CUE GENERATION:
HOW LEARNERS FLEXIBLY SUPPORT FUTURE RETRIEVAL

BY

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DISSERTATION

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Abstract

In a wide variety of situations, learners generate external cues that they can later use to support retrieval from memory. For instance, learners create shopping lists at home to help remember what items to later buy at the grocery store or set kitchen timers to remember to take the brownies out of the oven. In this dissertation, I investigated what types of cues learners generate, how they generate cues, and whether these cues effectively promote retrieval. Across seven experiments, learners generated a cue for each item in a list of to-be-remembered words and received these cues during a later cued recall test. In the first series of experiments (1-2), learners either intentionally generated cues that they knew they would receive during the test or generated descriptions of targets without knowledge that these descriptions would become cues during test. Learners generated different types of cues depending upon the instructions they received. Further, effective cues were more distinctive and had higher cue-to-target associative strength than ineffective cues. In the next set of experiments (3-5), learners either generated cues for themselves or for other learners. Learners effectively tailored their cues to support others' memory performance by reducing the distinctiveness of the cues and increasing the normative cue-to-target associative strength. Finally, in the third set of experiments (6-7), learners generated cues for triplets of targets, some of which were presented with related words and some of which were presented with unrelated words. When learners were encouraged to notice the relationships among competitors by presenting the three related items concurrently, the confusions among competing targets were reduced and cued recall performance was improved. The results of these experiments reveal that learners use sophisticated tactics to flexibly generate cues across a variety of different situations and, by doing so, effectively support future retrieval.

Keywords: cue generation, metacognition, control

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INTRODUCTION

When taking notes in meetings, making to-do lists, outlining readings, and naming computer files, learners support later retrieval by generating cues for their future selves. Learners create external cues to reduce the demands placed on their limited memories and enable later retrieval. The ability of a learner to remember target information may fade over time; a good external cue can sustain memory retrieval even in the face of considerable forgetting. The effectiveness of learners' self-generated external cues to support retrieval may underlie successful memory retrieval and play a vital role in many real-world activities. For example, patients often set up memory cues, like pill boxes and cell phone reminders, to aid in their adherence to medications. However, the external cues that patients utilize to support their memory often fail; patients forget to take their medication and the effectiveness of their prescription is undermined (Carasanos, Stewart, & Cluff, 1974; Haynes, McKibbon, & Kanani, 1996; Osterberg & Blaschke, 2005). Setting oneself up to remember tasks and information in the future is an important skill that carries heavy consequences. In the current experiments, I examined how effectively learners generate cues to support later memory retrieval. In the first series of experiments (Exp. 1-2), I examined how learners intentionally generate cues for themselves and evaluated how the use of idiosyncratic knowledge during cue generation impacts cue effectiveness. In the second set of experiments (Exp. 3-5), I examined how the intended recipient of the cues alters the quality and process of cue generation. In the third series of experiments (Exp. 6-7), I analyzed how characteristics of the to-be-remembered set of stimuli can alter the cues learners generate.

Cue generation lies at the intersection of a variety of well-researched topics, including prospective memory, metacognitive control processes, inter-personal communication, and

perspective-taking. How each of these relates to cue generation, and how cue generation can inform each, will be addressed in turn.

<u>Prospective Memory</u>

Cue generation is a distinctly prospective memory task: learners create cues in order to intentionally support their memory in the future. When writing a shopping list or taking notes in class, learners are generating cues to help retrieve concepts later. The type and quality of cues that learners generate impact how much is recalled. Research in prospective memory has focused almost exclusively on how automatic or effortful prospective memory is, and has not addressed how learners generate cues to support future retrieval. Throughout that literature, learners are required to act in response to an experimenter-chosen cue. For instance, in the most widely utilized prospective memory task, learners must press a specified key (e.g., the "1" key) whenever the specified cue (e.g., the word "rake") appears during a different, ongoing working memory task (Einstein & McDaniel, 1990; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Marsh, Hicks, 1998; Morrell & Mayhorn, 1997; Park, Hertzog, Kidder, & Morrell, 1997). In the only prospective memory task in which the cue is not an experimenter-determined word, learners name celebrities from pictures of their faces and, as their prospective memory task, must simultaneously circle a number when a face with glasses appears in the list. Even in this case, though, the specified cue is experimenter-determined: faces with glasses.

Prospective memory tasks have utilized these very controlled experiments to determine if prospective memory is an automatic, cue-driven process or a deliberate, resource-consuming process. These types of tightly controlled prospective memory tasks have produced many interesting results about the abilities of learners to successfully enact goals in response to external stimuli, but they have not addressed a fundamental issue in the use of prospective

memory: the ability of learners to choose for themselves the best cues to elicit the target behavior. Only one prospective memory task has allowed learners to generate external cues to support their later response. In Einstein and McDaniel (1990), learners were required to press a button when the word "rake" appeared during a working memory task. Some learners were allowed to use office supplies to create an external aid to use during this task while others were not. The authors report that the types of external cues used during this task were all highly similar: learners wrote the word "rake" on a piece of paper and taped it to the computer screen. Almost all learners who had the option to utilize the external aid did so, and external aids improved memory performance. Although learners were given some control over the external aid they used, the task tightly controlled the link between the cue ("rake") and the response (pressing a key). Learners were given some control, but that control was removed from the actual cue-response relationship. Since that experiment, studies have tightly controlled the cues that are given to learners during prospective memory tasks. In the series of experiments presented here, I expand on the research in prospective memory by focusing on how learners generate cues to support their memories.

