assessed via ARC), would be important factors in the formation of collective memories. At the same time, I had argued that the development of a shared organization across participants following collaboration would be an important factor in the persistence of collective memories. After examining the results, it became apparent that pre-collaborative, idiosyncratic and collaborative, group-level organizations were not as important in the formation of collective memories, but that the development of a shared organization was actually the key to accounting for both collective memory formation and its persistence over time. Thus, while I have retained the predictions as originally stated in my dissertation proposal, I will present analyses in this results section which shed light on the role of shared organization on the formation and persistence of collective memory.

In light of this above-mentioned point, I report below only those dependent variables which proved pertinent to the questions addressed by this dissertation. After examining the data, certain analyses were determined to be non-essential to the overall goals of this study. Non-essential analyses included the following: Hits and Intrusions, which assessed basic differences in the amount of study material participants were able to accurately reproduce during a recall session, as well as all the non-studied (false) information they produced; Proportion Corrected Recall, which is a more conservative measure of the amount of study material produced, formed

by subtracting the total number of Intrusions from the total number of hits and dividing that number by the total number of possible words; Adjusted Ratio of Clustering (ARC), a basic index of retrieval organization that quantifies the degree to which participants used a retrieval strategy in the form of clustering items together from the same taxonomic category; and Cumulative Recall and Cumulative Organization Curves, which examined the degree to which participants consistently recall their memories in the same manner across time. The means and standard errors of Hits, Intrusions, Proportion Corrected Recall, and Adjusted Ratio of Clustering for participants across conditions at Recall 1 and Recall 4 can be found in Table 2, while Cumulative Recall Curves for Recall 1 and 4 can be found in Figures 2 and 3 respectively, and Cumulative Organization Curves for Recall 1 and 4 can be found in Figures 4 and 5 respectively. As these particular analyses did not provide insight into the primary role of retrieval organization on the influence of collective memory formation and persistence, they will not be discussed further.

This study was primarily concerned with the influence of retrieval organization on the formation and persistence of collective memory, and the majority of this results section will detail analyses designed to address these goals. However, the design of this study also created an opportunity to examine the presence of collaborative inhibition at two time points (Recalls 2 and 3), and to evaluate the replication of this phenomenon and its attenuation as observed in past studies as a function of previous recall conditions (Weldon & Bellinger, 1997; Blumen & Rajaram, 2008; Congleton & Rajaram, 2011). The first opportunity occurred during Recall 2, where I was able to compare the collaborative recall of participants in the Early and Multiple

Collaboration conditions with nominal group recall of participants in the Individual condition. As was mentioned in the Introduction, nominal group recall is formed out of the pooled, non redundant responses of three individuals who worked by themselves. Results indicated there was a marginally significant difference between nominal (M = .66) and Early Collaboration participants (M = .60), $t(22) = 1.96$, p = .06, while there was a significant difference between nominal and Multiple Collaboration participants (M = .57), $t(22) = 2.85$, p = .01. Given the strong prediction regarding the collaborative inhibition effect in previous studies, a one-tailed test is justified and yields a significant collaborative inhibition effect for the Early Collaboration participants. Thus, the results demonstrate a replication of the collaborative inhibition effect during Recall 2.

The next opportunity to examine collaborative inhibition occurred during Recall 3, where I was able to compare the collaborative recall of participants in the Late and Multiple Collaboration conditions with the nominal group recall of participants in the Individual condition at that time point. Results indicated there was a significant difference between nominal (M = .67) and Late Collaboration participants (M = .60), $t(22) = 2.11$, p = .05, once again replicating the collaborative inhibition effect. However, there was no difference between nominal and Multiple Collaboration participants (M = .63), $t(22) = 1.21$, p = .24, demonstrating a lack of collaborative inhibition. This likely occurs because the Multiple Collaboration participants had two opportunities to collaborate, resulting in an elimination of the collaborative inhibition effect as seen in previous studies which included repeated collaboration (e.g., Blumen & Rajaram, 2008). From here onward, the results section will focus on addressing the primary questions

regarding the influence of retrieval organization on collective memories, and thus the collaborative inhibition data will not be discussed further.

The primary question of interest in this study was whether retrieval organization plays a role in the formation of collective memory, which is examined by calculating the degree to which people share overlapping memories with their fellow partners following collaboration. Collective memory was originally to be considered as a combination of collective recollections, which are shared recall of items, and collective omissions, which are shared forgetting or lack of recall of items. However, in the process of examining the data, it became apparent that collective omissions were so high (most likely due to the large nature of the study list) that their inclusion in an omnibus "collective memory" variable was obscuring the patterns observed in terms of collective recollections. In addition, there were no significant effects of group on collective omissions either at baseline levels or at Recall 4 such that no conclusions could be drawn from this measure. Therefore, I will focus on addressing questions of collective memory in terms of collective recollections (as has been done in previous studies; e.g., Cuc et al., 2006), and collective omissions will no further be discussed. For the sake of completion, means and standard errors of collective omissions can be found in Table 3.[3]

To assess baseline levels of collective recollections, a one-way between-subjects analysis of variance (ANOVA) was conducted with group as the factor. Results indicated there were no differences among conditions, $F(3, 44) = 1.99$, $MSE = 9.27$, $p = .13$. Means and standard errors across conditions are shown in Figure 6.

Next I wanted to examine how group condition following the various retrieval sequences influenced the formation of collective recollections. In order to control for baseline levels of collective recollections, I conducted an analysis of covariance (ANCOVA) in which the dependent variable was collective recollections at Recall 4, the independent variable was group, and the covariate was collective recollections at Recall 1. Prior to conducting the ANCOVA, I examined the assumption of homogeneity of regression by testing the interaction of the independent variable with the covariate. This interaction was small (increment in R-squared = .004) and was not significant, $F < 1$. The ANCOVA yielded a significant difference among the four conditions, $F(3, 43) = 12.94$, $MSE = 57.43$, $p < .001$, effect size (partial eta squared) = .48. Adjusted means and standard errors for the four conditions are shown in Figure 6. Follow-up pairwise comparisons indicated that after controlling for baseline (Recall 1) levels of collective recollections, participants in Early Collaboration (M =20.64, p = .04), Late Collaboration (M = 24.12, p =.001), and Multiple Collaboration (M = 31.18, p = .001) conditions all produced significantly better levels of collective recollections compared to participants in the Individual condition (M = 11.73). In addition, the Multiple Collaboration condition resulted in significantly greater collective recollection formation compared to Early Collaboration (p = .02), but not in comparison to Late Collaboration (p = .18). There was also no significant difference between Early and Late Collaboration conditions in terms of the amount of collective recollections produced (p = 1.00).

