COLLABORATIVE INHIBITION: EVALUATION OF THE PART-SET CUING HYPOTHESIS FOR KEY-TERM DEFINITIONS

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by

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INTRODUCTION

A substantial amount of recent research has focused on collaborative memory, exploring how memory is affected when learning occurs in a group environment (for reviews, see Rajaram, 2011; Rajaram & Pereira-Parasin, 2010). Although several recent studies have demonstrated that collaborative retrieval practice enhances subsequent individual memory (referred to as post-collaborative benefits; Blumen & Rajaram, 2008, 2009; Blumen & Stern, 2011; Congleton & Rajaram, 2011), a majority of the collaborative memory literature has focused on collaborative inhibition. Collaborative inhibition is the counterintuitive finding that learners working in a group recall less information compared to the combined non-redundant output of the same number of learners working individually (discussed in more detail below; Barber & Rajaram, 2011; Basden, Basden, Bryner, & Thomas, 1997; Congleton & Rajaram, 2011; Thorley & Dewurst, 2007; Weldon & Bellinger, 1997). However, a majority of collaborative memory research exploring collaborative inhibition has used relatively simple materials (e.g., word lists), which is not the type of material that students report using during collaborative retrieval practice; rather, students most often report using collaborative retrieval practice to learn key-term definitions (Wissman & Rawson, 2016). The goal of the current study was twofold: establish that collaborative inhibition emerges with key-term definitions and evaluate the extent to which the part-set cuing hypothesis explains the effect with key-term definitions.

Empirical Evidence for Collaborative Inhibition
In a typical collaborative memory experiment, learners are asked to study some type of to-be-learned material (e.g., word lists) during an initial study phase. Following the initial study phase, all learners engage in some form of retrieval practice (e.g., free recall). Critically, the retrieval practice phase is completed either individually or collaboratively, with a majority of research involving groups of 2-3 learners working together to retrieve the target material. After the retrieval practice phase, all learners then complete a final test phase. The final test phase is completed individually by all learners and occurs either immediately or after a delay. (See Figure 1 for an illustrative example of collaborative memory methodology.) Important for current purposes, collaborative inhibition is the finding that learners recall less information when the retrieval practice phase is completed collaboratively versus individually. To assess performance during the retrieval practice phase, the number of items recalled by the collaborative group is compared to the cumulative recall of the same number of learners working individually, referred to as the nominal group. To illustrate, imagine that a collaborative group of two learners recalled items A, C, D, E, and G; their collaborative recall score would total to five items. For learners working individually, imagine that Learner #1 recalled items A, B, D, E, F, and H and Learner #2 recalled items A, C, E, F, and G; Learners #1 and #2 comprise a nominal group, and their nominal recall would total to eight items (A, B, C, D, E, F, G, and H). The finding that recall is lower for collaborative groups than for nominal groups (e.g., five items versus eight items in the hypothetical illustration above) is the phenomenon referred to as collaborative inhibition.

Collaborative inhibition is a robust effect that has been well-established in the collaborative memory literature. For example, collaborative inhibition has been demonstrated across different age groups, including younger adults (Blumen & Stern, 2011; Henkel & Rajaram), older adults (Blumen & Stern, 2011; Henkel & Rajaram), and children (Leman &
Collaborative inhibition is the finding that learners working in a group recall less information compared to the combined non-redundant output of the same number of learners working individually during the retrieval practice phase. Post-collaborative benefits refer to the finding that collaborative retrieval practice enhances later individual memory during the final test phase.

Figure 1. Schematic of typical methodology used in collaborative memory experiments.
Oldman, 2005). In addition to exploring collaborative inhibition across different age groups, research has also investigated the effect using different types of materials. For example, collaborative inhibition has been shown with taxonomic categories (Barber & Rajaram, 2011), lists of unrelated words (Blumen & Rajaram, 2008), and lists of thematically related words (Roediger & McDermott, 1995). Beyond word lists, research has also established that collaborative inhibition emerges with more complex material such as social information (Reysen, Talbert, Dominko, Jones, & Kelley, 2011) and text material (Takahashi & Saito, 2004).

Although collaborative inhibition generalizes across different age groups and different materials, research has established several factors that moderate the effect. For example, the size of the group influences the magnitude of collaborative inhibition such that the effect is greater in larger versus smaller groups (Basden, Basden, & Henry, 2000; Thorley & Dewhurst, 2007). A majority of prior research has evaluated collaborative inhibition in triads (Basden et al., 1997; Blumen & Rajaram, 2008), but the effect also emerges in dyads (Finlay, Hitch, & Meudell, 2000). How learners implement collaborative retrieval practice (turn-taking versus free-flowing) also differentially affects the magnitude of collaborative inhibition. During turn-taking recall, learners alternate who recalls each next piece of information. For example, Learner #1 is instructed to recall the first word, Learner #2 is instructed to recall the next word, and so on. During free-flowing recall, learners openly recall the information however they see fit. For example, Learner #1 and Learner #2 are instructed to recall the words together at their own discretion. Research has shown that free-flowing recall versus turn-taking recall attenuates the magnitude of collaborative inhibition (Barber, Rajaram, & Aron, 2010). In addition, test format has been shown to moderate collaborative inhibition. For example, collaborative inhibition is robust when learners engage in free recall during retrieval practice (Barber, Harris, & Rajaram,
2015; Basden et al., 1997; Blumen & Stern, 2011). In contrast, collaborative inhibition is attenuated or eliminated when cued recall (Finlay et al., 2000) or recognition (Clark, Hori, Putnam, & Martin, 2000) tests are administered during retrieval practice (but see Kelley, Reysen, Ahlstrand, & Pentz, 2012; Danielsson, Dahlström, & Andersson, 2011).

In sum, collaborative inhibition occurs during the retrieval practice phase (see Figure 1), and prior research has investigated both the generalizability of the effect and factors that moderate the effect. Concerning generalizability of collaborative inhibition, the literature is somewhat limited concerning the types of materials that have been instantiated during collaborative retrieval practice. In particular, a substantial number of collaborative memory studies have used relatively simple materials, whereas only a few studies have explored the effect with more complex material. Of the prior research using more complex material, no collaborative memory research has used key-term definitions. This gap is perhaps surprising given that key-term definitions are one of the most common types of information that students are expected to learn in academic settings, with classroom instruction often directed at teaching students about these concepts. Furthermore, a recent survey showed that for learners who reported implementing collaborative retrieval practice when studying in a group, 87% reported using key-term definitions (Wissman & Rawson, 2016). Therefore, exploring the extent to which collaborative inhibition emerges with key-term definitions has important implications for applied purposes.