The current set of experiments expands the extant literature on prospective memory in two additional ways. First, the prospective memory task is the sole goal for the learners in the current studies. Across all prior literature, prospective memory tasks have been relegated to a secondary task that learners try to accomplish while engaged in a different, ongoing memory task. The impact of full attention on prospective memory tasks, then, is essentially unexplored. Second, learners are tasked with connecting multiple targets to multiple different cues in these studies. In the existing prospective memory literature, learners are sometimes tasked with responding to a variety of different cues, but they are asked to respond in the same way to all of

them. For instance, learners may be asked to press the zero key whenever "lion", "tiger", or "leopard" is displayed (Einstein, Holland, McDaniel, & Guynn, 1992). Learners, then, are required only to remember one particular response when engaged in the prospective memory task. I expand on this by requiring learners to respond differently to a variety of different cues. The current series of experiments examines memory performance in conditions that are not usually considered in prospective memory, including the use of learners' generated cues, the use of a prospective memory task as a solitary goal, and the assignment of multiple cues onto multiple responses.

Metacognitive Control

When given the opportunity, learners exercise strategic control over their memories during encoding (Benjamin, 2008) and memory retrieval (Goldsmith & Koriat, 2007). In fact, individuals' differing mnemonic abilities may arise largely from differences in the skill with which learners exercise strategic control over the encoding and retrieval processes (Benjamin, 2008). One largely unexplored aspect of metacognitive control over memory is how learners generate cues to support future retrieval. People often control the cues that will be present during retrieval by generating external cues for themselves. For example, in order to remember things, 100% of learners report putting items in a special place to remind them of something, 97% of learners report writing notes to themselves, 93% of learners report writing shopping lists, and 53% of learners report writing things on their hands (Harris, 1980). However, the effectiveness of cues has been studied in conditions greatly restricted by experimenters seeking tight control over stimuli. Experimenters seek this control over learners' behavior in order to reduce the extraneous variability associated with the idiosyncrasies of self-generated cues (Nelson & Narens, 1994). Across the experiments reported here, learners controlled the cues

they received during retrieval by generating their own cues during encoding and have, thus, increased the variability associated with cues.

Giving learners more control over their study usually boosts future memory performance. Learners deliberatively and strategically choose encoding tactics, study activities, study time allocation, and study schedules that boost mnemonic performance. Learners spontaneously engage in mnemonically beneficial encoding strategies. When given a list of words to learn, learners with no encoding restrictions perform better than those instructed to use rote rehearsal for each displayed item (Allen, 1968), which suggests that learners naturally utilize helpful encoding strategies when given the opportunity. Further, learners strategically adapt their encoding processes to the specific testing circumstances they face (Finley & Benjamin, 2012). Learners effectively choose which items they need to re-study as learners who are allowed to re-study the items that they choose out-perform those who are given other items (Kornell & Metcalfe, 2006; cf. Tullis & Benjamin, 2012). Further, learners purposefully select study activities to improve memory. Learners select to be tested on easy items in a list and re-study the more difficult items (Karpicke, 2009). When their selections are honored (by giving them the study activity they chose), learners remember more than when their selections are dishonored (by giving them the opposite; Tullis & Benjamin, in prep). Learners also schedule their learning in a mnemonically advantageous manner. When given control over how to distribute study time across items, learners' mnemonic performance improves (Tullis & Benjamin, 2011; Tullis, Benjamin, & Liu, under review). Learners also favor spacing over massing for the more difficult repetitions, which benefits memory (Benjamin & Bird, 2006; Son, 2004; Toppino, Davis, Cohen, & Moors, 2009). Learners, then, execute sophisticated metacognitive control over encoding to improve their memories.

Learners also exercise control over their own retrieval processes (Goldsmith & Koriat, 2007). Learners regulate the quality and amount retrieved in accordance with standards for accuracy and informativeness. To do so, they decide whether to report or withhold retrieved information and they control the precision or graininess of what they do report.

However, little research has addressed how learners exercise metacognitive control over their future testing circumstances. Research about the effectiveness of metacognitive control has focused almost exclusively on control decisions that boost the current level of learning, and has ignored how learners can control the circumstances during retrieval. Choosing what cues will be available during testing may have huge effects on memory retrieval. Generating effective cues requires that learners to set up circumstances to enhance the probability of successful later retrieval, rather than increase the current memory strength of the target item. To effectively do this, learners must predict their future cognitive context and the future state of the world, which may be a very challenging task.

Few studies have examined how learners control their retrieval environment, and they have revealed mixed results of giving learners control over testing circumstances. The first study investigated whether learners are aware of the benefits of transfer appropriate processing by letting learners choose how they would be tested on individual items (Finley & Benjamin, under review). Learners studied targets with either rhyming or semantic cues and then chose what type of cue (a rhyme or semantic associate) they wanted to receive during the test. Learners did not preferentially select testing circumstances that matched the conditions during encoding. In other words, learners did not effectively control their testing circumstances to take advantage of transfer appropriate processing.