Next I wanted to examine the influence of a shared organization across participants. To accomplish this goal, I constructed a measure that was novel to this particular dissertation: the

Shared Organizational Metric Analysis (SOMA). The analysis is essentially a variation on the paired frequency analysis (PF; Sternberg & Tulving, 1977). Paired frequency is designed to examine the degree to which items recalled in adjacent output positions during an initial recall are also recalled together on a follow-up recall. Thus, the paired frequency measure is a within-subject analysis. The variation used in the present dissertation is essentially a "horizontal" (i.e., between-subjects) paired frequency. This analysis examines the recall output positions *across* all three participants in order to determine if collective recollection items are in adjacent output positions (forward or backward) in the recall of all three participants. Given the nature of the paired frequency measure, which allows only for examination of two recall protocols at a time, it was necessary to conduct an analysis of Person A to B, Person B to C, and Person A to C, then average across the three.

To assess baseline levels of shared organization (SOMA), a one-way between-subjects ANOVA was conducted with group as the factor. Results indicated there were no differences in baseline levels of SOMA across conditions, $F(3, 44) = .21$, $MSE = .98$, $p = .89$. Means and standard errors across conditions are shown in Figure 7.

I then examined the influence of group following the retrieval sequences on the formation of shared organization (SOMA). Once again, in order to control for baseline levels of shared organization, I conducted an ANCOVA in which the dependent variable was shared organization (SOMA) at Recall 4, the independent variable was group, and the covariate was shared organization (SOMA) at Recall 1. Prior to conducting the ANCOVA, examination of the assumption of homogeneity of regression determined that the interaction between the covariate

and the independent variable was small (increment in R-squared = .02) and was not significant, $F < 1$. The ANCOVA yielded a significant difference among the four conditions, $F(3, 43) = 13.91$, $MSE = 3.73$, $p = .001$, effect size (partial eta squared) = .49. Adjusted means and standard errors for the four conditions are shown in Figure 7. Follow-up pairwise comparisons indicated that after controlling for baseline levels of shared organization, participants in Early Collaboration ($M = 6.14$, $p = .001$), Late Collaboration ($M = 5.27$, $p = .04$), and Multiple Collaboration ($M = 7.99$, $p = .001$) conditions all produced significantly better shared organization compared to the Individual condition ($M = 2.99$), where SOMA was measured across three individuals who never collaborated (i.e., in the form of nominal groups). In addition, Multiple Collaboration produced significantly better shared organization compared to Late Collaboration ($p = .01$), but not in comparison to Early Collaboration ($p = .15$). Once again, there was no difference between the Early and Late Collaboration conditions in terms of the amount of shared organization produced ($p = 1.00$).

The above-mentioned results intimate about the relationship between collective recollection formation and the development of shared organization. There appears to be a greater amount of shared organization developing among individuals who collaborate, particularly those who collaborate multiple times. At the same time, there also appears to be a greater amount of collective recollections formed after individuals collaborate, with greater collective recollections for those who collaborate multiple times. In order to further investigate the potential relationship between collective recollections and shared organization, I conducted a regression analysis in which collective recollections at Recall 4 was the criterion variable and

shared organization (SOMA) at Recall 4 was the predictor variable. The overall R-squared was .77, $F(1, 46) = 151.13$, $p = .001$, indicating a strong association between these two variables. In order to further determine if shared organization at Recall 4 was the best predictor of collective recollection formation at Recall 4 compared to all other potential predictors that could have any modulating influence, I conducted a forward stepwise regression analysis in which collective recollections at Recall 4 was the criterion variable and potential predictor variables were hits, proportion corrected recall, adjusted ratio of clustering (ARC), collective recollections, collective omissions, and shared organization (SOMA), all variables included at both Recall 1 and Recall 4. Results indicate that shared organization (SOMA) at Recall 4 was the best single predictor, accounting for 77% of the variance in collective recollections at Recall 4; recall 4 hits was the best additional predictor, accounting for a further 6% of the variance in collective recollections at Recall 4. None of the additional variables added a significant increment (at the .05 level).

Though these results indicate a strong association between collective recollections and shared organization, and they indicate that shared organization at Recall 4 is the single best predictor (and certainly accounts of the lion's share of the variance in comparison to a host of other predictors), there still is the specific question of the degree to which shared organization influences collective memory formation (or is tied to its presence at all). In order to further investigate this question, I conducted another ANCOVA in which the dependent variable was collective recollections at Recall 4, the independent variable was group, and the covariate was shared organization (SOMA) at Recall 4. In examining the assumption of homogeneity of regression, it was determined that the interaction between the covariate and independent variable

was small (increment in R-squared = .09) and was not significant, $p = .30$. Although after controlling for shared organization the ANCOVA continued to yield a significant difference, $F(3, 43) = 3.62$, $MSE = 20.71$, $p = .02$, effect size (partial eta squared) = .20, the follow-up pairwise comparisons revealed no significant differences among any of the four conditions. Importantly, when shared organization at Recall 4 was held constant across conditions, the amount of collective recollections formed during Recall 4 in the Individual condition jumped from 12.00 (uncorrected mean) to 19.58 (adjusted mean), bringing the amount of collective recollections formed by those participants who did not collaborate to the level of those who did. This indicates the importance (and perhaps necessity) for a strong, shared organization among individuals in order to result in a great amount of collective recollections. The earlier presented results indicate that in this experiment, the greatest amount of shared organization developed when participants collaborated with one another. Thus, when the Individual participants were provided the same advantage of shared organization as the Collaboration participants (by controlling for shared organization at Recall 4 via ANCOVA, and increasing Individual participants' SOMA at Recall 4 from 2.88 to the mean level of SOMA of 5.60), they produced a far greater amount of collective recollections that was essentially equivalent to those who had previously collaborated.