Despite the prevalence of students using collaborative retrieval practice to learn key-term definitions in applied settings, no collaborative memory research has evaluated whether collaborative inhibition emerges for this type of material. Importantly, there are two plausible reasons for why collaborative inhibition may not obtain for key-term definitions. First, previous
research has shown that collaborative inhibition is attenuated or eliminated when learners engage in cued recall (Finlay et al., 2000). Cued recall is the test format implemented when engaging in retrieval practice for key-term definitions, in that learners are provided with the key term and practice recalling the definition. Second, other research I have conducted suggests that effects which typically emerge in the collaborative memory literature may not emerge for key-term definitions (Wissman & Rawson, in preparation). In two prior experiments, learners studied 10 key-term definitions during the initial study phase. Following initial study, learners completed recall trials either collaboratively or individually during the retrieval practice phase. On each recall trial, learners were shown the key term (e.g., “What is positive reinforcement?”) and asked to recall the definition. Learners engaging in collaborative retrieval practice alternated asking versus recalling the key-term definition on each recall trial. For example, Learner #1 asked Learner #2 to recall “positive reinforcement” on the first recall trial, whereas Learner #2 asked Learner #1 to recall “negative reinforcement” on the next recall trial. Two days later, all learners individually completed a cued recall test during the final test phase.

In Experiment 1, the retrieval practice phase occurred for 30 minutes and learners were instructed to complete as many recall trials as they could. Results showed that learners who engaged in collaborative versus individual retrieval practice completed a fewer number of recall trials during the retrieval practice phase. In addition, performance on the cued recall test during the final test phase was lower for learners who engaged in collaborative versus individual retrieval practice (i.e., the pattern of post-collaborative benefits typically found with simpler verbal materials was not observed). In Experiment 2, the retrieval practice phase consisted of learners completing a total of 30 recall trials (three trials for each of the 10 key terms). Results showed that learners who engaged in collaborative versus individual retrieval practice took
significantly longer to complete the retrieval practice phase (28 minutes versus 19 minutes). In addition, performance on the cued recall test during the final test phase was similar for learners who engaged in collaborative versus individual retrieval practice (i.e., post-collaborative benefits were not observed). Similar levels of performance on the final test also suggests that additional time during the retrieval practice phase for learners engaging in collaborative versus individual retrieval practice did not enhance learning to a greater extent on a final test.

Given that the primary purpose of these prior experiments was to investigate post-collaborative benefits during the final test phase (see Figure 1) and that the collaborative group alternated asking and recalling during the retrieval practice phase (versus recalling the definitions together), these studies are not equipped to examine collaborative inhibition. However, outcomes are indirectly informative for current purposes in that they suggest that effects which have been demonstrated in the collaborative memory literature may operate differently when learning key-term definitions. If post-collaborative benefits do not obtain for key-term definitions then one plausible assumption is that collaborative inhibition may also not obtain for key-term definitions. Given that no prior research has evaluated collaborative inhibition with key-term definitions, one goal of the current research is to evaluate the extent which the effect emerges with this type of material.

**Theoretical Accounts of Collaborative Inhibition**

Even if collaborative inhibition obtains with key-term definitions, the effect may reflect different underlying mechanisms than with simpler materials. Investigating the processes underlying collaborative inhibition for key-term definitions has important implications for both theory and application. In this section, I first describe the retrieval disruption hypothesis, which is the leading theoretical account of collaborative inhibition. I then discuss why this account is
limited in explaining collaborative inhibition for key-term definitions. Lastly, I propose a new theoretical account for why collaborative inhibition emerges with key-term definitions, which I refer to as the part-set cuing hypothesis.

Retrieval disruption hypothesis. The leading theoretical account for collaborative inhibition is the retrieval disruption hypothesis (Barber & Rajaram, 2011; Basden et al., 1997; Basden, et al., 2000; Congleton & Rajaram, 2011; Finlay et al., 2000; Henkel & Rajaram, 2011; Weldon & Bellinger, 1997). Retrieval disruption refers to the idea that the output of one group member disrupts the way in which other group members have organized information to be output during retrieval. In general, each learner develops a retrieval organization during encoding which in turn facilitates recall during retrieval. If a learner’s retrieval organization is disrupted during retrieval then recall is also disrupted. To illustrate, imagine that learners were asked to study exemplars from different taxonomic categories (e.g., birds, colors, vegetables, sports) and then engage in collaborative retrieval practice. During the initial study phase, learners are presented with different exemplars from each category (e.g., baseball, sparrow, carrot, finch, blue, broccoli, yellow, soccer). During the retrieval practice phase, imagine that Learner #1 starts to recall exemplars from the “birds” category, but Learner #2 interrupts by recalling exemplars from the “colors” category. Because Learner #2 interjected, the retrieval organization of Learner #1 is disrupted, which decreases recall during the retrieval practice phase and results in collaborative inhibition.

Seminal research by Basden et al. (1997) evaluated the retrieval disruption hypothesis in a series of experiments, with results establishing that engaging in collaborative retrieval disrupts the retrieval organization of learners. In these studies, learners studied exemplars from taxonomic categories during the initial study phase. Learners then completed recall
collaboratively or individually during the retrieval practice phase. To evaluate the extent to
which retrieval disruption occurred, the authors measured clustering using the Adjusted Ratio of
Clustering formula (Roenker, Thompson, & Brown, 1971). Clustering scores quantify the extent
to which a learner outputs exemplars from the same category in serial order. Scores range from
-1 to 1 in which 0 indicates that grouping of responses from the same category is no greater than
chance and 1 indicates perfect clustering. To illustrate, if Learner #1 output all of the exemplars
from the category “birds” followed by all of the exemplars from the category “colors” then
Learner #1 would have a clustering score of 1. In contrast, if Learner #1 randomly output
exemplars from each of the two categories then Learner #1 would have a clustering score close
to 0. Results from Basden et al. (1997) showed significantly lower clustering scores for learners
who engaged in collaborative versus individual retrieval practice, suggesting that engaging in
collaborative retrieval practice disrupts a learner’s retrieval organization.

Finlay et al. (2000) provided further evidence for the retrieval disruption hypothesis by
exploring how encoding and test format affect the magnitude of collaborative inhibition.
Learners were asked to study a list of 30 word pairs during the initial study phase. During the
initial study phase, words were presented in either the same order across learners or in a different
order across learners. Following initial study, learners completed the retrieval practice phase
either individually or collaboratively. During the retrieval practice phase, learners completed
either a free recall test or a cued recall test. Results showed significant collaborative inhibition
during the retrieval practice phase for learners who engaged in free recall. In contrast,
collaborative inhibition did not occur for learners who engaged in cued recall. This outcome
suggests that when learners are required to output responses according to a specified retrieval
organization, collaborative inhibition is eliminated. Furthermore, for collaborative learners who
engaged in free recall during the retrieval practice phase, recall was numerically greater for learners who had studied words in the same order during encoding versus a different order during encoding. This outcome suggests that encoding items in a similar way during the initial study phase leads to similar organization, which decreases disruption during the retrieval practice phase.