The second study to explore how learners control their retrieval environment showed that learners effectively select cues from a set of options to support later memory performance (Finley & Benjamin, under review). For each target item, learners selected two out of four possible cues to receive during the memory test. Sometimes learners' selections were honored and the selected cues were presented at test; other times two random cues out of the possible four were presented instead. Learners recalled more targets when they received the cues that they chose than when they received random cues. Learners thus can effectively set up advantageous testing conditions by choosing cues to support later memory performance. Mäntylä (1986) has also shown that learner-generated descriptions of target items are very effective cues during a cued recall test, even when learners are not aware that their descriptions will later serve as cues.

Generating external cues is an example of learners controlling their memories by offloading mental processes onto the environment. Learners can take advantage of aspects of their physical environment, like the stability of written notes, to avoid the inherent limitations of their cognitive systems, like forgetting. Learners write down notes and take pictures to overcome long-term memory limitations, use calculators to overcome working memory constraints, and even search the internet for answers to questions to overcome gaps in semantic knowledge. In this way, the cognitive system, writ large, includes aspects of the learner's environment that they use in support of their cognitive goals. Harris (1980) surveyed learners about the external aids they used to aid retrieval and found widespread use of a variety of different external aids, including asking others to remind them, using a kitchen timer, writing on a calendar, and writing notes to oneself. The effectiveness with which learners use such external support has been most thoroughly examined with respect to prescription adherence (Carasanos, Stewart, & Cluff, 1974), and has shown that learners fail to offload cognition onto the

environment effectively (Haynes, McKibbon, & Kanani, 1996; Park, Morrell, Frieske, & Kincaid, 1992; Piette, Weinberger, Kraemer, & McPhee, 2001).

Qualities of good cues

People's cues often fail to support prospective memory performance in everyday life. People sometimes struggle to understand their notes from a class, do not know what computer file a file name refers to, and forget to take their medication. These failures suggest that the cues spontaneously utilized by learners do not flawlessly support retrieval. Research has shown that memory experts can sometimes choose cues that result in better prospective memory than those spontaneously utilized by learners, especially for medication adherence. Weekly phone calls, pill boxes, and beepers have been implemented to improve medication adherence, and often these interventions succeed in increasing rates of prescription adherence (Lachowsky & Levy-Toledano, 2002; Park, Morrell, Frieske, & Kincaid, 1992; Piette, Weinberger, Kraemer, & McPhee, 2001). Research suggests that the quality of the cue makes a big difference in whether desired tasks are completed.

Research in both retrospective and prospective memory suggests that good cues have the following three properties: they are strongly associated to the target, they are distinctive, and they are consistent across encoding and retrieval. First, the association between the target and cue influences how much is recalled. Cued recall performance increases as the cue-to-target associative strength in a word pair increases (Feldman & Underwood, 1957; Koriat & Bjork, 2006). Similarly, cues in a prospective memory task that are more strongly related to the intended action result in higher prospective memory than ones less closely related (Einstein et al., 1992; McDaniel, Einstein, Guynn, & Bruneweiser, 1996). Prospective memory theorists argue that the cue-to-target associative strength matters because it modulates the attentional

resources needed to monitor the environment for the cue (Einstein et al., 1992; Smith, 2003). When the cue is strongly associated to the target, fewer resources are needed to monitor for the cue (McDaniel & Einstein, 2000; McDaniel, Robinson-Riegler, & Einstein, 1998).

While most research has investigated the impact of normative cue-to-target associative strength, some has analyzed how idiosyncratic associations between cue and targets impacts recall. Learners likely rely upon the associations between items in their episodic memory to generate descriptions of to-be-remembered targets. Individuals' episodic memories differ widely between learners; consequently, relationships between items across subjects may be largely idiosyncratic. Using an individual's personal knowledge as a source for cues ensures a strong cue-to-target relationship, though that association may not generalize well across individuals. One source of evidence for this claim is the fact that when learners were cued with self-generated descriptions of to-be-remembered targets, cued recall performance was very high (around 90%), even with a very long list of to-be-remembered nouns (500; Mäntylä, 1986). Performance remained high (60%) on this cued recall test even after a week-long retention interval. Both normative and idiosyncratic cue-to-target associative strength greatly influences the effectiveness of a cue.

The second characteristic of cues that determines their effectiveness is their distinctiveness, or the number of targets a particular cue subsumes. The efficacy of a retrieval cue to support recall performance suffers when a cue is overloaded with a large number of targets. If a cue is associated to many targets or has become encoded as a part of many memories, the cue is less likely to elicit any single target due to competition among the targets. Cue overload, in fact, is thought to underlie numerous memory phenomena, including the list length effect (Mueller & Watkins, 1977), the buildup of proactive interference across categorized

lists (Watkins & Watkins, 1975), and part-list cuing (Mueller & Watkins, 1977). Some argue that a cue's distinctiveness is the single most important attribute of a cue that determines if a target memory is recalled or forgotten (Nairne, 2002). Further, research in prospective memory suggests that unusual, or distinct cues (e.g., sone or modad), better support prospective memory than common words (e.g., rake or method) because they have fewer extra-list associations (Einstein & McDaniel, 1990).