Next, we wanted to investigate potential explanations behind why Early and Late Collaboration conditions resulted in different amounts of collective recollections and shared organization compared to Multiple Collaboration at Recall 4. One potential variable may be the degree to which a person's current recall and organization is dependent upon the organization of

previous recalls. In order to identify the potential presence of previous recalls on the current recall, another analysis novel to this dissertation was created: the Origin Analysis. This analysis allows for the identification of the fingerprints or markers of individual and group influences on post-collaborative recall, where it is used to determine where each cluster originated.
In this analysis, I identified the clusters post-collaboratively (on Recall 4), selected specific items within the cluster, and then looked to both the pre-collaborative individual and collaborative recall sessions to determine what items surrounded each selected item at those times. One of the potential applications derived from this analysis is the identification of another variable novel to this dissertation that I have termed *Hyperparasitism*.

In ecology, hyperparasitism refers to a situation where a parasite is actually dependent upon another parasite which is dependent upon the host (or another parasite as the case may be in larger chains). In the case of retrieval situations, hyperparasitism refers to a situation in which a person's current retrieval organization in a recall session is dependent upon and forms as a result of the organization seen in retrievals further back in time than just the immediately preceding retrieval. Thus, to say that a person's retrieval is "hyperparasitic" means that it is dependent upon more than just the preceding retrieval (i.e., the current recall is very interdependent upon the previous ones). This situation is in contrast to one in which a person's current recall is dependent upon the retrieval organization of primarily the immediately preceding retrieval, a situation termed "parasitic" recall. There is some evidence to support the idea of hyperparasitic recall in the literature. It is known that memory cues typically do not activate single episodes from the past but parts of multiple episodes, what Neisser termed "repisodes" (Neisser, 1981). In

addition, the act of reactivating a particular memory trace itself causes another trace to be put down into long-term memory (Logan, 1988). After a while people may come to reactivate the "memories of remembering" more so than the original memory itself (Lindsay, 2008). In essence, if one's recall is composed of clusters from multiple previous retrievals, we can assume that the participant is actually accessing at least part of each previous representation. Thus, given that the act of retrieval activates parts of representations from many previous retrieval opportunities, it makes sense that they would be activating not only the information contained within each repisode but also the organized manner in which the information was recalled. As such, from a purely theoretical stance, the hyperparasitism analysis allows one to trace the influence of multiple versus single representations people have laid down into long-term memory in the past on one's present recall.

To determine the presence of parasitism versus hyperparasitism in a recall protocol, I coded all of the items produced by a participant during Recall 4 according to three variables: "orphan items," which are those items that do not form part of a cluster at all, "newborn clusters," which are clusters of items that did not previously appear on either participants' Recall 2 or Recall 3, and "synergistic clusters," which are those clusters where the items did co-occur together on previous recalls (which I named after Tulving's idea of synergistic ecphory – see Introduction above). These synergistic clusters were then assessed by means of the Origin Analysis to determine whether they appeared only during Recall 2, only during Recall 3, if they appeared on both Recalls 2 and 3, or if they were actually composed of a hybrid of clusters that appeared at different time points. For the sake of including only those variables that are

informative to this dissertation and are significant, I will not be discussing hybrid synergistic clusters, orphan items, or newborn clusters. Only synergistic clusters that appeared solely on Recall 2 or Recall 3, or those that appeared on both Recalls 2 and 3, will be discussed.

Thus, I examined the presence of parasitism and hyperparasitism on Recall 4 across Early and Late Collaboration conditions. A one-way between-subjects ANOVA determined that Late Collaboration participants (M = .30) were producing more synergistic clusters that could be uniquely traced back to their earlier collaborative session compared to Early Collaboration participants (M = .18), $F(1, 70) = 12.57$, MSE = .02, p = .001. In contrast, another one-way between-subjects ANOVA determined that there was no difference in the degree to which Late Collaboration participants (M = .33) and Early Collaboration participants (M = .36) were producing synergistic clusters that could be uniquely traced back to their earlier individual session, $F(1, 70) = 1.33$, MSE = .02, p = .25. At the same time, there was no difference in the extent to which Late Collaboration participants (M = .27) and Early Collaboration participants (M = .33) were producing synergistic clusters that occurred on both their earlier collaborative and individual sessions, $F(1, 70) = 2.65$, MSE = .02, p = .11.

Follow-up analyses indicated that for the Early Collaboration participants, the synergistic clusters produced on their Recall 4 were more likely to come from their earlier individual session (their Recall 3; M = .36) compared to their earlier collaborative session (their Recall 2; M = .18), $t(35) = -5.58$, p = .001. These results indicate that the Early Collaboration participants were displaying a pattern of parasitism, with their final individual recall (Recall 4) being dependent primarily upon their immediately preceding recall. On the other hand, follow-up analyses

indicated that for the Late Collaboration Participants, the synergistic clusters produced on their Recall 4 were equally likely to come from both their earlier individual session (their Recall 2; M = .33) and their earlier collaborative session (their Recall 3; M = .30), $t(35) = -.49$, $p = .63$. These results indicate that the Late Collaboration participants are displaying a pattern of hyperparasitism, with their final individual recall (Recall 4) being dependent upon both their immediately preceding recall and even earlier recall sessions. In other words, it appears that Early Collaboration participants are not accessing their earlier collaborative recall session to the same degree as the Late Collaboration participants, which may be one of the primary reasons behind the discrepancy between the amount of collective recollections formed by Early and Late Collaboration participants compared to Multiple Collaboration participants during Recall 4 (see Discussion section below for more details).