**Limitations of retrieval disruption hypothesis.** What does the retrieval disruption hypothesis predict concerning whether or why collaborative inhibition obtains for key-term definitions? To revisit, the retrieval disruption hypothesis refers to the idea that output of one group member disrupts the way in which other group members have organized information to be output during retrieval. Accordingly, retrieval disruption obtains when recall depends on a learner’s retrieval organization. Prior research provides evidence for the retrieval disruption hypothesis showing that if learners are required to output responses according to a specified retrieval organization (e.g., a cued recall test) then collaborative inhibition is eliminated (Finlay et al., 2000; also see Basden et al., 1997, Experiment 4). Cued recall is the test format implemented when engaging in collaborative retrieval practice for key terms in that learners are provided with the key term and practice recalling the definition. Indeed, recent research suggests that a cued recall test is comparable to how students report implementing collaborative retrieval practice when studying on their own (Wissman & Rawson, 2016). Thus, the retrieval disruption hypothesis predicts that collaborative inhibition will be eliminated for key-term definitions given that retrieval disruption is minimized on a cued recall test.

Note that this prediction is based on the assumption that retrieval organization is specified at the level of the key term (i.e., definitions are recalled in the order that the key terms are presented as cues on the cued recall test). One other possibility is that retrieval organization
occurs at the level of the individual idea units within each definition (versus at the level of the key term). More specifically, each definition contains at least two idea units which could potentially be organized for output in different orders across learners. Accordingly, the magnitude of collaborative inhibition might depend on the extent to which retrieval organization of idea units is disrupted. However, this possibility seems unlikely given that students will likely organize the idea units within a definition in canonical order. Furthermore, prior research has shown that encoding items in the same order leads to similar organization, which decreases retrieval disruption and eliminates collaborative inhibition (Finlay et al., 2000; also see Harris, Barnier, & Sutton, 2012). Given that all learners encode the idea units for each key-term definition in the same way (i.e., canonical order of the idea units within the definition) then retrieval organization should be similar across learners. Thus, even if retrieval organization occurs at the idea-unit level, the retrieval disruption hypothesis still predicts that collaborative inhibition will be eliminated for key-term definitions given that a similar retrieval organization across learners during encoding will decrease retrieval disruption during recall.

Regardless of the level at which retrieval organization is defined (i.e., at the level of the key terms or at the level of idea units within a definition), the retrieval disruption hypothesis predicts that collaborative inhibition will not obtain for key-term definitions. In turn, the account is silent concerning what underlying mechanisms may contribute to the effect for this type of material. To foreshadow, Experiment 1 demonstrated that collaborative inhibition does occur with key-term definitions, which leaves open the question of why the effect emerges with key-term definitions.

**Part-set cuing hypothesis.** Given that the retrieval disruption hypothesis is not a viable explanation for collaborative inhibition with key-term definitions, other theoretical explanations
for why the effect emerges with this type of material are necessary. To this end, I propose the
part-set cuing hypothesis, which states that the initial but incomplete output of one group
member acts as a part-set cue that reduces recall of the remaining information by the other group
member and contributes to collaborative inhibition. The part-set cuing hypothesis is based on
prior research showing that providing learners with part of the to-be-remembered information as
a cue during retrieval decreases the amount of the remaining information that is recalled, referred
to as part-set cuing (Basden, et al., 1997; Brown, 1968; Cole, Reysen, & Kelley, 2013;
Nickerson, 1984; Slamecka, 1968). To illustrate, Bäuml and Aslan (2004) asked learners to
study lists of exemplars from different taxonomic categories, with each list being comprised of
eight target items and four non-target items. Following initial study, learners either completed a
distractor task (control condition) or were given the non-target items and told that these items
should be used as cues when recalling the remaining items on a later test (part-set cuing
condition). Results on the final cued recall test showed that recall of the target items was lower
for the part-set cuing condition compared to the control condition. These outcomes suggest that
providing learners with part of the to-be-remembered information as a cue during recall
interferes with retrieval of remaining information.

One theoretical explanation for why part-set cuing occurs is retrieval inhibition (Bäuml
& Aslan, 2004; also see, Anderson, Bjork, & Bjork, 1994). According to the retrieval inhibition
account, the presentation of part-set cues results in learners engaging in covert retrieval of the
(provided) cue items, which in turn leads to inhibition of the un-cued items. Providing learners
with a part-set cue inhibits memories of un-cued items by suppressing the memory
representations, which makes the un-cued items less available at retrieval. Another theoretical
explanation for why part-set cuing occurs is the retrieval competition hypothesis (Rundus, 1973).
According to the retrieval competition hypothesis, the presentation of part-set cues strengthens the memory representation of the (provided) cue items, which in turn results in these items becoming stronger candidates for retrieval. Providing learners with a part-set cue strengthens the accessibility of the cue items, which blocks access to the un-cued items at retrieval. Although the current research is not intended to diagnose potential bases of part-set cuing more generally (for extended discussions of theoretical accounts of part-set cuing, see Cole et al., 2013; Fritz & Morris, 2015), both of the aforementioned theoretical accounts may be applicable to the hypothesis evaluated in the current research for key-term definitions.

By extension, I am proposing the *part-set cuing hypothesis* as a theoretical explanation for why collaborative inhibition emerges with key-term definitions. To revisit, the part-set cuing hypothesis states that the initial but incomplete output of one group member acts as a part-set cue that reduces recall of the remaining information by the other group member and contributes to collaborative inhibition. To illustrate, imagine that Learner #1 and Learner #2 are working together to recall the definition of positive reinforcement, defined as “when something pleasurable is added or experienced after a behavior occurs the behavior is more likely to occur again in the future”. The definition of positive reinforcement contains five idea units: (1) when something pleasurable (2) is added or experienced (3) after a behavior occurs (4) the behavior is (5) more likely to occur again in the future. During retrieval practice, Learner #1 starts recall by outputting the first two idea units (i.e., when something pleasurable is added or experienced) but does not finish recalling the remaining part of the definition. Consequently, the recall of the first two idea units provided by Learner #1 serves as a part-set cue to Learner #2. In turn, Learner #2 outputs fewer of the remaining idea units which results in collaborative inhibition during collaborative retrieval practice.
Overview of the Current Research

The purpose of the current research was twofold: (1) to investigate whether collaborative inhibition emerges with key-term definitions, and (2) to evaluate the extent to which the part-set cuing hypothesis explains the effect. In Experiment 1, learners were asked to study key-term definitions during the initial study phase. Learners then completed the retrieval practice phase, which occurred either collaboratively or individually. Learners in the individual group were provided with the key term and asked to recall the definition. Learners in the collaborative group were provided with the key term and asked to work together to recall the definition however they saw fit. Two days later, all learners completed a final individual cued recall test. Outcomes of primary interest concern performance during the retrieval practice phase (see Figure 1). To foreshadow, I found significant collaborative inhibition during retrieval practice such that recall was lower for learners in collaborative groups versus nominal groups of individuals. Experiment 1 provides novel evidence to the collaborative memory literature by demonstrating that collaborative inhibition emerges with key-term definitions.

