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PREVENTING THE DISRUPTION: PREVIOUS COLLABORATIVE RECALL
CANCELS OUT RECONSOLIDATION DISRUPTION

by

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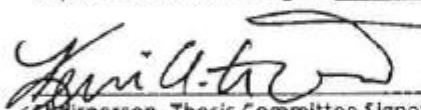
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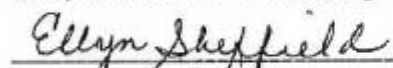This is to certify that the thesis prepared by ___Iiona D. Scully___

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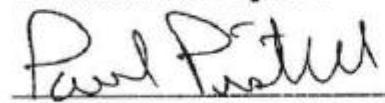
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Abstract

Preventing the Disruption: Previous Collaborative Recall

Cancels Out Reconsolidation Disruption

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Once you have consolidated a memory, it can be reactivated and brought into a labile

state, this is called memory reconsolidation. Overall, the reconsolidation research

paradigm has focused on disrupting the reconsolidation process when stimuli have been

encoded and recalled individually. However, in real word situations, humans tend to

remember information in the company of others. This process is known as collaborative

recall. Using a 3-day reconsolidation paradigm, the present study examined the effects of

collaborative recall on memories that were later disrupted using fear during

reconsolidation. Results replicated the robust collaborative inhibition effect and showed

that reconsolidation was only disrupted for nominal groups, suggesting that previous

collaboration cancels out reconsolidation disruption. Theoretical explanations of these

results and future directions are discussed.

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Chapter One:

Introduction

Since the late 1960s, animal research has found that once you have consolidated a

memory, it can be reactivated and brought into a labile state before reintegrating into long

term memory. This process is now referred to as *memory reconsolidation*. To show that

the reconsolidation period is plastic and labile, recent research has revealed that

memories can be modified during reconsolidation. For example, researchers have shown

that during reconsolidation, memory can be enhanced (Lee, 2008), changed (Hupbach,

Gomez, Hardt, & Nadel, 2007) and disrupted (Nader, Schafe, & LeDoux, 2000). Animal

research has focused on disrupting the reconsolidation process, usually with either

systematic drug injections or electroconvulsive shock (see Nader & Hardt, 2009 for

review). Over the last decade, however, research has begun to examine reconsolidation in

humans (see Schiller & Phelps, 2011 for review).

Overall, the reconsolidation research paradigm has focused on disrupting the

reconsolidation process when stimuli have been encoded and recalled individually.

However, humans interact predominantly in social situations. That is, in real word

situations, humans tend to remember information in the company of others. This process

is known as collaborative recall (Basden, Basden, Bryner, & Thomas, 1997; Rajaram,

2011; Rajaram & Pereira-Pasarin, 2010; Weldon & Bellinger, 1997). Collaborative recall

research is used to assess the costs and benefits of remembering as part of a group. One

of the costs of remembering in a group is that a group remembers less information

together than a group whose non-repetitive responses are pooled together after

remembering individually. This effect is known as *collaborative inhibition* (Weldon &

Bellinger, 1997).

  If reactivated memories were previously recalled collaboratively and memory can

be disrupted after it has been reactivated (cf. Nader & Hardt, 2009; Schiller & Phelps,

2011), it is possible that collaborative inhibition could cause further disruption to these

memories over time. The present study examined the effects of collaborative recall on

memories that will later be disrupted during reconsolidation.

Reconsolidation

  In the 1960s and 70s researchers demonstrated a consolidation process that

occurred after retrieval (Macctutus, Riccio, & Ferek, 1979; DeVietti & Kirkpatrick, 1976;

Misanin, Miller, & Lewis, 1968; Lewis, 1969; Lewis, Bergman, & Mahan, 1972;

Schneider & Sherman, 1968). Thirty years later, this process, called reconsolidation, was

demonstrated repeatedly in animals using fear conditioning. Newly created fear

memories were subsequently disrupted during reconsolidation with drug administration

(Nader & Hardt, 2009). For example, in a study now considered as the initial resurgence

of reconsolidation research, Nader and colleagues (2000) examined the plasticity of

memory reconsolidation, using auditory fear conditioning in rats. In this study, rats were

presented with a foot shock paired with a tone to create conditioned fear for the tone.

After 24 hours, the fear conditioning was reactivated with the representation of the tone.

Immediately following the tone, the rats were injected with anisomycin, a drug known for

its amnesiac effects in animals. The injection targeted the part of the brain important to

the connection between the behavior and its consolidation, the basolateral nucleus in the

amygdala. Nader et al. found that the rats did not demonstrate fear to the sound of the

tone following the drug administration even though they had previously consolidated the learned association between the tone and the shock. They further demonstrated that reactivation of well consolidated fear conditioning could be brought back into a labile state only to be disrupted and essentially forgotten. Following this pivotal finding, reconsolidation research using animal subjects burgeoned.

Within the last decade, researchers have begun to explore human reconsolidation (see Schiller & Phelps, 2011 for review). This includes research on amygdala-dependent memories (Agren, Engman, Frick, Björkstrand, Larsson, Furmark, & Fredrickson, 2012; Brunet, Orr, Tremblay, Robertso, Nader, & Pitman, 2008; Golkar, Bellander, Olsson, & Öhman, 2012; Kindt, Soeter, & Vervliet, 2009; Soeter & Kindt, 2010; Schiller, Monfils, Raio, Johnson, Ledoux, & Phelps, 2010), research on episodic memories (Hupbach et al., 2007; Forcato, Burgos, Argibay, Molina, Pedeira, Maldonado, 2007; Rodriguez, Campos, Forcato, Leiguarda, Maldonado, Molina, & Pedreira, 2013; Strange, Kroes, Fan, & Dolan, 2010) and research on procedural memories (Walker, Brakefield, Hobson & Stickgold, 2003).

Amygdala-dependent memories are memories involving emotion or emotionally laden events (e.g., conditioned fear). In order to access amygdala-dependent memories in humans, reconsolidation researchers have either reactivated already consolidated traumatic memories, such as those associated with post-traumatic stress disorder (PTSD; Brunet et al., 2008), or researchers had healthy participants undergo fear conditioning (Agren et al., 2012; Golkar et al., 2012; Kindt et al., 2009; Schiller et al., 2010). Brunet et al. examined human reconsolidation with participants who had been diagnosed with PTSD, a chronic disorder marked by intrusive memories of extremely emotional events.