The second major question of this dissertation was the extent to which retrieval organization influenced the persistence of collective recollections across time. Thus, these analyses are primarily concerned with collective recollections and shared organization on Recall 5 following the one week delay. A number of interesting patterns emerged from these analyses of performance after the one week delay. While these patterns are worth considering, it is also important to keep in mind that the collective recollections data after delay are at floor (all conditions produced levels of collective recollections between 4%-10%). Thus, the following results are presented primarily for completeness' sake, without a great amount of further investigation (or presentation of non-essential variables), and should be interpreted cautiously. In addition, it should be noted that 4 triads of participants (2 from Early Collaboration and 2

from Late Collaboration) were excluded from the analyses, as these participants did not return for the second part of the experiment following the one week delay.

In order to determine the influence of group on collective memory persistence (examining collective recollections at Recall 5), a one-way between-subjects ANOVA was performed with group as the factor. Means and standard errors across the four conditions can be seen in Figure 8. Results indicate a main effect of group on collective recollections at Recall 5, $F(3, 40) = 7.41$, $MSE = 19.28$, $p = .001$. Follow-up pairwise comparisons reveal that Multiple Collaboration participants ($M = 12.58$) have greater amounts of collective recollection persistence compared to Individual participants ($M = 4.75$), $p = .001$. In addition, Late Collaboration participants ($M = 11.50$) also had greater collective recollection persistence compared to Individual participants, $p = .005$. However, there was no difference in the amount of collective memory persistence for participants in Early Collaboration ($M = 8.80$) versus the Individual participants, $p = .22$. Finally, there was no difference between Early and Late Collaboration participants ($p = 1.00$), between Early and Multiple ($p = .31$), or between Late and Multiple ($p = 1.00$).

Next, in order to investigate the influence of group on shared organization persistence across delay, another one-way between-subjects ANOVA was conducted with group as the factor. Means and standard errors across the four conditions are shown in Figure 9. Results indicate a main effect of group, $F(3, 40) = 5.06$, $MSE = 2.53$, $p = .005$. Follow-up pairwise comparisons indicates that Multiple Collaboration participants ($M = 3.63$) are maintaining a significantly higher level of shared organization compared to Individual participants ($M = 1.12$),

p = .002. However, there appears to be no differences between Individual and Early Collaboration (M = 2.31, p = .54), between Individual and Late Collaboration (M = 2.63, p = .19), between Early and Late Collaboration (p = 1.00), between Early and Multiple Collaboration (p = .35), or between Late and Multiple Collaboration (p = .90).

CHAPTER 4

Discussion

The goal of this experiment was to investigate how retrieval organization influences both the formation of collective memory and its persistence across time. Across numerous foundational and novel analyses, it was determined that the development of collective memory is strongly tied to the amount of shared organization that develops among participants.

In terms of collective memory formation, all three collaborative groups resulted in greater amounts of collective recollections compared to participants in the Individual condition who never collaborated, even after controlling for baseline levels of collective recollections formed at the start of the experiment. The greatest amount of collective recollection formation occurred for those who collaborated multiple times. Thus, it appears that working together with others to reconstruct the past, particularly multiple times, leads to a greater likelihood of sharing the same information about the past. This is a natural extension of research on conversational remembering that demonstrates that people's collective recollections are greater on their post-conversational recall compared to pre-conversational recall following collaboration (Cuc et al., 2006).

Completely novel to this study, the extent of collective organization and its relation to collective recollection were examined. All three collaborative conditions produced greater amounts of shared or overlapping organization (measured via SOMA) compared to participants in the Individual condition who never collaborated. Parallel to the collective recollections results, participants who collaborated multiple times had the highest levels of shared

organization. Follow-up regression and ANCOVA analyses demonstrated the strength of the relationship between collective recollection formation and the degree of shared organization, such that levels of collective recollections can be considered comparable across all conditions when shared organization is held constant (via ANCOVA). These results all point to the idea that collective memories are more likely to form among individuals who develop similar ways of carving up the world into idiosyncratic chunks of information, and the results of this experiment indicate that people are more likely to develop greater amounts of shared organization if they collaborate to reconstruct the past. This study, therefore, provides a novel demonstration of the importance, and perhaps necessity, of the structure of memory formed among individuals as underlying the common memory that they share.

As was said at the beginning of the Results section, the original predictions put forward regarding the influence of idiosyncratic and group-level organization (both measured via ARC) were determined to be non-essential to the development of collective recollection formation. Thus, the original predictions among conditions with regard to these specific organizational variables are not as relevant to discuss. However, our results demonstrated that the conditions do result in differing amounts of collective recollections that are very pertinent to discuss in terms of the development of shared organization. For example, it was determined that though Early Collaboration participants developed less collective recollections compared to Multiple Collaboration participants as we had predicted (assessed on Recall 4), they developed the same amount of shared organization. At the same time, though the Late Collaboration participants developed less shared organization compared to the Multiple Collaboration participants, they had

the same amount of collective recollections. To understand these differences, we can turn to the results of our Hyperparasitism analyses to help shed some light on these interesting findings.

The Origin and Hyperparasitism analyses indicated that the synergistic clusters, those clusters of items that co-occurred together on previous recalls, produced by the Early Collaboration participants during Recall 4 primarily originated during their immediately preceding recall (Recall 3), which was an individual recall session. Thus, it is possible that participants in this condition had lower levels of collective recollections than Multiple Collaboration participants because they were not accessing their Recall 2 collaborative session, indicating the importance of accessing earlier collaborative representations in order to develop similar memories. However, perhaps the reason that there are no differences in shared organization between Early and Multiple Collaboration participants is that all three participants adopted the organization of the group at Recall 3 which was then maintained on Recall 4 where shared organization was assessed. Such an explanation is possible based on what we had originally predicted about the interplay between idiosyncratic and group-level organization. Specifically, as group-level organization likely arises out of the inhibited idiosyncratic organization brought to collaboration, participants in the Early Collaboration condition likely adopted on their Recall 3 the organization of the group to which they were exposed during Recall 2 and which was then maintained on Recall 4. As a result of this maintenance of an adopted group organization, the participants would have similar organizations that make their final shared organization comparable to Multiple Collaboration participants.