Third, the consistency between cues at encoding and retrieval determines how much is recalled. Cues present during both encoding and retrieval are much more beneficial for retrieval than cues that are present only during one phase (Tulving & Osler, 1968). Internal and external contextual elements can serve as cues to recall the study items (Estes, 1955). When the context matches between study and test, memory performance benefits (Tulving, 1979). The match between cues during encoding and retrieval can be promoted by reinstating the internal and external contexts in which the original learning took place or by sustaining the original encoding context through retrieval. Transfer appropriate processing and encoding specificity are two general principles of memory that reveal how the match between the cues during encoding and retrieval impact memory performance. Transfer appropriate processing suggests that the degree of overlap between mental operations at study and at test determines mnemonic performance (Fisher & Craik, 1977; Morris, Bradford, & Franks, 1977). The processing engaged during retrieval can be used as an effective cue to retrieve targets if it matches processing used during encoding. Similarly, encoding specificity suggests that effective retrieval cues must be specifically encoded with the target (Tulving & Thompson, 1973). Changing the cues between encoding and retrieval, even if the cues are equally associated to the target, greatly reduces later recall (Tulving & Osler, 1968). Further, according to encoding specificity, the effectiveness of a

cue depends much less upon the cue-to-target associative strength than upon the match between encoding and retrieval. In one famous example (Tulving & Thompson, 1973), learners encoded cue-target word pairs with weak cue-to-target associative strengths, but those weak cues were much more effective at supporting memory at test than strongly associated unstudied cues.

Even when a cue is encoded specifically with the target, its effectiveness may wane with time. The interpretation of words is variable and fluctuates with circumstances and the learner's current internal context. For example, when learners generated three descriptions of a target item, there was only a 46% intrasubject overlap between descriptions generated three weeks apart (Mäntylä & Nilsson, 1988). If the cognitive environment fluctuates between the time of the cue generation and retrieval, the cue from encoding may not match the cognitive context at retrieval very well, even when it is nominally the same, and recall of the target will suffer.

Utilizing cues that have stable meanings can support long-term cued recall performance. Learners can generate descriptions of the target items that do not fluctuate in time when instructed to do so. Instructing learners to generate "focused" descriptions of target items that they would likely generate again increases the intrasubject overlap between descriptions generated three weeks apart from 46% to 61% (Mäntylä & Nilsson, 1988). Focused descriptions are also less susceptible to forgetting over long periods of time. When provided with self-generated focused descriptions, memory performance only dropped from 95% to 80% over six weeks; when provided with self-generated spontaneous descriptions, performance dropped from 80% to 40% over the same time. Cues, then, can vary in their contextual stability and this stability can cause large differences in mnemonic performance over time. Effective cues must be somewhat immune to the many transitory influences of fluctuating experiences and knowledge.

Good cues do not rely on relationships that are likely to change, on knowledge that is likely to be forgotten, or on information that is currently available but not particularly well learned.

Although the interpretations of cues and targets vary over time within a learner, they vary to an even greater extent between learners. Intersubject overlap between generated descriptions of target words was only 21% (compared to the intrasubject overlap of 46% described above; Mäntylä & Nilsson, 1988). The low intersubject overlap between generated descriptions of targets reveals large idiosyncrasies in individuals' encoding of targets. Idiosyncrasies during encoding create large differences in the effectiveness of the cues created between learners. In another set of experiments, during a cued recall test, learners received descriptions of target items that they or other subjects generated during encoding. Learners recalled far fewer words when they received descriptions generated by another learner compared to when they received their own descriptions (Anderson & Ronnberg, 1997; Mäntylä, 1986). However, if the other's cues matched self-generated cues, learners' memory performance remained very high (Mäntylä, 1986). Research reveals that interpretations during encoding are largely idiosyncratic among learners, and that learners' recall benefits from receiving retrieval cues consistent with their own encoding processes.

If learners receive cues generated by others, idiosyncratic encoding of the targets and cues can prevent high levels of recall. Having subjects work together to generate descriptions of targets or using descriptions that are generated most frequently across subjects should decrease the personal idiosyncrasies of encoding. When idiosyncrasies of cues are reduced, the likely match between encoding and retrieval for a different learner should increase. Some evidence hints that generating descriptions of targets by pairs of subjects produces cues that are more helpful to other learners than producing descriptions by oneself (Andersson & Ronnberg, 1997).

Further, providing the descriptions generated most frequently across a group of subjects to a new group of subjects results in greater memory performance than providing a single prior subject's cues (Mäntylä & Nilsson, 1983). Reducing the personal idiosyncrasies of retrieval cues can improve the effectiveness of cues for a different learner because it increases the likely match between that different learner's encoding and retrieval contexts. Across this paper, cue-to-target associative strength, distinctiveness, and match between encoding and retrieval will be analyzed in order to describe the types and effectiveness of cues that learners generate.