Experiment 2 was designed to replicate the collaborative inhibition effect observed in Experiment 1 and extend on Experiment 1 by evaluating the part-set cuing hypothesis. The part-set cuing hypothesis states that the initial but incomplete output of one group member acts as a part-set cue that reduces recall of the remaining information by the other group member. To evaluate this hypothesis, Experiment 2 included three groups. The collaborative group and the individual group were identical to Experiment 1. Learners in the part-set individual group engaged in retrieval practice individually but were also provided with part of the definition (i.e., a part-set cue) and asked to recall the remaining part of the definition. As in Experiment 1, outcomes of primary interest were performance during the retrieval practice phase. Based on
Experiment 1 results, I predicted that recall would be lower for learners in the collaborative group versus the individual group (i.e., collaborative inhibition will be observed). Based on the part-set cuing hypothesis, I predicted that recall would also be lower for learners in the part-set individual group versus the individual group (i.e., collaborative inhibition will be observed). If part-set cuing contributes to collaborative inhibition for key-term definitions, providing part of the definition to learners engaging in individual retrieval practice will interfere with recall to the same extent as compared to learners engaging in collaborative retrieval practice. Thus, performance during retrieval practice will be lower for learners in the part-set individual group compared to the individual group.
EXPERIMENT 1

Method

Participants and design. Undergraduates who participated for course credit were assigned to one of two groups: collaborative or individual (ns = 44 and 35, respectively).

Materials. Materials included a short passage on operant conditioning. The passage included 10 key terms and their definition. Table 1 provides all 10 key-term definitions.

Procedure.

Initial study phase. The initial study phase was the same for all participants, and all tasks in this phase were completed individually. Participants studied the text containing the 10 key-term definitions on operant conditioning for six minutes. After initial study, participants restudied each key-term definition in isolation for 15 seconds. All participants then completed an initial practice cued recall test. On each test trial, participants were shown the key term and given 30 seconds to recall the definition. After the initial cued recall test, all participants engaged in one last restudy trial.

Retrieval practice phase. After the initial study phase, the research assistant told participants that the next phase of the experiment involved recall of the previously studied key-term definitions. The research assistant then told participants that recall would be completed either collaboratively or individually. Dyads were randomly created by combining participants based on the day of the month on which they were born. Specifically, participants with the lowest days of the month were assigned to the dyad, with the lowest day designated as the scribe
Table 1. Material set used in Experiments 1-2.

**Key terms and definitions**

*Positive reinforcement:* When something pleasurable is added or experienced after a behavior occurs the behavior is more likely to occur again in the future.

*Negative reinforcement:* When something unpleasant is removed or escape or avoidance is allowed after a behavior occurs the behavior is more likely to occur again in the future.

*Positive punishment:* When aversive event or stimulus is presented after a behavior occurs the behavior is less likely to occur again in the future.

*Negative punishment:* When something pleasurable is diminished or taken away after a behavior occurs the behavior is less likely to occur again in the future.

*Interval schedule:* Reinforcement only occurs if responses are made after a certain amount of time has elapsed.

*Ratio schedule:* Reinforcement depends only on the number of responses.

*Continuous schedule:* Reinforcement takes place after each and every correct response, leads to rapid learning.

*Satiation:* When a reinforcer loses effectiveness from repeated use and leads to a decrease in the behavior.

*Extinction:* When a previously reinforced behavior no longer receives reinforcement the likelihood of the behavior eventually decreases.

*Partial schedule:* Responses that are reinforced sometimes but not every time, which leads to behaviors that are very resistant to extinction.

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*Note.* Part-set cues provided to the part-set individual group in Experiment 2 are underlined.
who would type in the responses during collaborative recall (e.g., for participants with birthdates of April 8, June 10, May 4, and July 15, dyad assignment was based on the numbers 4 and 8, with the participant with the birthdate on the 4th designated as the scribe). The remaining participants completed the retrieval practice phase individually.

On each recall trial, participants were shown the key term and asked to recall the definition (see Figure 2). After recalling the definition, participants were shown the correct answer along with their response and asked to make a monitoring decision about the accuracy of their response (see Figure 3). Participants entered a decision about whether their response was wrong, partially correct, mostly correct, or completely correct. Participants were asked to recall each of the 10 key-term definitions three times, for a total of 30 recall trials. Participants in the collaborative group sat at one computer, and the scribe was instructed to type in the dyad’s response.

Final test phase. Two days later, all participants completed two final tests. For both tests, all participants worked individually. For the cued recall test, learners were shown the key terms one at a time and were asked to recall the definition for each key term. Following the cued recall test, participants completed a multiple choice test consisting of 20 comprehension questions. The multiple choice test included two questions for each of the 10 key terms.

Scoring.

All scoring was completed by trained research assistants. Given the substantial number of responses to be hand-scored, multiple raters were trained to complete the scoring. I chose a random sample of protocols from a prior experiment to serve as the training set. Raters were given the training set to score and the reliability of his or her scores was checked against other trained raters (all $rs > .93$). Given the high reliability across raters, data protocols for the current
Figure 2. Screenshot shown during the retrieval practice phase when learners were asked to recall the key-term definition.
Figure 3. Screenshot shown during the retrieval practice phase when learners were asked to make a monitoring decision about the accuracy of their response.
experiment were scored by one of the trained raters. Responses were scored based on the proportion of idea units contained in the learner’s response. Table 2 provides the 10 key-term definitions parsed into the idea units used for scoring purposes. Of the 10 key-term definitions, four key terms contained five idea units, three key terms contained four idea units, two key terms contained three idea units, and one key term contained two idea units. Performance was calculated as proportion scores for each key term and then averaged across all 10 key terms. Credit was given for verbatim responses or correct paraphrases of the idea units.

Results and Discussion

Cohen’s $d$ values were computed using pooled standard deviations. For tests of a priori directional predictions, I report one-tailed p-values. Split-half reliability was acceptable for the cued recall test during the retrieval practice phase ($\alpha = .89$) and for the cued recall test during the final test phase ($\alpha = .96$).

Consistent with the collaborative memory literature, I report nominal recall (instead of individual recall) for outcome measures of primary interest. (Performance at the individual level for these measures is reported in Appendix A for interested readers.) Nominal groups were formed by creating post-hoc groups of learners who completed the retrieval practice phase individually, which resulted in a total of 19 nominal groups. Nominal groups consisted of learners who completed the experiment in the same session or learners who completed the experiment on approximately the same day.

Nominal recall was computed post-hoc by pooling non-redundant idea units from the recall protocols of each learner within each nominal group. For example, imagine that Learner #1 provided the idea units “when something pleasurable”, “is added”, and “more likely to occur in the future” and Learner #2 provided the idea units “the behavior is” and “more likely to occur
**Positive reinforcement:**
- When something pleasurable is added or experienced after a behavior occurs, the behavior is more likely to occur again in the future.