Because PTSD has been attributed to an over-active amygdala, disrupting reconsolidation seemed an ideal approach to lessen the emotional intensity of these memories. In this study, participants were asked to write a description of the event that caused their PTSD. This was used to reactivate the memory and begin the reconsolidation process. Immediately after retrieval, half of the participant received the drug Propranolol, a drug that produces amnesiac effects, while the other half received a placebo. One week later, participants were once again reminded of the event by listening to an audio recording. The researchers recorded various autonomic nervous system measures, including heart rate and skin conductance responses. They found that participants' autonomic nervous system measures were reduced for those who had received Propranolol during reconsolidation. This suggests that Propranolol might be an effective way to reduce negative physiological responses to traumatic memories. This also demonstrates that deeply-rooted, emotional memories can be disrupted during the reconsolidation process.

Expanding the findings of Brunet et al. (2008), and to further test Propranolol's reconsolidation disruption abilities, Kindt et al. (2009) examined conditioned fear reconsolidation disruption using healthy participants. In this study participants underwent fear conditioning using images of spiders as fear-relevant stimuli paired with a mild electric shock. A day later, to reactivate the consolidated conditioning sequence, participants were presented with an image of a spider. Propranolol was administered 1.5 hours before this presentation on Day 2, presumably so the drug would have enough time to get through the body and trigger after the presentation of the spider image. On the third day, participants went through an extinction session, then were given shocks without the pairing of the image to again reactivate the memory. They found that

participants who were given Propranolol did not show spontaneous recovery of

conditioned fear after extinction, whereas participants not given the drug still showed a

fear response. Kindt et al. suggested that using Propranolol during reconsolidation also

disrupts conditioned fear responses in healthy participants. Such findings further suggest

that this effect can be demonstrated for newly consolidated amygdala-dependent

memories.

Another way amygdala-dependent memories have been disrupted in humans is

through interference at the time of reconsolidation (Schiller et al., 2010). Schiller et al.'s

experiment was conducted over three days. On the first day participants experienced fear

conditioning with the pairing of an electric shock and a colored square. On Day 2, the

conditioning was reactivated through the representation of the colored square. The

researchers then used extinction as interference. The extinction process involved

presenting the colored square repeatedly without the shock. Half of the participants

underwent extinction 10 minutes after the reactivation, and the other half underwent

extinction 6 hours later (when the reconsolidation window opens and closes, respectively,

based on Nader et al., 2000). They found that the participants who underwent extinction

during reconsolidation showed no spontaneously recovered fear response, whereas the

participants who received extinction afterward did. The findings of this study suggest that

incorporating new information at the time of reconsolidation can disrupt fear

conditioning. This type of research opened the door for researchers to examine the types

of information that can disrupt memories, rather than focusing on a drug-induced amnesia

at the time of reconsolidation (Brunet et al., 2008; Kindt et al., 2009).

In animal studies, reconsolidation is traditionally examined within amygdala-dependent memories (Nader & Hardt, 2009), which naturally led to studies focused on human amygdala-dependent memories. More recently however, researchers have begun to examine reconsolidation with regard to episodic memories (Hupbach et al., 2007; Forcato et al., 2007; Rodriguez et al., 2013; Strange et al., 2010). Within the reconsolidation paradigm, episodic memory has been examined using objects (Hupbach et al., 2007), paired-associates (Forcato et al., 2007), and nouns (Rodriguez et al., 2013; Strange et al., 2010). In order to disrupt episodic memory reconsolidation, these studies have used one of three types of disruption: new learning (Hupbach et al., 2007; Forcato et al., 2007), Clonazapam (Rodriguez et al., 2013), and exposure to a fearful stimulus (Strange et al., 2010).

Two studies in particular focus on word-based stimuli (Forcato et al., 2007; Strange et al., 2010). Using a paired-associate list learning paradigm, Forcato et al. demonstrated reconsolidation by having participants learn a second list during the reconsolidation period. In their study, participants were asked to learn pairs. One item of the pair was the cue syllables and the other item of the pair was the response syllable (e.g., FLI paired with AIO, respectively). A day later, participants were reminded of the first list with the cue syllable. After the reminder, during the reconsolidation period, all participants were asked to learn a second list of paired associates. On Day 3, participants went through a final test phase, in which participants were asked to recall, with the help of the cue syllables, both lists. Focato et al. found that the second list impaired memory for the first list when the second list was learned during the reconsolidation period. They also found that participants incorrectly remembered second list items during first list

recall. Forcato et al. suggested that learning new similar information can cause a consolidated memory to be both impaired and systematically changed during the reconsolidation period.

Introducing emotional information during reconsolidation has also been found to impair memory. Strange et al.'s (2010) Experiment 3 focused on impairing a specific target in memory over a 3-day and a 9-day period. On the first day, participants were presented with 240 unrelated nouns to memorize. Then, on Day 2 participants' memories were reactivated by completing word-stems of the nouns that they studied on the first day. After the presentation of 3, 4, or 5 word stems, an aversive facial expression appeared. Then, either one day, or one week later, participants were asked to recall the nouns. They found that recall was impaired for words that immediately preceded the aversive facial expressions. This suggests that the use of fear can disrupt newly consolidated episodic memories. Like Strange et al.'s experiment, the current study used fear to disrupt reconsolidation. More specifically, collaboratively retrieved episodic memories (associative words) were reactivated, then exposed to a fearful auditory stimulus during reconsolidation in order to disrupt the previously consolidated memories.

Collaborative Recall and Inhibition

We often remember in the company of others. Due to this fact, cognitive researchers have begun to investigate the effects of remembering with others using a collaborative recall paradigm (Basden, Basden, Bryner, & Thomas, 1997; Rajaram, 2011; Rajaram & Pereira-Pasarin, 2010; Weldon & Bellinger, 1997). One outcome of the study of collaborative recall has been the phenomenon of collaborative inhibition which occurs when a collaborative group remembers less than a group remembering individually

(which is referred to as the nominal group; Weldon & Bellinger, 1997). Collaborative inhibition is a robust finding that has been found to occur in groups that contain as few as two participants (Andersson & Rönnberg, 1996; Barber, Rajaram, & Aron, 2010; Dahlström, Danielsson, Emilsson, & Andersson, 2011; Finlay, Hitch, & Meudell, 2000; Reysen, Talbert, Dominko, Jones, & Kelley, 2011; Wright & Klumpp, 2004; Yaron-Antar & Nachson, 2006).