Operationalizing Qualities of Good Cues

Before describing the individual experiments, the theoretical constructs of cue-to-target associative strength, distinctiveness, and match between encoding and retrieval must be operationalized. Cue-to-target associative strength was determined by the normative cue-to-target associative strength found in the University of South Florida Free Association Norms (Nelson, McEvoy, & Schreiber, 1998). While idiosyncratic cue-to-target associative strength may play a larger role than normative cue-to-target associative strength in recall, idiosyncratic cue-to-target associative strength cannot be determined for individual learners. The normative cue-to-target associative strength reported in this database is the best approximation available.

Cue distinctiveness, the quantity of targets subsumed by a particular cue, was operationalized using a variety of related measures. The number of targets associated to each cue according to the South Florida database is the closest analogue to distinctiveness available, with more distinctive cues associated to fewer targets. However, the number of targets associated to each cue does not characterize how strong the relationships are between the target and possible cues. To characterize the strength of all cue-to-target relationships, the total cumulative cue-to-target associative strength was also calculated. The total cumulative cue-to-

target associative strength is the sum of the cue-to-target associative strengths from a cue to all possible associated targets in the database. The larger the total cumulative strength from a cue to all possible targets, the less distinctive a cue is. Finally, if a cue is not located in the South Florida Free Association Norms, it is assumed to be (relatively) distinctive.

The quality of match between the internal and external cues present at encoding and retrieval cannot be explicitly measured. Instead, the match between encoding and retrieval was manipulated in two ways: first, by providing cues generated by oneself or by others to learners during the cued recall test, and second, by sometimes increasing the retention interval between encoding and test. Cues generated by others are less likely to be consistent with a learner's encoding of the target event than cues generated by oneself. Further, the cues at test are less likely to match the encoding context when the test is at a delay.

INTRODUCTION TO EXPERIMENTS

In these studies, learners were explicitly asked to generate cues to help their later recall, which no prior study has explicitly done. Instead, across the few prior studies with self-generated cues (Mäntylä, 1986), learners have been asked to generate descriptions of a set of nouns without any foreknowledge of the upcoming cued recall task. Learners have also generated descriptions of items to help in future identification of ambiguous targets (Fussell, 1987; Fussell & Krauss, 1989). Generating descriptions of targets and generating mnemonic cues may involve different processes and produce different results. Learners should be very effective at generating cues to support future mnemonic performance because they can rely upon their rich, idiosyncratic knowledge to produce effective cues. Learners are experts at their own personal semantic knowledge and prior experiences, so they should be able to generate distinctive, stable cues with high cue-to-target associative strength. Whether learners value cue distinctiveness or cue-to-target associative strength while generating cues remains unknown.

I draw analogies between generating messages for others and generating messages for the future self throughout this paper. Generating messages for others and for a future self entails stepping outside of one's current cognitive state, predicting a possibly different state, and creating a message consistent with that different state. An individual's current cognitive context may differ from his future cognitive contexts, just like others' cognitive contexts differ from our cognitive contexts. When communicating with others, one must determine what another person's mental context is in order to predict what the other person will understand. Similarly, when communicating with the future self, one must anticipate how the current cognitive state will differ (or remain consistent) across time in order to create a message that the future self will understand. In fact, generating messages for the future self may be more difficult than

generating messages for others: the future self cannot ask the past self for message clarification, while contemporaneous listeners consistently request clarifications from the original speaker (Horton & Gerrig, 2005). Because generating messages for others and for the future self relies upon somewhat similar underlying principles, data from analogous situations in interpersonal communication will often be referenced.

Throughout these experiments, learners generated cues to support future memory performance. In the first series of experiments, learners generated cues for themselves and the types of cues learners utilized and the characteristics of effective cues were examined. In the second series of experiments, learners generated cues to support others' memory. I examined how effectively learners overcome the biasing effects of personal knowledge, take the perspective of another learner, and generate cues for others. I explored how learners change the types of cues generated based upon the cue's intended recipient and the costs and benefits of doing so for later memory. In the third set of experiments, learners attempted to remember a set of targets which were selected to be confusable with other targets. I explored the circumstances under which learners generate cues that mitigate intra-target confusion.

PART I: CUES FOR SELF

In the first pair of studies, the effectiveness of learners' cue generation to support their own retrieval during a cued recall task was evaluated. Prior studies (Bäckman & Mäntylä, 1988; Mäntylä, 1986; Mäntylä & Nilsson, 1983; Mäntylä & Nilsson, 1988) have evaluated the quality of cues that were learner-generated descriptions of target items; here, I implemented the more metacognitively relevant case where learners generate cues specifically in anticipation of using those cues to support their later retrieval. I explored whether learners generated different types of cues depending on the instructions they receive. Some learners received instructions to generate descriptions of target words (as in prior research: Mäntylä, 1986), while others received instructions to generate cues for an upcoming memory test. I analyzed the characteristics of the generated items, compared the characteristics of effective and ineffective memory cues, and tested whether distinctiveness, cue-to-target associativity, and match between encoding and retrieval were important for effective retrieval.