**Negative reinforcement:**
- When something unpleasant is removed or escape or avoidance is allowed after a behavior occurs, the behavior is more likely to occur again in the future.

**Positive punishment:**
- When aversive event or stimulus is presented after a behavior occurs, the behavior is less likely to occur again in the future.

**Negative punishment:**
- When something pleasurable is diminished or taken away after a behavior occurs, the behavior is less likely to occur again in the future.

**Interval schedule:**
- Reinforcement only occurs if response are made after a certain amount of time has elapsed.

**Ratio schedule:**
- Reinforcement depends only on the number of responses.

**Continuous schedule:**
- Reinforcement takes place after each and every correct response leads to rapid learning.
Satiation:  
When a reinforcer loses effectiveness from repeated use and leads to a decrease in the behavior

Extinction:  
When a previously reinforced behavior no longer receives reinforcement, the likelihood of the behavior eventually decreases

Partial schedule:  
Responses are reinforced sometimes but not every time which leads to behaviors that are very resistant to extinction
in the future”; their nominal recall would be 4 (out of 5) idea units, which yields a proportion score of 80%. Performance on the individual cued recall test that took place during the initial study phase is reported as nominal recall. Nominal recall was computed post-hoc by pooling non-redundant idea units from the recall protocols of the two learners within each nominal group and of the two learners within each collaborative group. For performance during the retrieval practice phase, outcomes are reported as collaborative group recall and nominal group recall. For performance during the final test phase, outcomes are reported at the individual level.

Performance on the individual cued recall test that took place during the initial study phase showed no baseline differences for learners in the collaborative group ($M = 58\%, SD = 24$) versus individual group ($M = 57\%, SD = 16$), $t(34) = .078, p = .938$. Of greatest interest for current purposes, recall during the retrieval practice phase was lower for learners who engaged in collaborative versus individual recall. As shown in Figure 4, recall was lower for learners in the collaborative group ($M = 69\%, SD = 21$) versus the individual group ($M = 79\%, SD = 14$), $t(42) = 1.82, p = .038, d = .55$. This outcome provides novel evidence to the collaborative memory literature, demonstrating that collaborative inhibition emerges with key-term definitions.

Interestingly, outcomes also suggest that learners who engage in collaborative retrieval practice may not be performing to their full potential. More specifically, performance during the initial study phase established similar baseline levels of performance across all learners. Given that learners then engaged in restudy, learning of the key-term definitions should be further enhanced. Accordingly, learners who engaged in individual retrieval practice showed a substantial boost in performance from the initial study phase to the retrieval practice phase (57% to 79%). In contrast, learners who engaged in collaborative retrieval practice showed a smaller boost in performance from the initial study phase to the retrieval practice phase (58% to 69%).
Figure 4. Performance during retrieval practice phase in Experiment 1. *Individual* refers to learners who completed retrieval practice individually and *Collaborative* refers to learners who completed retrieval practice in a dyad.
These outcomes suggest that learners may not be recalling the optimal amount of available information when engaging in collaborative retrieval practice.

Of secondary interest for present purposes, performance on the individual final tests (i.e., performance during the final test phase) was similar for learners who completed retrieval practice collaboratively versus individually (see Table 3). Performance on the final cued recall test was similar for learners in the collaborative group and the individual group, \( t(77) = 0.05, p = .48, d = .01 \). Performance on the multiple choice test was also similar for learners in the collaborative group and the individual group, \( t(77) = .16, p = .43, d = .04 \). Although several recent studies have documented post-collaborative benefits (Blumen & Rajaram, 2008, 2009; Blumen & Stern, 2011; Congleton & Rajaram, 2011), these studies have used relatively simple materials (e.g., word lists). Thus, the extent to which post-collaborative benefits extend to key-term definitions remains unclear (also see, Wissman & Rawson, in preparation).
Table 3. Performance on the final individual cued recall test and multiple choice test in Experiments 1-2.

<table>
<thead>
<tr>
<th></th>
<th>Collaborative</th>
<th>Individual</th>
<th>Part-set individual</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cued recall</td>
<td>.59 (.26)</td>
<td>.59 (.24)</td>
<td>N/A</td>
</tr>
<tr>
<td>Multiple choice</td>
<td>.67 (.18)</td>
<td>.68 (.19)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Experiment 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cued recall</td>
<td>.62 (.22)</td>
<td>.60 (.23)</td>
<td>.63 (.20)</td>
</tr>
<tr>
<td>Multiple choice</td>
<td>.72 (.17)</td>
<td>.68 (.14)</td>
<td>.70 (.19)</td>
</tr>
</tbody>
</table>

*Note. Collaborative refers to learners who completed retrieval practice in a dyad. Individual refers to learners who completed retrieval practice individually. Part-set individual refers to learners who completed retrieval practice individually and were provided with part-set cues (Experiment 2 only). Cued recall performance is reported as proportion scores across recall of all 10 key-term definitions. Multiple choice performance is reported as proportion scores across all 20 questions. Standard deviations are reported in parentheses.*
EXPERIMENT 2

The goal of Experiment 2 was to replicate and extend on the effects observed in Experiment 1. Given that Experiment 1 provided the first evidence that collaborative inhibition emerges with key-term definitions, one goal of Experiment 2 was to replicate this effect (for the importance of replicating novel findings, see LeBel & Peters, 2011; Pashler & Harris, 2012; Roediger, 2012; Schimmack, 2012; Simons, 2014). To that end, Experiment 2 included the collaborative and individual groups used in Experiment 1. Additionally, Experiment 2 evaluated the part-set cuing hypothesis as a possible explanation for why collaborative inhibition emerges with key-term definitions. To revisit, the part-set cuing hypothesis states that the initial but incomplete output of one group member acts as a part-set cue that reduces recall of the remaining information by the other group member. To evaluate the part-set cuing hypothesis, Experiment 2 also included a part-set individual group in which learners working individually were provided with the key term and part of the definition during retrieval practice. If part-set cuing contributes to collaborative inhibition for key-term definitions, then providing part of the definition to learners engaging in individual retrieval practice will interfere with recall to the same extent as compared to learners engaging in collaborative retrieval practice. Thus, the part-set cuing hypothesis predicts that performance during retrieval practice will be lower for learners in the part-set individual group compared to the individual group.

Method
Participants and design. Undergraduates who participated for course credit were assigned to one of three groups: collaborative, individual, or part-set individual (ns = 82, 81, and 85, respectively). Given that Experiment 2 was intended to replicate and extend on Experiment 1, I had two planned comparisons of interest. The targeted sample size was 252, based on an a priori power analysis, with power set at .80 and \( \alpha = .05 \) to detect an effect of \( d = .55 \) (i.e., the effect size observed in Experiment 1).