At the same time, the results of Origin and Hyperparasitism analyses indicated that the synergistic clusters produced by the Late Collaboration participants during Recall 4 were equally likely to originate during either their immediately preceding recall (Recall 3), which was a collaborative recall session, or their earlier individual recall session (Recall 2). Thus, it is possible that participants in Late Collaboration have equivalent amounts of collective recollections on Recall 4 compared to Multiple Collaboration participants because they are able to access their Recall 3 collaborative session. However, perhaps the reason there are differences in the shared organization between Late and Multiple Collaboration participants is that Late Collaboration participants had two opportunities to produce their own idiosyncratic organization prior to collaborating. Thus, their organizations were less likely to be adversely affected by the act of collaboration and they would be less likely to adopt the organization of the group on their Recall 4. As a result of this lack of adoption of group-level organization, the participants would have divergent organizations that make their final shared organization less than Multiple Collaboration participants. While the possible explanations provided by the Origin and Hyperparasitism analyses are reasonable, they are not capable of being addressed by the indexes of this study without major alterations to analyses to overcome the limitations of basic indexes of retrieval organization (such as ARC), and thus are considered outside the scope of the present dissertation. However, future research will address these possibilities.

However, the Origin and Hyperparasitism results cannot address the question as to why Early and Late Collaboration participants have similar amounts of collective recollections and shared organization. Perhaps it is simply the case that collaborating once, at any time point, will

lead to comparable levels of these variables. The important factor for determining collective memory formation may therefore not be the time at which one collaborates, but simply the number of times in which one collaborates. The time point of singular collaboration appears to affect only the amount of collective recollections or shared organization developed in comparison to people who collaborate multiple times.

In terms of the persistence of collective recollections across time, the results indicate that all three collaborative groups maintained higher levels of collective recollections compared to participants in the Individual condition who never collaborated. It also appears that people who collaborate multiple times have greater shared organizational persistence across time compared to those who do not collaborate at all. At the same time, there appears to be no difference in the amount of shared organization that is maintained across time between the Early Collaboration, Late Collaboration, and Individual conditions. Thus, it appears that the key factor behind collective recollection and shared organizational persistence is the number of times one collaborates with others to reconstruct the past, rather than the time point at which one collaborates if one is collaborating only once. In fact, collaborating only once does not protect the persistence of a shared organization across time, regardless of when in one's past retrieval history one has collaborated. Of course, all of these results must be interpreted with caution given the fact that collective recollection levels are at floor.

This study demonstrated that collaborating with others to reconstruct the past leads to far greater collective memory formation and the development of a shared organization than simply recalling by oneself. In addition, through the development and employment of several analyses

completely novel to this study, it was demonstrated that there is a strong relationship between the amount of shared organization that develops among individuals post-collaboratively and the amount of collective memories they develop. These results add to our understanding of how collective memories form by both demonstrating the importance of collaborating with others to reconstruct the past and of developing similar ways of carving up that past and structuring one's memories following collaboration. As most non-psychological research on collective memories has not even considered collaborating with others to be essential in the development of collective memories, this study provides important considerations for understanding this complex phenomenon.

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Appendix A: Footnotes

1. The idea of rebound is similar to inhibition of reminiscence found in the part-set cuing literature (see Basden, Basden, & Henry, 2000), but we chose the term 'rebound' to avoid confusion about the inhibited versus blocked nature of information because at this stage of investigation we are agnostic about these possibilities.

2. It has been demonstrated that final individual recall does not vary as a function of a participant's scribe status (i.e., scribe vs. non-scribe) during collaboration (Blumen & Rajaram, 2009).

3. There are two popular methods of collaboration: free flowing and turn-taking (see Pereira-Pasarin & Rajaram, 2010; Thorley & Dewhurst, 2007). In turn-taking, participants are forced to recall items one person at a time, where the participants are not allowed to comment on their partners' output. As a result, intrusions are more common in this procedure. In free flowing, participants are able to recall their words as they wish with no structure. Thus they are able to comment on their partners' output and correct mistakes, preventing intrusions. The free flowing method is considered more naturalistic and thus is more useful for our study in that it simulates conversational recall, a paradigm that has demonstrated the formation of collective memories (e.g., Cuc et al., 2006).

4. Unless otherwise noted, for any analysis presented in the Results section where there were follow-up pairwise comparisons to assess differences across conditions, a Bonferroni adjustment for multiple comparisons was implemented.

Appendix B: Tables and Figures

Table 1. Experimental design for the four conditions.

Control	Early Collaboration	Late Collaboration	Multiple Collaboration
Study	Study	Study	Study
Distracter	Distracter	Distracter	Distracter
I-Recall	I-Recall	I-Recall	I-Recall
I-Recall	C-Recall	I-Recall	C-Recall
I-Recall	I-Recall	C-Recall	C-Recall
I-Recall	I-Recall	I-Recall	I-Recall
	----------Delay of One Week ----------		
I-Recall	I-Recall	I-Recall	I-Recall

Legend: I-Recall = Individual Recall, C-Recall = Collaborative Recall

Table 2. Means and standard errors for Hits, Intrusions, Proportion Corrected Recall, and Adjusted Ratio of Clustering at Recalls 1 and 4.

	Control	Early Collaboration	Late Collaboration	Multiple Collaboration
Recall 1				
Hits	38.25 (1.49)	42.67 (1.82)	39.03 (1.37)	37.36 (1.60)
Intrusions	1.03 (0.26)	0.69 (0.15)	0.75 (0.21)	0.81 (0.19)
PCR	0.31 (0.01)	0.35 (0.02)	0.32 (0.01)	0.30 (0.01)
ARC	0.57 (0.02)	0.61 (0.03)	0.59 (0.03)	0.58 (0.03)
Recall 4				
Hits	46.56 (1.80)	56.22 (1.90)	54.69 (2.18)	59.83 (1.81)
Intrusions	1.72 (0.37)	1.03 (0.19)	1.28 (0.24)	0.58 (0.13)
PCR	0.38 (0.02)	0.46 (0.02)	0.45 (0.02)	0.49 (0.02)
ARC	0.74 (0.02)	0.81 (0.02)	0.77 (0.02)	0.80 (0.02)

Legend: PCR = Proportion Corrected Recall, ARC = Adjusted Ratio of Clustering

Table 3. Means and standard errors for Collective Omissions across conditions at Recalls 1 and 4.