Collaborative inhibition has also been consistently demonstrated using a variety of stimuli; no one stimulus has been determined as any stronger than another type of stimulus. Collaborative inhibition has been demonstrated using unrelated word lists (Blumen & Rajaram, 2008; Blumen & Rajaram, 2009; Blumen & Stern, 2011; Weldon & Bellinger, 1997, Experiment 1), story recall (Weldon & Bellinger, 1997, Experiment 2), categorized word lists (Barber & Rajaram, 2011; Basden et al., 1997; Basden et al., 2000; Congleton & Rajaram, 2011), words pairs (Finlay et al., 2000), pictures (Finlay et al., 2000; Weldon & Bellinger, 1997, Experiment 1), emotionally laden events (Yaron-Antar & Nachson, 2006), paragraphs (Reysen et al., 2011), and associatively related items (Basden, Reysen, & Basden 2002; Wright & Klumpp, 2004).

One of the more common ways in which collaborative inhibition has been reported is when using categorized word lists (Barber & Rajaram, 2011; Basden et al., 1997; Basden et al., 2000; Congleton & Rajaram, 2011). For example, Basden et al (1997, Experiment 1) used two word lists, one comprised of six categories, and one with 15 categories, to test for collaborative inhibition. In their study, participants were exposed to either one of the two categorized lists. During recall, participants were either recalled as part of a group (containing three people) or recalled individually. The researchers

found that the collaborative groups recalled fewer words than the nominal group. In addition, they found that collaborative groups recalled fewer categories than the nominal group and that the collaborative inhibition effect was greater with larger numbers of categories. This suggests that associative information does not alter the collaborative inhibition effect. In fact, greater numbers of associative information impairs collaborative group recall.

Other studies using categorized word lists have continued to show collaborative inhibition effects (Barber & Rajaram, 2011; Basden et al., 2000; Congleton & Rajaram, 2011). Basden et al. (2002) and Wright and Klumpp (2004) furthered this area of study through the use of specifically associated items, rather than base categories. For example, both Basden et al. and Wright and Klumpp used Deese-Roediger-McDermott (DRM) word lists (Roediger & McDermott, 1995; Stadler, Rodegier, & McDermott, 1999) to examine collaborative inhibition. The DRM word lists, typically used to assess false memories, are lists of related words (e.g., bed, rest, snooze, alarm) that are linked to a critical lure (i.e., sleep).

Basden et al. (2002) used nine 12-item DRM lists to test for collaborative inhibition and false memories. They shortened the original 15-items (not including the critical word that all items were related to) to 12-item lists for testing; the other three items in each list were used as false memory lures, in addition to the critical lure for the list. After the presentation of the word lists, participants were separated into three experimental groups. In the first group, participants were placed in front of a computer screen and were told that they were the fourth member of a group that would be taking turns recalling words. They were also told that the other "three members" would each

respond and their answers would appear on the computer screen (the other "three

members" did not actually exist but were preprogrammed computer responses). The other

computer generated "three members" responded with words that actually appeared during

test. The second experimental group was examined using the same procedure, however

some of the words recalled by the other "three members" were false memory lures. The

third group completed an individual recall task. All participants were then given a final

recognition task to assess false memory. Basden et al. not only found collaborative

inhibition, but those in the collaborative false memory lure condition had more false

memories during the final recognition task than participants who did not presumably

collaborate. Basden et al. suggested that specific associative information is susceptible to

collaborative inhibition and that collaborative inhibition increases false memory. Thus,

not only are the groups recalling less, but they are also less accurate (i.e., more false

memories).

Wright and Klumpp (2004) used four DRM words lists. In their experiment,

participants were separated into three groups: nominal, the *see* collaborative condition,

and the *not see* collaborative condition. In all conditions, participants studied words

individually. During recall all participants were given a sheet with the category names on

top to facilitate recall. In the nominal condition, participants recalled individually. In both

collaborative conditions participants recalled as a group. In the *see* condition participants

shared a recall sheet and in the *not see* condition participants had their own individual

recall sheets. Thus, Wright and Klumpp assessed whether seeing the collaboratively

retrieved words caused more collaborative inhibition than not seeing others' recall

responses. Following the initial recall, all participants completed a final recall phase

individually. Wright and Klumpp found that participants recalled significantly fewer words in the *see* condition than in the *not see* and nominal conditions. The *not see* and nominal conditions did not differ, suggesting that the use of semantic associate words lists and categorized word lists exhibits collaborative inhibition. This finding also implies that the knowing what the other person recalls is important to obtaining collaborative inhibition. The current study utilized parts of Wright and Klumpp's (2004) procedure to test collaborative recall and reconsolidation for semantic associates.

Current Study

The reconsolidation research paradigm has focused exclusively on the reconsolidation process where information has been individually studied and tested. However, humans also encode and retrieve information as part of an interactive group. Using a 2 (Nominal v. Collaborative) x 2 (Control v. Fear) between-subjects factorial design, the current study examined (a) differences in recall between collaborative groups and nominal groups (i.e., collaborative inhibition); and (b) differences in recall when reconsolidation is disrupted by a stimulus that causes fear in contrast to a control stimulus. Collaborative inhibition was examined similar to Wright and Klumpp (2004)'s procedure using semantically associative word lists on Day 1, in which participants retrieved list items either individually or in pairs. On Day 2, participants were reminded of the word lists using their category names, before they went through the reconsolidation manipulation. During reconsolidation, participants were exposed to a fearful auditory stimulus, similar to Strange et al (2010) fearful face paradigm, or a control auditory stimulus. On Day 3, a final recall test will determine the effects of collaboration and the effects of disruption on reconsolidation.

Based on findings showing collaborative inhibition for word categories and associative words lists (Barber & Rajaram, 2011; Basden et al., 1997; Basden et al., 2000; Basden, Reysen, & Basden 2002; Congleton & Rajaram, 2011; Wright & Klumpp, 2004), I hypothesized that participants in the collaborative group would correctly recall fewer words than participants in the nominal group, demonstrating a collaborative inhibition effect. Second, based on reconsolidation research showing that adding a fearful stimulus disrupts reconsolidation (Strange et al., 2010), I hypothesized that participants in the fear condition would correctly recall fewer words after the reconsolidation period than participants in the control condition. Third, I hypothesized that participants in the collaborative-fear condition will overall recall fewer words, followed either by the collaborative-control or the nominal-fear; participants in the nominal-control condition should recall the most words.