Materials and procedure. Materials were identical to Experiment 1. The procedure for learners in the collaborative and individual group was identical to Experiment 1 except that learners completed the final test phase after a 10-minute delay (instead of 2 days later). The procedure for learners in the part-set individual group was identical to the procedure in the individual group except that learners were provided with the key term and a portion of the definition on each recall trial during retrieval practice. Specifically, learners were provided with either the first idea unit or the first two idea units (depending on the length of the definition) for each key term. The part-set cues given for each key term are provided in Table 1. This approach resulted in learners in the part-set individual group receiving approximately 35% of the

---

1 Given that the primary purpose of Experiment 2 was to evaluate the part-set cuing hypothesis, performance during the retrieval practice phase is of greatest interest. Because performance on the individual final tests was only of secondary interest, I opted to eliminate the longer delay. Additionally, other research has shown that post-collaborative benefits emerge and are stronger on an immediate versus delayed individual test (see Blumen & Stern, 2011; Wissman & Rawson, 2015), and thus the shorter retention interval is also useful for examining whether post-collaborative benefits emerge for key-term definitions after a short delay.
definition as a part-set cue, which is functionally equivalent to what learners in the collaborative group experienced in Experiment 1.²

Experiment 2 also included an observation sheet that was completed by the research assistant running the collaborative group during the experiment (see Appendix B for a shortened version of the observation sheet). On the observation sheet, the research assistant tracked which group member recalled which idea on each recall trial during the retrieval practice phase. Tracking this information during the retrieval practice phase for the collaborative group affords two exploratory analyses. First, tracking which learner recalls which idea unit provides an estimate for approximately how much of the definition a learner received as a part-set cue during collaborative retrieval practice. Second, tracking which idea units are recalled during retrieval practice affords the opportunity to compare the extent to which learners in the collaborative group were exposed to the same part-set cue provided to learners in the part-set individual group.

**Scoring.**

The scoring plan was similar to Experiment 1, such that raters were given the training set to score and the reliability of his or her scores was checked against other trained raters (all $rs > .98$). Given the high reliability across raters, data protocols for the current experiment were scored by one of the trained raters.

**Results and Discussion**

Cohen’s $d$ values were computed using pooled standard deviations. For tests of *a priori* directional predictions, I report one-tailed p-values. Split-half reliability was acceptable for the

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² Recall during the retrieval practice phase for the collaborative group was approximately 70% in Experiment 1. Assuming that a group member is providing a part-set cue to their partner, this would result in each group member contributing approximately 35% of the definition on any given recall trial.
cued recall test during the retrieval practice phase ($\alpha = .90$)\(^3\) and for the cued recall test during the final test phase ($\alpha = .91$).

As in Experiment 1, I report nominal recall (instead of individual recall) for outcome measures of primary interest. (Performance at the individual level for these measures is reported in Appendix A for interested readers.) Nominal groups were formed by creating post-hoc groups of learners who completed the retrieval practice phase individually, which resulted in a total of 41 nominal groups and 39 nominal part-set groups. To revisit, nominal recall was computed post-hoc by pooling non-redundant idea units from the recall protocols of each learner within each nominal group. Performance on the individual cued recall test that took place during the initial study phase is reported as nominal recall. For performance during the retrieval practice phase, outcomes are reported as collaborative group recall and nominal group recall. For performance during the final test phase, outcomes are reported at the individual level.

Novel to Experiment 2, I calculated nominal recall for the part-set individual group using two different approaches. First, nominal recall was calculated as the proportion of idea units out of all possible idea units that were recalled, which includes the idea units provided as the part-set cues. For example, the proportion score for the key term “positive reinforcement” was calculated out of five idea units, with credit given for the two idea units included in the part-set cue and for any of the remaining three idea units included in the recall response. This cue-inclusive nominal recall score for the part-set individual group was compared to nominal recall in the individual group. Second, cue-exclusive nominal recall was calculated for the part-set

---

\(^3\) Given that the part-set individual group was provided with a portion of the definitions as a cue, split-half reliability for the retrieval practice phase was computed based on recall in the collaborative group and the individual group. Split-half reliability for cue-exclusive recall in the part-set individual group was also acceptable ($\alpha = .89$).
individual group as the proportion of idea units recalled out of the total number of idea units not included in the part-set cue. For example, the proportion score for the key term “positive reinforcement” was calculated out of three idea units because the first two idea units were provided as the part-set cue. This cue-exclusive nominal recall score for the part-set individual group was compared to nominal recall in the individual group.

Performance on the individual cued recall test that took place during the initial study phase showed no significant baseline differences for learners in the collaborative group ($M = 50\%, SD = 22$) versus the individual group ($M = 45\%, SD = 17$) versus the part-set individual group ($M = 51\%, SD = 23$), $F (2, 104) = 1.02, p = .363$.

Concerning replication of Experiment 1, recall during the retrieval practice phase was lower for learners who engaged in collaborative versus individual recall. As shown in Figure 5, recall was lower for learners in the collaborative group ($M = 65\%, SD = 17$) versus the individual group ($M = 73\%, SD = 15$), $t(80) = 2.11, p = .019, d = .47$. This outcome replicates Experiment 1 and further extends the collaborative memory literature by demonstrating that collaborative inhibition emerges with key-term definitions. Similar to Experiment 1, outcomes also suggest that learners who engage in collaborative retrieval practice may not be performing to their full potential. More specifically, performance during the initial study phase established similar baseline levels of performance across learners. Given that learners then engaged in restudy, learning of the key-term definitions should be further enhanced. Accordingly, learners who engaged in individual retrieval practice showed a substantial boost in performance from the initial study phase to the retrieval practice phase (45% to 73%). In contrast, learners who engaged in collaborative retrieval practice showed a smaller boost in performance from the initial study phase to the retrieval practice phase (50% to 66%). These outcomes suggest that
Figure 5. Performance during retrieval practice phase in Experiment 2. *Individual* refers to learners who completed retrieval practice individually and *Collaborative* refers to learners who completed retrieval practice in a dyad.
learners may not be recalling the optimal amount of available information when engaging in collaborative retrieval practice.

Concerning extending on Experiment 1, I tested the part-set cuing hypothesis by comparing performance during the retrieval practice phase for learners in the individual group versus the part-set individual group. As discussed above, I used two analytic approaches (cue-inclusive and cue-exclusive) for computing nominal recall in the part-set individual group, each of which will be discussed in turn. Concerning cue-inclusive, recall was greater for learners in the part-set individual group ($M = 85\%, SD = 10$) versus the individual group ($M = 73\%, SD = 15$), $t(78) = 4.10, p < .001, d = .92$ (see Figure 6). This finding is not surprising, given that learners in the part-set individual group were given credit for the idea unit(s) provided as the part-set cue. Concerning cue-exclusive, in contrast to predictions, recall was greater for learners in the part-set individual group ($M = 78\%, SD = 14$) versus the individual group ($M = 73\%, SD = 15$), $t(78) = 1.50, p = .07, d = .34$ (see Figure 6). This outcome provides evidence against the part-set cuing hypothesis, suggesting that a part-set cuing mechanism does not contribute to collaborative inhibition for key-term definitions.