	Control	Early Collaboration	Late Collaboration	Multiple Collaboration
Recall 1	43.75 (2.20)	36.58 (2.12)	41.50 (1.86)	43.75 (1.86)
Recall 4	34.50 (2.46)	30.83 (2.27)	34.33 (2.42)	33.00 (1.82)

Figure 1. *A theoretical framework for the cognitive mechanisms underlying the effects of collaboration on memory. The top three ovals refer to the preexisting cognitive structures that three individuals might bring to the experimental situations. The bottom three ovals represent the idiosyncratic organization of the study materials each individual develops for the study materials. The symbol ''-ve'' refers to a negative influence of collaboration (a process that impairs accurate retrieval), and the symbol ''+ve'' refers to a positive influence.*

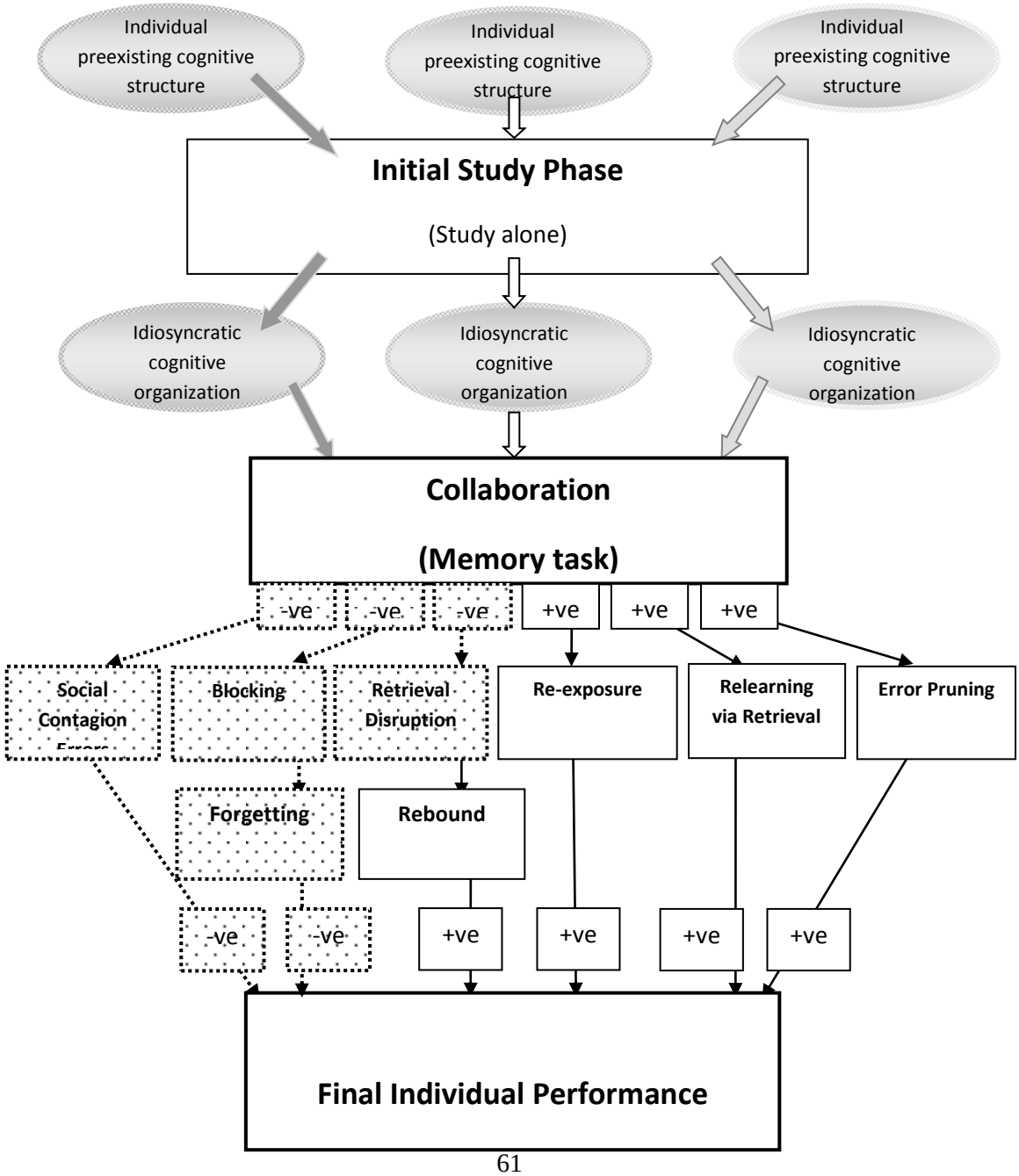

Figure 2. *Cumulative Recall Curves at Recall 1 across conditions.*

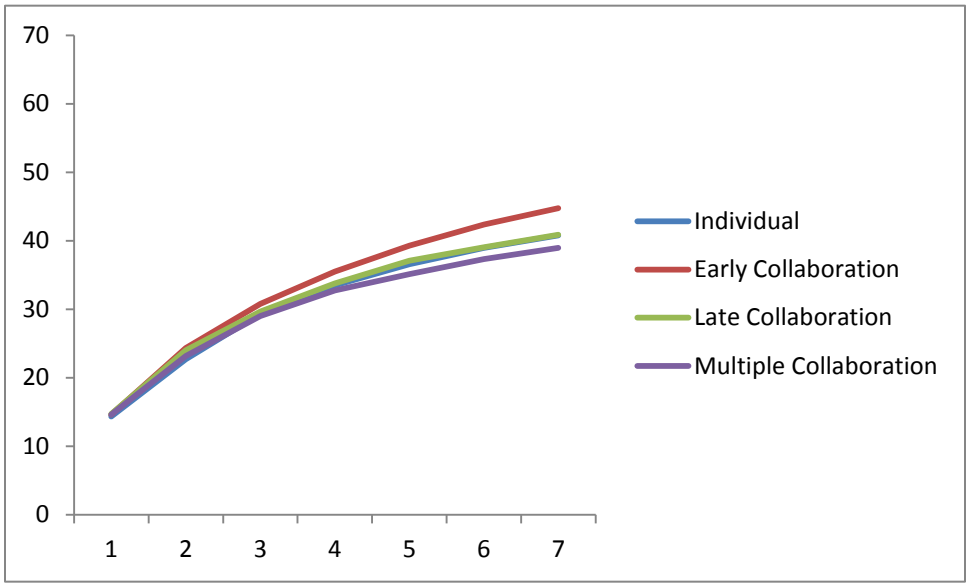

Figure 3. *Cumulative Recall Curves at Recall 4 across conditions.*

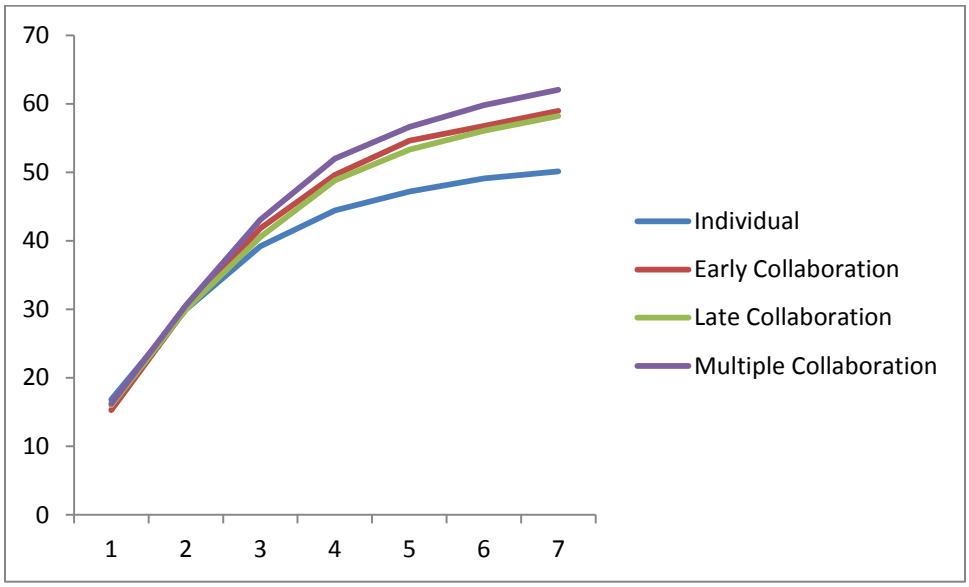

Figure 4. *Cumulative Organization Curves at Recall 1 across conditions.*