Experiment 1

In the first experiment, I evaluated differences in intentionally generating cues and descriptions of to-be-remembered items. In prior work (Bäckman & Mäntylä, 1988; Mäntylä, 1986; Mäntylä & Nilsson, 1983; Mäntylä & Nilsson, 1988), learners were instructed to generate descriptions of the target item. Learners had no knowledge that they would be given these descriptions during the final memory test. Further, all extant studies but one (Bäckman, Mäntylä, & Erngrund, 1984) have utilized incidental learning conditions and surprise cued recall tests to measure the effectiveness of self-generated cues. Here I analyzed whether knowing that items will be used as cues during a future cued recall test impacts how learners generate their cues. In a between-subjects manipulation, learners were either asked to generate descriptions of

each target item, like prior studies (Mäntylä, 1986), or were asked to generate cues that would be given back to them during a later memory test. Unlike most prior research, all learners were informed of the upcoming memory test for the target words. If learners are deliberative and strategic in the types of cue they generate, differences in the characteristics of generated cues are expected between instruction conditions. Further, if learners are effective at generating cues to support memory performance, learners in the cue generation condition should show better memory performance than learners in the description generation condition, even though both groups expect a final memory test.

Participants

Fifty introductory psychology students at the University of Illinois at Urbana-Champaign participated for partial course credit.

Materials

Sixty words were collected from the University of South Florida Free Association Norms (Nelson et al., 1998) with the intention that college-aged subjects would have some personal experiences with the items. Examples of words include "favorite," "haircut," and "roommate." The Thorndike-Lorge written frequencies ranged from 27 to 2218, with a mean of 536 and a standard deviation of 510.

Method

The experiment was presented using the Psychophysics toolbox in MATLAB on personal computers in individual testing rooms. Instructions about the memory task were first presented on the personal computer screens; these indicated that subjects would study a list of sixty words and would later be tested on their memory for these words. Subjects were told that their memory for the words presented on the right side of the screen would be tested. Subjects were assigned

to either the *description generation* or *cue generation* conditions according to a counterbalancing scheme that evenly distributed learners across conditions. The counterbalancing scheme further yoked subjects to prior subjects in their same condition half of the time and to prior subjects in the other condition half of the time. The first subject on each of the six different computers received all of the cues that they generated. All other subjects were yoked to the immediately prior subject on that same computer. Half of the cues that these subjects received were generated by them and half were generated by the previous subject.

The 26 subjects in the *description* condition received the following instructions: "For each target word, you will need to generate some aspect of the word that constitutes an appropriate description of the target item. This aspect or description can be created according to your own life experiences. Your memory for the target words will be tested at the end of the experiment. Once again, for each target in the list, we ask that you type in one word that, according to your own experiences, describes the target word or is an aspect of the target word. You can use any description. However, the target word cannot serve as its own description."

The 24 subjects in the *cue generation* condition received the following instructions: "For each target word, you will generate some type of cue to help you remember the target word at a later test. At the time of the test, you will be given the cue word you generated and will be asked to remember the specific target word for each cue. Please generate the cues that will be most useful to you in remembering the target words. You can use any cue. However, the target word cannot serve as its own cue."

Subjects studied the to-be-remembered targets one at a time in a random order in black 25 point Arial font on the right side of the computer screen. To the left of each target item, an empty cue box was presented. For each word, subjects typed a single word into the cue box and

pressed return. After generating cues for all of the items, subjects completed an unrelated face

memory task for 10 minutes. Subjects finally completed a cued recall test of the target items.

Subjects were informed that "For some cue-target pairs, you will be given the cue word that

another person generated for that target. We still ask you to try your best to recall the target for

every cue word." The targets and cue types were randomly ordered during the recall test.

Subjects were presented with a cue on the left side of the screen and were asked to type the

corresponding target item in the empty response box on the right side of the screen. As during

the study list, subjects proceeded through the test at their own rate.

Results

Unless otherwise noted, all statistics throughout these experiments are reported at an

alpha level of $\alpha < 0.05$. Cued recall performance results throughout all experiments were based

upon strict scoring, such that only the responses that matched the target identically were counted

as correct. For this and all following studies that involve yoking between subjects, the data from

the first subjects in each room will not be included in the data analysis. These subjects

experienced a different type of testing experience because they received only the cues they

generated themselves and never cues from others. For each experiment, I analyzed

characteristics of the cues between conditions, cued recall performance, and characteristics of

effective cues. The strategies subjects used to generate cues across all experiments are

categorized in Appendix 1.

Cue Characteristics

The cue-to-target associative strength and the distinctiveness of the cues generated

between conditions were analyzed and are presented in Table 1. Learners in the cue generation

condition did not generate cues with significantly higher cue-to-target associative strength than

learners in the description generation condition ($t(42) = 0.63$, $p = 0.53$). The target-to-cue

associative strength, which may reflect a metacognitive illusion but is not anticipated to impact

final cued recall performance (Koriat & Bjork, 2005), for cues across all experiments is

compared to cue-to-target associative strength in Appendix 2. Significant differences in the

distinctiveness of the cues were found between conditions. The cues generated by learners in the

cue generation condition were associated to fewer possible targets than cues generated by

learners in the description generation condition ($t(42) = 2.55$). Similarly, the cumulative cue-to-

target associative strength for all possible targets was smaller for cue generation learners than for

description generation learners ($t(42) = 2.42$). The cues generated in the cue generation

condition were less likely to be in the South Florida database than cues generated in the

description generation condition ($t(42) = 2.55$). Finally, cue uniqueness was calculated by

measuring the proportion of cues that overlapped with other learners. Cue uniqueness was

significantly greater under cue generation instructions ($M = 0.70$) than under description

generation instructions ($M = 0.63$; $t(59) = 5.02$).