Although not relevant for replication or theoretical purposes, I also analyzed the information recorded on the observation sheet by research assistants during the retrieval practice phase. Concerning how much of the definition a learner received as a part-set cue, outcomes showed that approximately 56% of the definition was provided by one group member before the other group member started to recall information. This outcome suggests that providing learners in the part-set individual group with only 35% of the definition underestimated the size of the part-set cue received in a collaborative setting (discussed further in the General Discussion). Concerning the extent to which learners in the collaborative group were exposed to the same
Figure 6. Performance during retrieval practice phase in Experiment 2. *Individual* refers to learners who completed retrieval practice individually and *Part-set individual* refers to learners who completed retrieval practice individually and were provided with part-set cues.
part-set cue provided to learners in the part-set individual group, the information provided by one
group member before the other group member started to recall information contained 64% of the
part-set cue on average. This outcome indicates reasonable overlap in the information contained
in the part-set cue to which learners in the part-set individual group and the collaborative group
were exposed.

Of secondary interest, performance on the individual final tests (i.e., performance during
the final test phase) was similar for learners who completed retrieval practice collaboratively
versus individually (see Table 3). Performance on the cued recall test was similar for learners in
the collaborative group and the individual group \([t(160) = 0.59, p = .28, d = .09]\), which
replicates the outcomes observed in Experiment 1. This pattern is inconsistent with other
collaborative memory research that has shown post-collaborative benefits emerge on an
immediate test (Blumen & Stern, 2011; Wissman & Rawson, 2015), which I elaborate on in the
General Discussion. With that said, outcomes on the multiple choice test showed a modest trend
for greater performance for learners in the collaborative versus individual group \([t(160) = 1.64, p
= .05, d = .26]\)
GENERAL DISCUSSION

The current research investigated whether collaborative inhibition emerges with key-term definitions and the extent to which the part-set cuing hypothesis explains the effect. Outcomes from Experiments 1-2 demonstrated that collaborative inhibition obtains for key-term definitions, providing novel evidence to the collaborative memory literature. Recent research in the field has emphasized the importance of replication of novel findings (e.g., Braver et al., 2014; Cumming, 2008; Ferguson & Heene, 2012; Francis, 2012; LeBel & Peters, 2011; Maner, 2014; Pashler & Harris, 2012; Roediger, 2012; Schimmack, 2012; Schmidt, 2012; Simmons et al., 2011; Simons, 2014) and has recommended running replication studies to provide multiple effect size estimates on which to base conclusions. Accordingly, I adopted the continuously cumulating meta-analysis (CCMA) approach recommended by Braver, Thoemmes, and Rosenthal (2014), who suggest that the approach “would be far more informative than simply reporting whether each single study succeeded or failed” (p. 340). The CCMA compares performance during the retrieval practice phase for learners in the collaborative group versus the individual group. Results from the CCMA are reported in Table 4, with outcomes supporting the conclusion that collaborative inhibition emerges for key-term definitions. Specifically, recall is lower for learners who engaged in collaborative versus individual retrieval practice: pooled $d = 0.50$, 95% CI = 0.18, 0.81.
Table 4. Continuously cumulating meta-analysis (CCMA) outcomes for collaborative inhibition (i.e., the difference in recall for learners in the collaborative group versus the individual group) in Experiments 1-2.

<table>
<thead>
<tr>
<th>Mean Diff</th>
<th>( S_{pooled} )</th>
<th>( t )</th>
<th>( p ) (2-tail)</th>
<th>Cohen’s ( d )</th>
<th>( Z )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieval practice recall:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment 1</td>
<td>-10</td>
<td>18</td>
<td>2.42</td>
<td>.018</td>
<td>0.55</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>-7</td>
<td>15</td>
<td>2.04</td>
<td>.044</td>
<td>0.45</td>
</tr>
<tr>
<td>CCMA results</td>
<td></td>
<td></td>
<td></td>
<td>.001</td>
<td>0.50</td>
</tr>
</tbody>
</table>

*Note.* Mean Diff = mean difference in performance for the collaborative group minus the individual group during the retrieval practice phase in each experiment. Effect size homogeneity test was non-significant for retrieval practice recall \([Q(1) = 0.09, p = .76]\).
In addition to replicating the collaborative inhibition effect observed in Experiment 1, the goal of Experiment 2 was to evaluate the part-set cuing hypothesis as a possible explanation for why collaborative inhibition emerges for key-term definitions. To revisit, the part-set cuing hypothesis states that the initial but incomplete output of one group member acts as a part-set cue that reduces recall of the remaining information by the other group member. Outcomes provided evidence against this account as an explanation for why collaborative inhibition emerges. In particular, recall during the retrieval practice phase was numerically greater (instead of lower) for learners in the part-set individual group as compared to learners in the individual group. This outcome suggests that a part-set cuing mechanism does not contribute to collaborative inhibition for key-term definitions.

Why did part-set cuing not emerge for key-term definitions? One possible explanation for why part-set cuing did not occur with key-term definitions concerns the size of the cue. For example, Roediger, Stellon, and Tulving (1977; Experiment 1) presented learners with a list of 48 unrelated words. Following initial study, all learners completed a recall test. Critically, some of the learners were given 16 words as a part-set cue (small cue group) and some of the learners were given 32 words as the part-set cue (large cue group). Results showed that the proportion of non-cue words recalled was lower for learners in the large cue group versus the small cue group, suggesting that the magnitude of part-set cuing depends on the size of the cue (for similar results, see Dagnall, Parker, & Munley, 2008). By comparison in the current research, learners in the part-set individual group received approximately 35% of the definition as a part-set cue, whereas learners in the collaborative group received approximately 56% of the definition (from their partner) as a part-set cue. If part-set cuing is greater when learners receive more cues versus fewer cues, it is perhaps not surprising that recall was not impaired to the same extent in the part-
set individual group (as compared to the collaborative group). Thus, the size of the cue may be one explanation for why part-set cuing was not observed in the current research with key-term definitions.

Another plausible explanation for why part-set cuing did not obtain for key-term definitions concerns cue-target similarity. To illustrate, Aslan and Bäuml (2009) evaluated the extent to which similarity between the provided cues and targets affects the degree of part-set cuing. Learners studied a list of 12 words from a semantic category (e.g., animals), with half of the words belonging to one subcategory (e.g., carnivore) and half of the words belonging to another subcategory (e.g., herbivore). During recall, some of the learners received three words as a part-set cue (part-set cuing group) and some of the learners received no part-set cue (control group). Critically, the researchers examined performance for high-similarity items (e.g., recall of herbivores when the part-set cue was comprised of herbivores) and low-similarity items (e.g., recall of herbivores the when part-set cue was comprised of carnivores). Results showed that part-set cuing was observed when cue-target similarity was low, whereas part-set cuing was eliminated when cue-target similarity was high. Important for present purposes, providing a portion of the key-term definition as the part-set cue and asking learners to recall the remaining portion of the definition would likely be considered high cue-target similarity. Therefore, high cue-target similarity may be another explanation for why part-set cuing was not observed in the current research with key-term definitions.