Chapter Two:

Method

Participants

A total of 97(43 collaborative-fear, 21 collaborative-control, 17 nominal-fear, 16 nominal-control) undergraduate students between the ages of 18 and 30 ($M = 20.13$, $SD = 2.19$) recruited from the Towson University subject pool participated in this experiment. These participants included 27 males and 70 females. All participants were recruited in pairs of two. Only 94 participants completed all three days of the study. The other three participant's data was used for purposes of Day 1 and Day 2 analyses only. All participants received course credit or extra-credit in their psychology courses for participating in this study. Participation was voluntary, and all participants completed an informed consent form before beginning the study. This research was approved by the Towson University Human Research Review Board.

Materials

Study items were composed of four neutral word lists taken from Stadler, Roediger, and McDermott's (1999) word norms (COLD, FOOT, SHIRT, and MOUNTAIN; see Appendix C for all words used). The first 12 items from each of these 15-item lists were used for the present study.

During the reconsolidation period, two audio recordings were used to affect the participant's mood state. The participants were either asked to listen to a recording of Vreisveld's "Purple Tree" (https://soundcloud.com/vriesveld/purple-tree) or to an audio recording of a séance from the film Séance (https://vimeo.com/25320119). Both recordings were 7 minutes and 23 seconds long.

To assess the mood state of the participants, both initially and after the reconsolidation manipulation, participants were administered the Visual Analog Mood Scales (VAMS; Nyenhuis, Stern, Yamamoto, Luchetta, Terrien, Parmentier, & Arruda, 1997). This scale was used as a manipulation check to ensure that the participants' moods were appropriate for the situation that they were presented with (i.e., the fear audio recording or the neutral audio recording). The participants were assessed across five mood states: Afraid, Confused, Energetic, Happy, and Tense. The VAMS measures mood by giving the participants a 100 mm vertical line with endpoints labeled Neutral at the top and with the mood word labeled at the bottom. Participants must then draw a horizontal line indicating their current mood (see Appendix B for example).

Procedure

Participants were assigned to one of four conditions: a nominal-control, nominal-fear, collaborative-control, or collaborative-fear condition. All participants were tested in pairs on Day 1. In the nominal conditions each member of the pair worked alone during initial recall and in the collaborative conditions participants worked together during initial recall on Day 1. All participants were tested individually on Days 2 and 3; Day 2 was the reminder and reconsolidation manipulation, and Day 3 included a final recall test and post-experiment survey.

During Day 1, participants signed a consent form (Appendix D) and they were reminded that the study would take place over a three day period. Participants were then brought to individual computers to complete the study phase. Participants were informed that they were involved in a memory test and told to pay attention to the presented words. These instructions were presented on the computer. They were also informed that after all

lists were presented that they would be asked to solve simple addition problems before recalling the items.

During study, the participants viewed the words on the computer screen presented at a rate of 2 seconds each, with a 1 second inter-stimulus interval. All words were presented consecutively by list. The lists were counterbalanced across participants. After all of the words were presented, participants completed a series of addition problems for 1 min. They were given a sheet of paper to record their responses.

During recall, participants either participated in the nominal or collaborative recall conditions. All participants were given a sheet of paper with one of Stadler et al.'s (1999) category names on top of each recall sheet (i.e., COLD, FOOT, SHIRT, and MOUNTAIN). The order of category names on the recall sheets were counterbalanced across participants. They were told that they can recall the lists in any order and that they may switch between lists. All participants were given 5 min to recall as many words as they could. In the nominal conditions participants recalled individually without discussion with other participants. In the collaborative conditions, participants recalled the words together in pairs. Specifically, both participants were informed that they should work together to recall words and that they must reach a consensus for each item. To reach a consensus, participants must have both agreed that the item was on the study list in order to write it down (Harris, Barnier, & Sutton, 2012). One participant was assigned to serve as the scribe. After recall, participants were reminded to return the next day for further testing to ensure that the word lists studied would be fully consolidated in memory.

On Day 2, participants first completed the VAMS to assess their initial mood state. In order to do this, participants were asked to indicate their mood by drawing a horizontal line across the vertical line. After completion of the VAMS, participants had their memory of the word lists from Day 1 reactivated by re-presenting the participants with the category names one at a time. Once presented, participants were asked to briefly think about the words that belonged in each category. Participants were given 1 minute per category to reactivate their memory for the words (Schiller & Phelps, 2011). Immediately after reactivation participants completed another distractor task of addition problem for 3 min (Monfils Cowansage, Klann, & LeDoux, 2009). After the distractor task, participants participated in one of two conditions: the control condition or the fear condition. In both conditions, participants were given a blindfold and headphones. They were instructed to listen attentively to the audio recording for later testing. In the control condition participants listened to Vreisveld's "Purple Tree," and in the fear condition participants listened to a recording of a séance from a film entitled Séance. After listening to the recording, participants again completed the VAMS. Participants were then asked to return the next day (reconsolidation is complete by 6 hours; Nader, Schafe, & LeDoux, 2000) to complete a series of follow-up questions about the experiment. Participants were not told that they were participating in a final recall test on Day 3. This was to ensure that participants did not consciously continue to reactivate the words, and so that the natural course of reconsolidation could examined.

On Day 3, all participants were asked to recall as many words as they could from the lists from Day 1. All participants recalled words individually. Participants were given a sheet of paper with the same category headings (counterbalanced) as on Day 1. They

were told that they could recall the lists in any order and that they could switch between

lists. All participants were given 5 min to recall as many words as they could. At the

completion of the final recall test, participants were given a brief survey (Appendix E)

including demographic information (gender, age) and their reactions to the study (e.g.,

satisfaction). They were then debriefed on the purpose of the study.