Table 1. Characteristics of cues generated under different instructions in Experiment 1. Boxes

highlighted in gray show significant differences between instruction conditions.

	Description	Cue generation
Cue-to-target associative strength	0.051	0.056
Number of targets associated to cue	10.10	8.23
Cumulative associative strength from cue	0.58	0.49
Proportion of cues in the database	0.73	0.61

Table 2 shows the Pearson intercorrelation matrix between the measured cue

characteristics and reveals that all measures are positively correlated. Measures of

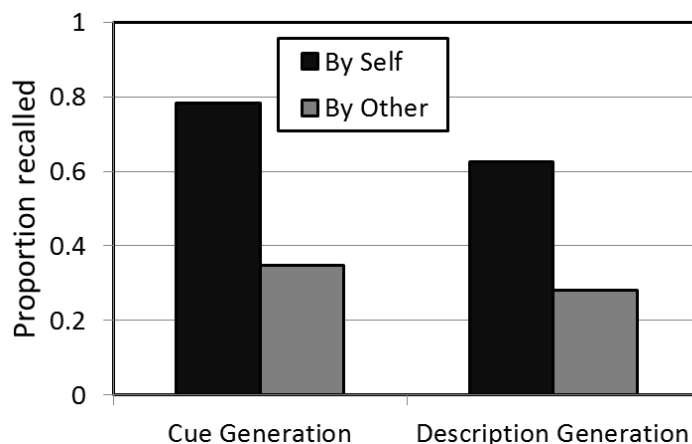distinctiveness are very highly correlated ($r > 0.75$) to each other.

Table 2. Intercorrelation matrix of cue characteristics from Experiment 1.

	Cue-to-Target associative strength	Number associated to cue	Cumulative strength from cue
Number associated to cue	0.12		
Cumulative strength associated from cue	0.31	0.79	
Cue in database	0.28	0.84	0.98

Memory Performance

The instruction manipulation resulted in differences in mnemonic performance, as shown in Figure 1. A 2 (instruction condition: cue generation or description generation) x 2 (cues originator: self or other) mixed model ANOVA on cued recall performance revealed a significant main effect of cue originator. Receiving cues generated by oneself led to greater cued recall than receiving cues generated by others $(F(1,40) = 228.06)$. A significant interaction was found between instruction condition and cues generated by oneself $(F(1,40) = 17.48)$, but no significant interaction was found between instruction conditions for cues generated by others $(F(1,40) = 1.08; p = 0.30)$.

Figure 1. Cued recall performance by cue originator and instruction condition of the cue originator for Experiment 1.

Characteristics of effective cues

The characteristics of cues or descriptions that supported future memory were analyzed and their means are displayed in Table 3. The characteristics of effective cues depended upon the cue originator, so cue characteristics were split by cue originator. The following analyses are correlational in nature and are corrected for multiple comparisons using Bonferroni corrections such that only analyses significant at an alpha level of less than 0.005 are considered significantly different. Cues were considered successful or effective if the cue's associated target was correctly recalled. Successful cues generated by oneself were more highly associated to the target and were more distinctive than unsuccessful cues, as determined by the cue-to-target associative strength listed in the South Florida Free Association Norms. Effective cues generated by oneself had higher cue-to-target associative strength ($t(44)=6.55$), fewer targets associated with them ($t(44)=4.16$), smaller cumulative associative strength to all possible targets ($t(44)=4.49$), and were less likely to be listed in the South Florida database ($t(44)=4.43$) than unsuccessful cues. While both cue-to-target associative strength and distinctiveness were beneficial when cues were generated by oneself, only cue-to-target associative strength impacted the effectiveness of a cue when it was generated by another. Effective cues by others had higher cue-to-target associative strength than ineffective cues ($t(42)=5.26$). Effective and ineffective cues by others did not differ in measures of distinctiveness: the number of targets associated to a cue was similar ($t(42)=1.72$; $p = 0.09$), the total cumulative associated strength was similar ($t(42)=0.41$; $p = 0.68$), and the likelihood of being in the South Florida database was similar ($t(42)=0.06$; $p = 0.95$).

Table 3. Characteristics of cues that led to successful and unsuccessful retrieval split by cue originator. Significant differences between effective and ineffective cues are highlighted in grey.