Failure to observe a part-set cuing impairment suggests the two theoretical accounts discussed earlier (retrieval inhibition and retrieval competition hypothesis) are not operative here. Why might retrieval inhibition and/or retrieval competition not operate in the current context? One potential explanation concerns differences in dosage. More specifically, part-set
cuing research typically has learners completing one recall trial for a given word list, whereas the current research had learners complete three recall trials for each key term. Importantly, a substantial amount of research has established that practice testing enhances subsequent learning and retention (for reviews of testing effects, see Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Rawson & Dunlosky, 2011; Roediger & Butler, 2011; Rowland, 2015). Thus, more retrieval practice may overcome the initially reduced availability (retrieval inhibition) and/or accessibility (retrieval competition) of the un-cued items. Although the current research was not intended to evaluate different theoretical accounts of part-set cuing, it seems plausible that differences in dosage may explain why retrieval inhibition and/or retrieval competition were not operative in the current context.

Although not of primary interest for current purposes, outcomes from Experiments 1 and 2 did not show post-collaborative benefits on the final (individual) test. This is perhaps surprising given that recent research has shown the effect for other types of to-be-learned material on a delayed final test (Blumen & Stern, 2011; Congleton & Rajaram, 2014), and that the effect is even stronger on an immediate final test (see Blumen & Stern, 2011; Wissman & Rawson, 2015). One potential explanation for why post-collaborative benefits did not emerge for key-term definitions may be indirectly related to why existing theories of collaborative inhibition may not apply for key-term definitions. More specifically, predictions from the retrieval disruption hypothesis would predict that collaborative inhibition should not emerge for this type of material; Experiments 1 and 2 provide evidence to the contrary.

If different mechanisms contribute to collaborative inhibition for key-term definitions, then presumably different mechanisms may also contribute to post-collaborative benefits for this type of material. One potential explanation for why different mechanisms are operative for key-
term definitions concerns methodological differences between the current research and prior research. However, prior collaborative memory research has shown greater post-collaborative benefits when learners complete two (versus one) recall trials during retrieval practice (Blumen & Rajaram, 2008; 2009). Given that learners in the current research completed three recall trials (for each key term) during retrieval practice, one would expect even greater post-collaborative benefits on a final test. The current outcomes showed no post-collaborative benefits, suggesting that a methodological explanation for why different mechanisms are operative for key-term definitions seems unlikely. What about theoretical differences? One theoretical account of post-collaborative benefits is re-exposure, which refers to when one group member recalls an item that another group member may have otherwise forgotten, which in turn provides additional restudy and increases learning (Blumen & Rajaram, 2008; Weldon & Bellinger, 1997). In contrast to a majority of collaborative memory research, the current research included feedback during the retrieval practice phase. More specifically, after recalling each key term, learners were presented with the correct definition for restudy. Thus, the opportunity to engage in restudy may supplant the benefits of re-exposure in a typical collaborative setting. Investigating what mechanism(s) occur during collaborative retrieval practice for key-term definitions and which mechanism(s) may contribute to post-collaborative benefits for this type of material is an important direction for future research.

To conclude, the current research contributes novel outcomes to the collaborative memory literature by demonstrating that collaborative inhibition obtains for key-term definitions. In addition, the current outcomes suggest that a part-set cuing mechanism does not explain why the effect emerges for key-term definitions. Given that recent research has emphasized the importance of replication for novel findings (e.g., Braver et al., 2014; Cumming, 2008; Ferguson...
& Heene, 2012; Francis, 2012; LeBel & Peters, 2011; Maner, 2014; Pashler & Harris, 2012; Roediger, 2012; Schimmack, 2012; Schmidt, 2012; Simmons et al., 2011; Simons, 2014), future research should replicate and further evaluate the effects observed here.
REFERENCES


Maner, J. K. (2014). Let’s put our money where our mouth is: If authors are to change their ways, reviewers (and editors) must change with them. *Perspectives on Psychological Science, 9*, 343-351.


Appendix A. Performance at the individual level during the initial study phase and the retrieval practice phase.

<table>
<thead>
<tr>
<th></th>
<th>Collaborative</th>
<th>Individual</th>
<th>Part-set individual</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial study phase</td>
<td>.39 (.24)</td>
<td>.37 (.17)</td>
<td>N/A</td>
</tr>
<tr>
<td>Retrieval practice phase</td>
<td>N/A</td>
<td>.59 (.26)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Experiment 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial study phase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cue-inclusive</td>
<td>.34 (.20)</td>
<td>.28 (.16)</td>
<td>.36 (.19)</td>
</tr>
<tr>
<td>Cue-exclusive</td>
<td>.30 (.20)</td>
<td>.23 (.15)</td>
<td>.31 (.19)</td>
</tr>
<tr>
<td>Retrieval practice phase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cue-inclusive</td>
<td>N/A</td>
<td>.51 (.21)</td>
<td>.43 (.18)</td>
</tr>
<tr>
<td>Cue-exclusive</td>
<td>N/A</td>
<td>.48 (.21)</td>
<td>.59 (.21)</td>
</tr>
</tbody>
</table>

*Note. Collaborative refers to learners who completed retrieval practice in a dyad. Individual refers to learners who completed retrieval practice individually. Part-set individual refers to learners who completed retrieval practice individually and were provided with part-set cues (Experiment 2 only). For the initial individual practice test, performance is reported as a proportion score across recall of all 10 key-term definitions. For retrieval practice, performance is reported as proportion scores across recall of all 10 key-term definitions across all 30 recall trials. Standard deviations are reported in parentheses.*
Appendix B. Observation sheet completed by research assistants in Experiment 2.

---

GROUP ID # ____________
subID #1 (scribe) ________ subID #2 ________ Date _______
Name: _________________ Name: _________________
Where scribe sitting: left right

Instructions to Research Assistants: On each trial during the group portion of the study:

1. Mark the order in which each idea unit is recalled on each trial (e.g., 1, 2, 3); note that tracking the order may exceed the total number of idea units for a given key term.
2. Mark which participant (LEFT or RIGHT) contributed each provided idea unit; note that for some idea units you can mark left and right.

---

Term on Trial 1: Positive reinforcement
When something pleasurable is added or experienced after a behavior occurs the behavior is more likely to occur again in the future
---

Term on Trial 2: Negative reinforcement
When something unpleasant is removed or escape or avoidance is allowed after a behavior occurs the behavior is more likely to occur again in the future
---

Term on Trial 3: Positive punishment
When aversive event or stimulus is presented after a behavior occurs the behavior is less likely to occur again in the future
---

Term on Trial 4: Negative punishment
When something pleasurable is diminished or taken away after a behavior occurs the behavior is less likely to occur again in the future