Chapter Three:

Results

Manipulation Check (VAMS)

As a manipulation check, a 2 (Before Audio v. After Audio) x 2 (Fear v. Control) mixed design multivariate analysis of variance (MANOVA) was performed on all five mood states represented on the VAMS: Afraid, Confused, Energetic, Happy, and Tense. The five mood states represent the dependent variables while time (Before Audio v After Audio) and type (Fear v. Control) represent the independent variables. The MANOVA revealed a significant multivariate main effect for time, Wilks' $\lambda = .74$, $F(1, 95) = 32.55$, $p < .001$, $\eta^2 = .25$, and a significant interaction effect for time and type of audio, Wilks' $\lambda = .83$, $F(1, 95) = 18.81$, $p < .001$, $\eta^2 = .16$. To assess changes for each of the five mood state based on time and type, univariate main effects were conducted for each mood state (see Table 1 for analyses). The results of the individual univariate analyses show that that the fear audio condition caused participants to feel more afraid and tense compared to the control condition, indicating a successful mood manipulation. An additional analysis was also conducted to determine whether or not the gender of the participants was a factor that affects mood states. It was found that there was a significant interaction between gender (Male v. Female), mood state, and condition type (Fear v. Control), Wilks' $\lambda = .88$, $F(4, 86) = 2.93$, $p < .05$, $\eta^2 = .12$. More specifically, additional univariate analyses indicated that in the fear condition only females ($M = 38.78$) were significantly more confused in then males ($M = 25.31$), $F(1, 89) = 4.83$, $p < .05$, $\eta^2 = .05$, and females ($M = 32.19$) were also significantly more fearful then males ($M = 21.85$) in the fear condition, $F(1,89) = 4.61$, $p < .05$, $\eta^2 = .04$.

Day 1 Recall

All Day 1 recall data used in this analysis was aggregated between the pair of participants. In the collaborative groups two participants contributed to one recall sheet, while in the nominal groups two participant's individual non-repetitive responses were pooled together. To test the hypothesis that the participants in the collaborative group would recall less information than the participants in the nominal group an independent samples *t*-test was performed, with proportion of words recalled as the dependent variable and group type as the independent variable (See Figure 1). This analysis revealed that the nominal group (*M* =.57, *SD* = .08) recalled significantly more words than the collaborative group (*M* =.41, *SD* =.11), $t(46) = 5.14$, $p < .001$.

Day 3 Recall

All Day 3 recall data uses in these analyses were collected from individual free-recall responses on Day 3. To test the hypotheses that participants in the fear condition recalled less information than the control condition, that participants in the collaborative-fear condition overall recalled less information, followed either by the collaborative-control or the nominal-fear, and that participants in the nominal-control condition recalled the most words, initially a 2(Group: nominal v. collaborative) X 2 (Audio Type: control v. fear) X 2 (Gender: male v. female) between-subject factorial analysis of variance (ANOVA). No significant effects of gender were found. Therefore participants were collapsed and a 2 (Group: nominal v. collaborative) x 2 (Audio Type: control v. fear) between-subjects factorial ANOVA was performed for the total number of words recalled on Day 3. A within-subjects analysis could not be performed comparing Day 1 recall to Day 3 recall because data on Day 1 was aggregated between two participants.

The results revealed that there was no significant main effect of group, $F(1, 90) = .112$, $p > .05$, $\eta^2 = .001$ nor a significant main effect of audio type, $F(1, 90) = .835$, $p > .05$, $\eta^2 = .01$. However, there was a significant interaction between group and audio type on Day 3 recall, $F(1, 90) = 7.33$, $p < .01$, $\eta^2 = .07$. To examine this interaction post hoc univariate tests for simple effects revealed no significant difference between the collaborative-fear ($M = .34$, $SD = .08$) and collaborative-control ($M = .31$, $SD = .08$), conditions, $F(1, 90) = 2.20$, $p > .05$. However, the participants in the nominal-control condition ($M = .35$, $SD = .02$) recalled significantly more words than participants in the nominal-fear condition ($M = .28$, $SD = .01$), $F(1, 90) = 5.17$, $p < .05$ (see Figure 2).

Chapter Four:

Discussion

This study supports and replicates previous findings demonstrating the collaborative

inhibition effect (Andersson & Rönnberg, 1996; Barber & Rajaram, 2011; Barber,

Rajaram, & Aron, 2010; Basden et al., 1997; Blumen & Rajaram, 2008; Blumen &

Rajaram, 2009; Blumen & Stern, 2011; Congleton & Rajaram, 2011; Dahlström et al.,

2011; Finlay et al., 2000; Reysen et al., 2011; Rajaram, 2011; Rajaram & Pereira-Pasarin,

2010; Weldon & Bellinger, 1997; Wright & Klumpp, 2004; Yaron-Antar & Nachson,

2006). These data also extend the collaborative inhibition effect by examining it with the

memory reconsolidation paradigm. Contrary to the hypothesis, participants who

collaborated with a peer did not show the greatest deficit in later recall. Rather,

participants who initially recalled individually and whose level of fear was heightened

during reconsolidation recalled fewer items on Day 3 when compared to the participants

who initially recalled individual and did not experience the fear. Participants who initially

recalled as a partner, regardless of mood, experienced the greatest loss of information,

whereas individuals in who recalled individually initially and did not experience fear

were no different from those who recalled with a partner initially. The finding that

participants who recalled initially individually and experienced fear during

reconsolidation produced a deficit in recall however does coincide with previous research

demonstrating that fear can be used to disrupt reconsolidation (Strange et al., 2010).

Retrieval disruption is one theoretical explanation for the collaborative inhibition

effect that was conceptually replicated in the current study (Basden et al., 1997).

According to this explanation, a participant who is recalling as part of a collaborative

group's recall is disrupted when he/she is exposed to another group member's memory. More specifically, when an individual encodes information, that individual develops an idiosyncratic cognitive organization for that information. Then, once they are entered into a collaborative group, each individual's idiosyncratic cognitive organization interferes with one another, which may result in a disruption of recall.

Basden et al. (1997) and Wright and Klumpp (2004) developed studied participants who were not exposed to the other person recall for some of the words. The lack of exposure allowed participants to recall more words and abolish the collaborative inhibition effect. Based on the retrieval disruption hypothesis and on previous research on deficits in recall that can be produced during reconsolidation (Strange et al., 2010; see Schiller & Phelps, 2011 for review), It was originally hypothesized that participants who recalled as part of a group and experienced fear during reconsolidation would recall the least amount of words. It was further hypothesized that this would be followed by either the participants who initially recall individually and experienced fear or the individuals who recalled as part of a group and did not experience fear. Participants who recalled initially individually and did not experience fear were hypothesized to have the most amount of recall. However, the current results demonstrate that participants who recalled initially individually and experienced fear during reconsolidation produced the least amount of words during recall with no differences between the other groups. Such results can be explained in the context of other collaborative recall research. Basden, Basden, and Henry (2000) examined recall of collaborative and nominal groups subsequent to the initial recall. They found that when recalling alone after the initial collaborative or nominal recall, those in the collaborative group remembered more than those in the

nominal group. Additionally, they demonstrated that those who previously recalled

collaboratively incorporated additional items into their later recall. This suggests that

those who recall together initially experience a deficit (collaborative inhibition), but when

they recall individually later they experience a benefit greater than those who initially

recalled in a nominal group. In the context of this study, this finding has interesting

implications. It is possible that in the current study those in the collaborative-fear group

would have experienced a memory deficit due to the disruption of reconsolidation if they

had not recalled collaboratively previously. In other words, the benefit that participants

received from subsequent recall cancelled out the deficit they received from

reconsolidation disruption.