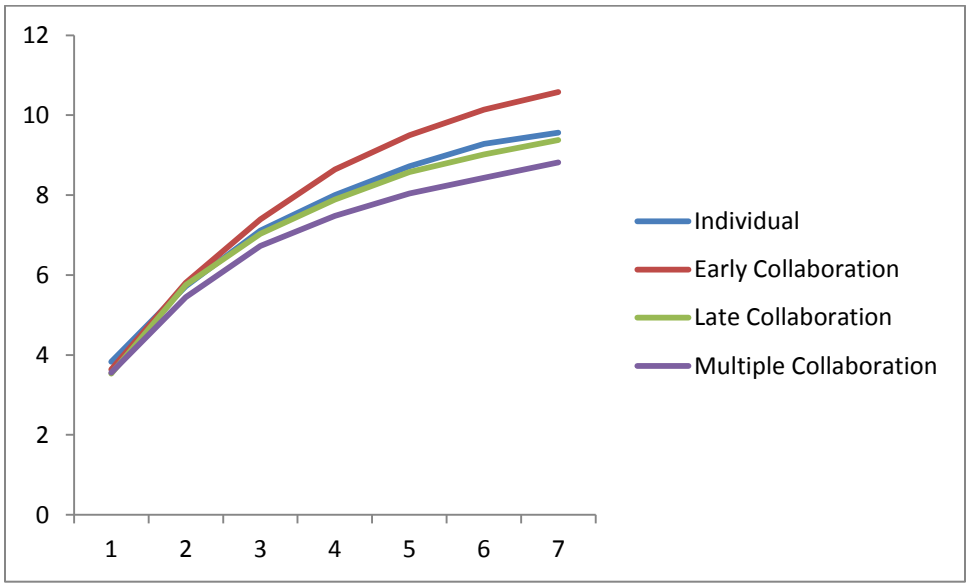

Figure 5. *Cumulative Organization Curves at Recall 4 across conditions.*

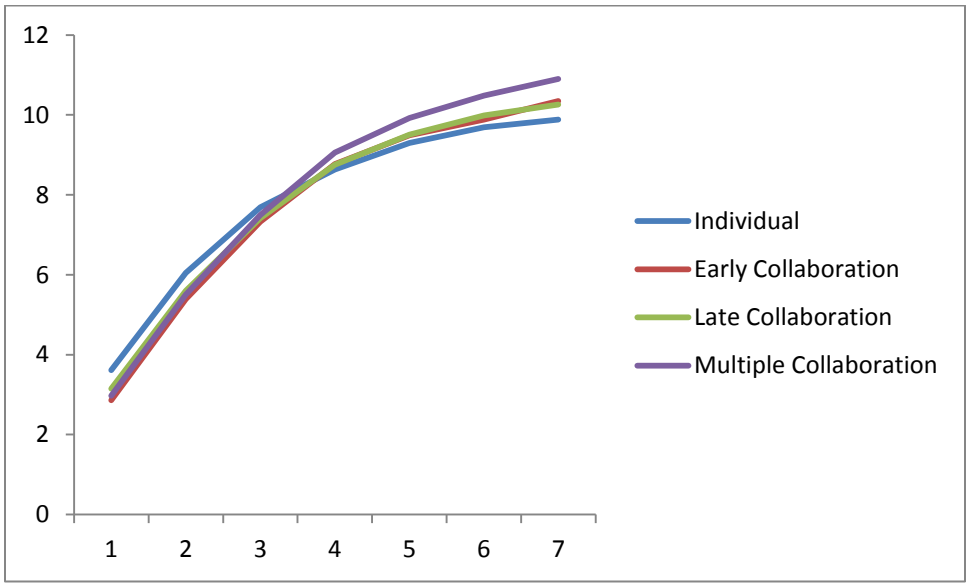

Figure 6. *Collective Recollections at Recalls 1 and 4.*

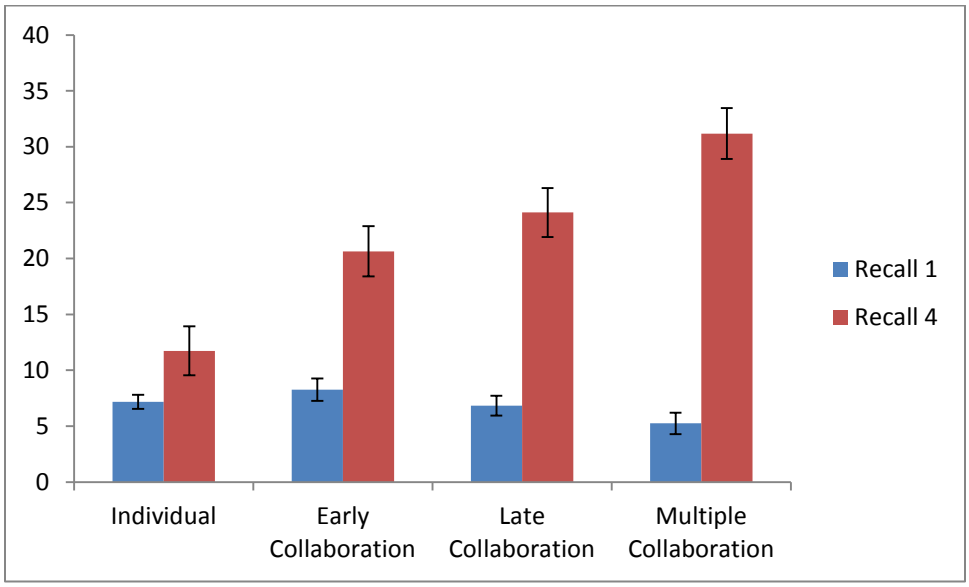

Figure 7. *Shared Organization (SOMA) at Recalls 1 and 4.*

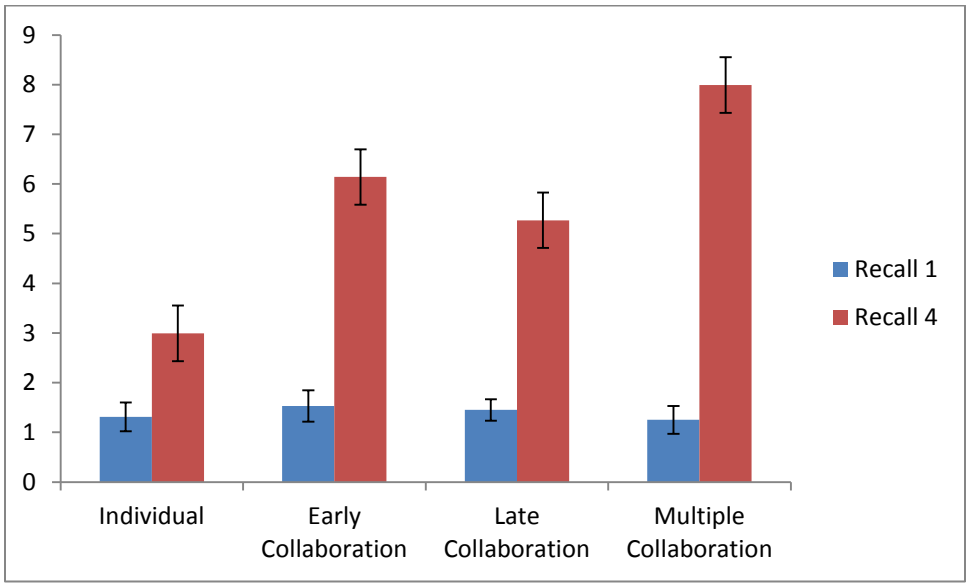

Figure 8. *Collective Recollections at Recall 5 (Delayed Recall).*

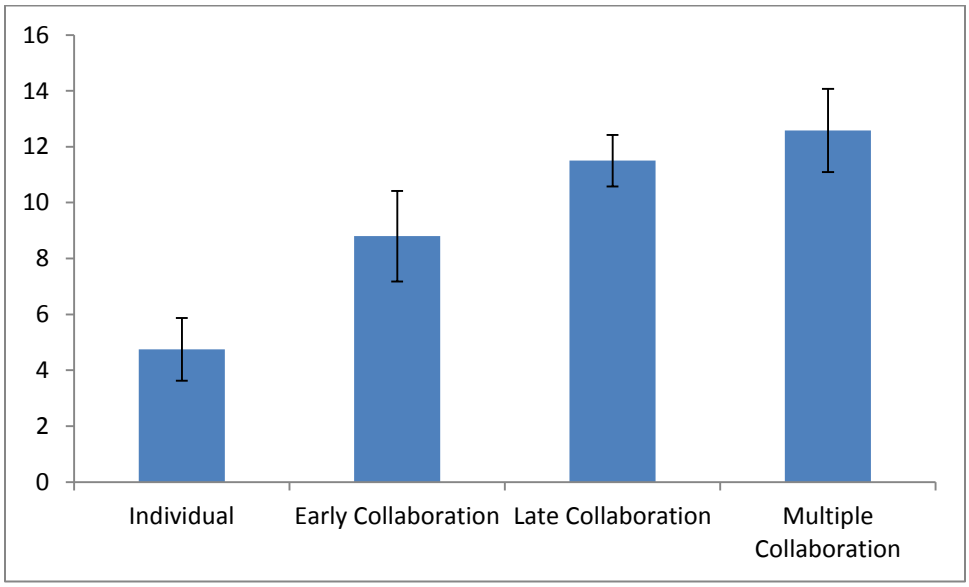

Figure 9. *Shared Organization (SOMA) at Recall 5 (Delayed Recall).*