Although the finding that the participants who recalled as part of a group and

experience fear during reconsolidation did not experience a deficit in recall can be

explained by the literature (Basden et al., 2000), the finding that it is not significantly

different from the participants who did also recalled as part of a group but did not

experience fear is more difficult to explain. If participants experienced a benefit from

previous collaboration enough to cancel out the reconsolidation deficit, this should have

given participants in the collaborative-control condition (who received no reconsolidation

disruption) a bigger boost to word recall. It is possible that the small number of

participants in both of the nominal groups and the collaborative-control group contributed

to this issue. It is possible that some of the participants in the group that recalled

collaboratively and did not experience fear may have had a larger effect of the findings as

a whole than they would have if a larger sample was collected. Another possibility for

these results was data collection timing. The data for the participants who recalled as part

of a group and did not experience fear was collected during the last few weeks of classes

during the fall semester of 2013. The stress of exams may have adversely affected the

recall of participants in that condition. On Day 2 when the reconsolidation window

opened, participants were kept for a limited amount of time in the laboratory. Since the

reconsolidation window does not close for 6 hours (Nader, Schafe, & LeDoux, 2000) it is

possible the stressors, created by exams or other outside factors may have also disrupted

reconsolidation leading to a similar result as the collaborative-fear condition.

Further research should be conducted to examine the possible canceling effect

that previous collaboration appears to have on reconsolidation disruption. Additionally,

research should address this by conducting this experiment with consistently

demonstrated method of reconsolidation disruption (e.g. using a second word list as a

form of interference; Hupbach, 2007). It would also be beneficial to examine this effect

with a no- audio control, rather that the audio control. The results of the manipulation

check show that the control audio affected the energy, happiness, and confusion that the

participants felt prior to listening to the audio. It is possible that these changes may also

have some small influence on reconsolidation; therefore no-sound control condition

would be ideal. To address the limitations of this research, further research should also be

conducted that includes more participants. Ideally, for purposes of power the current

number of participants needs to be increased. Due to such a small sample size it is

possible that an outlier may over affect the results in this study, therefore resulting in

some of the non-significant effect in my study. Finally, further research should also

address other mood states and their possible influence on reconsolidation. In examining

mood states it would also be valuable for further research to examine reconsolidation

disruption using fear within the context of gender. In the current study, it was found that females were significantly more fearful and significantly more confused than males, those this effect did not influence memory performance. Future research with a more balanced sample of males and females should explore the possibility that females' memory may be more influenced by a fearful disruption. Like, Hupbach and Dorskind's (n.d.) study which examined reconsolidation using male males and stress as a disrupter (for hormonal reasons) it may also be valuable to do further research using only one gender.

This research can be applied to several different settings, especially in an educational context. Often when studying for exams students will study together in groups. This includes learning and retrieving information critical for later retrieval. Based on the effect of collaborative inhibition, these students may experience a deficit because they are learning and retrieving initially in a group. The findings of this study further suggest that students may actually see no effect or a possible long-term benefit from the initial collaborative retrieval. During exam preparation students often experience extreme emotions including feeling fearful or tense which are associated with stress. The memory deficit that this produces may in fact be counteracted by prior collaborative retrieval. It is possible that this prior collaborative retrieval may be affecting the participant's confidence in their ability to remember words, which may also counteract the negative mood state later. Thus, future research should examine the effect of confidence in this research paradigm.

In summary, the current research replicates the robust collaborative inhibition effect and extends the study of collaborative recall to include the reconsolidation process.

Individuals who initially recalled alone and experienced fear during reconsolidation experienced a disruption due to a fearful auditory stimulus presented during reconsolidation. Interestingly however, individuals in who also experienced fear, but recalled initially as part of a group condition did not experience this deficit. These findings seem to suggest that prior collaborative retrieval cancels out the reconsolidation disruption. This finding has interesting implications to both the costs and benefits of collaborative retrieval and re-retrieval. Future research on this topic would help researchers to better understand the inter-workings of both collaborative memory and reconsolidation.

APPENDICES

Appendix A: Tables and Figures

Table 1

Mean, Standard Deviation, and ANOVA Results for VAMS Mood States

Condition	Mood State	Before Audio		After Audio		F	η^2
		M	*SD*	*M*	*SD*		
Control							
	Confused	16.92	21.93	38.03	31.39	18.90***	.17
	Energetic	39.05	23.40	28.24	24.31	5.41*	.05
	Afraid	9.57	12.01	17.24	23.61	3.04	.03
	Tense	29.78	28.97	33.32	32.09	.51	.01
	Happy	61.54	23.28	49.62	29.01	8.22**	.08
Fear							
	Confused	20.46	19.84	48.42	27.82	53.74***	.36
	Energetic	35.06	23.67	39.05	24.24	1.92	.01
	Afraid	10.43	11.08	45.65	29.74	103.79***	.52
	Tense	29.28	25.15	55.70	26.82	46.47***	.33
	Happy	57.06	25.36	33.95	26.61	50.15***	.35

*$p < .05$. **$p < .01$. ***$p < .001$.

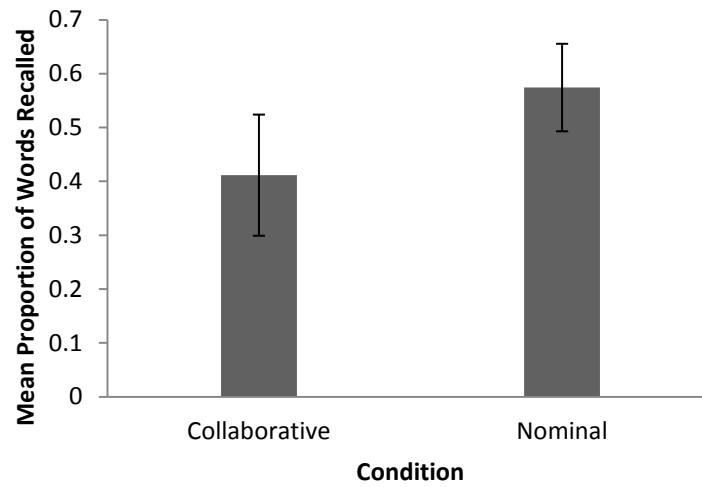*Figure 1*. Mean proportion of words recalled for each condition. Error bars represent

standard deviation.
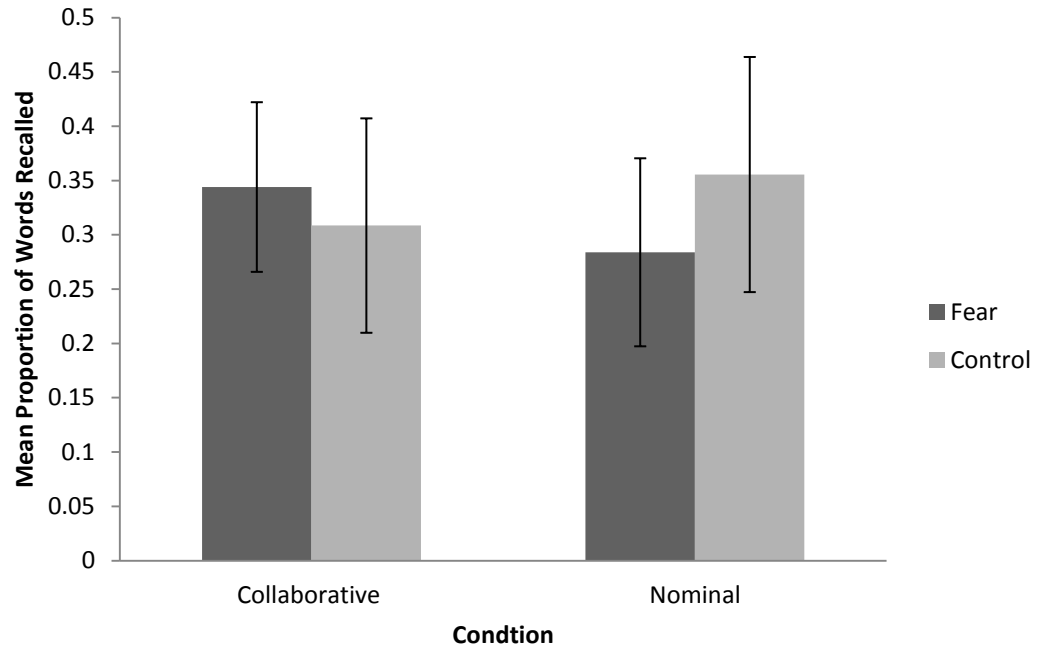
Figure 2. Mean proportion of words recalled by audio type and condition. Error bars represent standard deviation.

Appendix B: VAMS

Sample Page from the Visual Analog Mood Scales (VAMS)

(Nyenhuis et al., 1997)

Please write a horizontal line (—) across the line to indicate your current mood state.

Neutral

Afraid

Appendix C: Word Lists (Stadler et al., 1999)

Capitalized words are critical, non-presented words.

Word Lists

COLD	FOOT
hot	shoe
snow	hand
warm	toe
winter	kick
ice	sandals
wet	soccer
frigid	yard
chilly	walk
heat	ankle
weather	arm
freeze	boot
bir	inch
SHIRT	MOUNTAIN
blouse	hill
sleeves	valley
pants	climb
tie	summit
button	top
shorts	molehill
iron	peak
polo	plain
collar	glacier
vest	goat
pocket	bike
jersey	climber

Appendix D: Informed Consent Form

Informed Consent

I freely and voluntarily and without undue inducement of any element of force, fraud, deceit, duress, or other form of constraint or coercion, consent to be a participant in the research project entitled "Auditory Perception and Memory" to be conducted at Towson University by Iiona D. Scully as Principal Investigator. I understand that I will be asked to remember a set of word lists for a memory test and that I may be asked to listen to an audio recording lasting approximately 8 minutes. In understand that some the words lists may induce a sense of unease or discomfort, although this feeling should be temporary. I understand that the audio recording may induce a sense of discomfort, although this discomfort should be temporary. I understand that it is my right to end participation of the study at any time if I feel uncomfortable or for any other reason. I understand that this study will take approximately 45 minutes to complete, over the course of three testing sessions.

I understand that a personal computer will permanently record my responses in this experiment. All records will be anonymous, and identification of participants will be recorded by assigned numbers only. The records of this research which identify me will be kept in locked storage cabinets in the laboratory and be used for research purposes only. All records will be kept for a minimum of three years and will be accessible only to the primary researcher. Journal publishers require that data be kept for five years from the date of publication. Therefore, data will probably be kept for five to ten years because of the time involved in data analysis, manuscript preparation, etc. Five years after journal publication, all data will be destroyed. At the latest, all data and recordings will be destroyed by December 2023.

The attendant discomforts and risks reasonably to be expected by my participation in this project have been explained to me and I understand them to be minimal. I understand that my participation may help researchers learn about the mental processes involved in auditory perception and memory.

I understand that this consent may be withdrawn at any time without prejudice, penalty or loss of benefits to which I am otherwise entitled. I have been given the right to ask and have answered any inquiry concerning the foregoing. Questions, if any, have been answered to my satisfaction. In the future, I understand that I may contact Iiona D. Scully (t: 607-207-8314; email: iscull1@students.towson.edu) or Dr. Kerri Goodwin in the Psychology Department at Towson University, (t: 410-704-3202; email: kgoodwin@towson.edu) for answers to pertinent questions about this research, my rights, or in case of a research-related injury. This research has been approved by the Towson University Institutional Review Board for the Protection of Human Subjects in Research. Any concerns about these procedures may be directed to Dr. Debi Gartland, IRB (t: 410-704-2236).

I have read and understand the foregoing.

Participant: _____   Date _____
                    (signature)

                    _____
                    (printed name)

Witness: _____   Date _____

Appendix E: Post-Experiment Survey

1. In your opinion, describe what you believe the purpose of this study was.

2. What is your gender?   (circle one)

FEMALE   MALE   PREFER

NOT TO ANSWER

3. What is your age (in year)? _____

4. To what degree are you satisfied that you participated in this research?   (circle a number)

1	2	3	4	5
very	dissatisfied	neutral	satisfied	very
dissatisfied				satisfied

5. Briefly explain your response to #4 in the space below.

Appendix F: IRB Approval

TOWSON
UNIVERSITY

APPROVAL NUMBER: 14-A029

To: Iiona   Scully
           Attn Kerri Goodwin, 8000 York RD
           Towson   MD   21252

From: Institutional Review Board for the Proctection of Human
          Subjects Beth Merryman, Member

Date: Thursday, October 10, 2013

RE: Application for Approval of Research Involving the Use of
          Human Participants

Office of University
Research Services

Towson University
8000 York Road
Towson, MD 21252-0001

t. 410 704-2236
f. 410 704-4494

Thank you for submitting an Application for Approval of Research
Involving the Use of Human Participants to the Institutional Review
Board for the Protection of Human Participants (IRB) at Towson
University. The IRB hereby approves your proposal titled:

Memory reconsolidation and collaborative memory

If you should encounter any new risks, reactions, or injuries while
conducting your research, please notify the IRB. Should your research
extend beyond one year in duration, or should there be substantive
changes in your research protocol, you will need to submit another
application for approval at that time.
We wish you every success in your research project. If you have any
questions, please call me at (410) 704-2236.

CC: Kerri Goodwin
       File

Appendix F: IRB Approval cont.

Date: Thursday, October 10, 2013

NOTICE OF APPROVAL

TO: Iiona   Scully   DEPT: PSYC

PROJECT TITLE: *Memory reconsolidation and collaborative memory*

SPONSORING AGENCY: None

APPROVAL NUMBER: 14-A029

The Institutional Review Board for the Protection of Human Participants has approved the project described above. Approval was based on the descriptive material and procedures you submitted for review. Should any changes be made in your procedures, or if you should encounter any new risks, reactions, injuries, or deaths of persons as participants, you must notify the Board.

A consent form: [✓] is [ ] is not required of each participant

Assent: [ ] is [✓] is not required of each participant

This protocol was first approved on: 10-Oct-2013
This research will be reviewed every year from the date of first approval.

_____, MPA (for)
Beth Merryman, Member
Towson University Institutional Review Board

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The case of Rabin's assassination. *Memory, 14,* 46-56.

Iiona D. Scully B.S.

Curriculum Vitae

Education

Towson University, Towson, Maryland	2013-Present

M.A. in Experimental Psychology (Estimated Conferral, May 2014)

Syracuse University, Syracuse, NY	2011-2013
Elmira College, Elmira, New York	2007-2011

B.S. in Psychology (Conferred, June 5th, 2011), *summa cum laude*

Academic Honors, Awards, Recognitions and Scholarships

Towson University

Distinguished Graduate Student Award	2014

Syracuse University

Teaching Fellow Award/Appointment	2011-2013

Elmira College

Dean's List	2007-2011
Elmira College's Presidential Honor Scholarship	2007-2011
Cowles, Senior, and Honor's Scholar	2007-2011
Psi Chi Travel Grant	2011

Posters and Publications

Scully, I.D., & Terry, C.P. (2011). Self-referential memory for the Big-Five personality traits. *Psi Chi Journal of Undergraduate Research, 16(3)*, 123-128

Scully, I.D., & Terry, C.P. (May 18, 2011). *Self-Referential Memory for the Big-Five Personality Traits*. Poster presented at the Elmira College 2010-2011 Student Research Poster Session, Elmira, NY

Scully, I.D., & Terry, C. (March 10-13, 2011). *Self-Referential Memory for the Big-Five Personality Traits*. Poster presented at the 2011 Eastern Psychological Association Annual Conference, Cambridge, MA

Scully, I.D. (October 9, 2010). *Does semantic priming cause the isolation effect?* Poster presented at the Elmira College 2010 Parents Weekend Student Research Poster Session, Elmira, NY

Scully, I.D. (May 19, 2010). *Does semantic priming cause the isolation effect?* Poster presented at the Elmira College 2009-2010 Student Research Poster Session, Elmira, NY
  - Won a first place prize

Lovett, B.J., & **Scully, I.D.** (April 17, 2010). *ADHD and extra time on tests*. Poster presented at 25th Annual University of Scranton Psychology Conference, Scranton, PA

Scully, I.D., & Kilgour, M. (April, 2009). *Words remembered using visual, auditory, and rote memorization techniques.* Poster presented at Elmira College Student Research Poster Session, Elmira, NY

Research Experience

Towson University

Master's Thesis	2013-Present

Research Assistant	2014
Syracuse University	
Statistical Consultant	2013
Meta-Analysis	2012-2013
First-Year Project	2011- 2012
Elmira College	
Pre-Graduate Internship	2010-2011
Research Assistant	2009-2010

Teaching Experience

Towson University
Teaching Practicum
PSYC 314: Research Methods in Psychology (with Lab)   Spring Term 2014
Syracuse University
Teaching Assistant   Fall & Spring Term2011-2012 & 2012-2013
PSY 205: Foundations of Human Behavior
Grader   Spring Term 2012 & 2013
PSY 337: Psychology of Adult Life and Aging
Elmira College
Peer Tutor   Winter Term 2011
PSY 3410: Cognitive Process
Academic Fellow   Fall Term 2010
PSY 4010: History and Systems of Psychology
Academic Fellow   Winter Term 2010
PSY 2602: Quantitative Methods of Psychology
Peer Tutor   Fall Term 2009
PSY 3410: Cognitive Process

Invited Talks

Presenter, Trustees Meeting, *Elmira College*   Spring 2011

Professional Activities

Reviewer
- APSSC (Association for Psychological Science Student Caucus) 2014 Student Research Award Competition
- APS (Association for Psychological Science) 2014 Student Grant Competition
- APSSC (Association for Psychological Science Student Caucus) 2013 and 2014 RISE Research Award Competition

Professional and Honor Society Memberships

Omicron Delta Kappa
Association for Psychological Science Graduate and Undergraduate Member
Psychology Action Committee Experimental Representative *(Syracuse University)*
Who's Who Among Students in American Universities and Colleges
APS Student Caucus Representative *(Elmira College)*
Eastern Psychological Association Associate Member
Pi Gamma Mu
Psi Chi
Phi Eta Sigma