	Cue by oneself		Cue by other	
	Correct	Incorrect	Correct	Incorrect
Cue-to-target associative strength	0.06	0.03	0.11	0.04
Number of targets associated to cue	8.44	10.51	8.71	9.33
Cumulative associative strength from cue	0.51	0.62	0.56	0.54
Proportion of cues in the database	0.63	0.75	0.69	0.67

The characteristics of effective cues were also analyzed using a hierarchical linear model, as shown in Appendix 3. A hierarchical linear model provides some advantages over the traditional method outlined above. First, hierarchical linear models simultaneously analyze the contributions of the different explanatory variables. The HLM can show which cue characteristics meaningfully contribute to predictions about recall performance and which cue characteristics overlap with others and do not improve the predictive ability of the model. This procedure lessens concerns about multiple comparisons that are espoused above. Second, the HLM can easily analyze the interactions between cue originator and the effectiveness of each cue without computing multiple ANOVAs. Finally, the HLM gives more power to the analysis because it considers each target item a unit of analysis, rather than each subject. The main conclusions of the HLM analysis replicate those found in the traditional analysis: cue generation instructions influence recall, self-generated cues show a higher likelihood of recall than other-generated cues, greater cue-to-target associative strength enhances likelihood of recall regardless of cue originator, and the influence of cue distinctiveness depends upon cue originator.

Discussion

Instructions impacted how well learners generated cues and consequently how well they remembered the targets. Learners generated more distinctive cues under cue generation

instructions than under description generation instructions. Under cue generation instructions, cues were associated to fewer possible target items, had smaller cumulative cue-to-target associative strength, were less likely to be found in the South Florida database, and had less overlap among learners. Learners, thus, make deliberate and purposeful choices when generating cues to support their later memory performance. Learners selected cues to support memory that were more idiosyncratic than learners who generated descriptions of items, as shown by a measure of cue uniqueness. Interestingly, the cue-to-target associative strength did not significantly differ between instruction conditions. Learners may value cue distinctiveness more than cue-to-target associative strength when generating cues to support future memory.

Instructions not only changed the types of cues learners generated, but also led to large performance differences. Cues generated under cue generation instructions supported higher levels of cued recall than cues generated under the description generation instructions. Whether cue generation instructions alter both the quality of the cues and the underlying memory strengths of the target items remains unknown. Future research could eliminate the impact of cue quality on memory performance and determine if instructions alter target memory strength by using a free recall memory test. Prior research suggests that generating descriptions of target items does not impact later free recall performance compared to studying a list without generating descriptions (Mantyla & Nilsson, 1983); however, the influence of generating mnemonic cues on free recall performance has not been measured.

Learners' self-generated cues support retrieval more than others' cues. This result reveals the importance of match between encoding cues and retrieval cues. Learners generated a variety of different cues during encoding according to their own idiosyncratic interpretation of the target. Learners' idiosyncratic knowledge prevents their cues from being as beneficial when

presented to others. Other learners have not encoded the targets in a similar context and, therefore, do not benefit as much when receiving other's cues during retrieval.

Learners generated more distinctive cues when trying to support future memory performance, but did not alter the cues' cue-to-target associative strength. Distinctiveness was important for supporting future memory performance for cues created by oneself, while distinctiveness did not matter for the effectiveness of cues generated by others. Distinctive cues generated by others may rely upon idiosyncratic knowledge, which is not available to a different learner, and therefore does not impact memory. Cue-to-target associative strength determined whether cues generated by others effectively supported recall.

The characteristics of effective cues may be compromised in this experiment because cues that were fed to different learners were generated under two different types of instructions: description and cue generation conditions. When feeding these two types of cues to other learners, the cues may have different effects on others' cued recall performance. Characteristics of *descriptions* that support memory performance may be different than characteristics of *cues* that support memory performance. Consequently, cue generation instructions were used exclusively in Experiment 2 so that more power could be used to more cleanly analyze the characteristics of successful and non-successful cues.

Experiment 2

In Experiment 2, the cue generation condition from Experiment 1 was replicated with a new set of items in order to more powerfully analyze the qualities of successful and unsuccessful memory cues. Further, the impact that cue distinctiveness and cue-to-target associative strength had on later memory performance was more cleanly assessed without differing instruction conditions.

<u>Participants</u>

Forty-two introductory psychology students at the University of Illinois at Urbana-Champaign were run across 6 different computers. The data from each of the first subject on each of the computers was not analyzed because they received only their own generated cues during the test, which left 36 subjects worth of data.

<u>Materials</u>

A new set of forty nouns and verbs was collected from the University of South Florida Free Association Norms (Nelson et al., 1998). The Thorndike-Lorge written frequencies ranged from 2 to 392, with a mean of 113 and a standard deviation of 101.

<u>Method</u>

The procedure of Experiment 2 was identical to Experiment 1, except that all subjects received cue generation instructions.
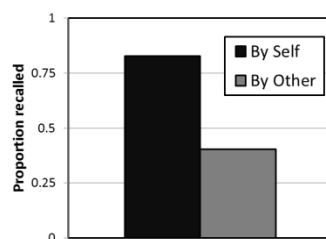
<u>Results</u>

Instructions were consistent across all subjects, so cue characteristics cannot be analyzed with respect to different conditions. Instead, memory performance will be analyzed first.

Memory Performance

As shown in Figure 2, subjects recalled significantly more items when they received their own cues than another subject's cues (t(35) = 14.42).

Figure 2. The proportion of targets correctly recalled in response to cues generated by self and by others in Experiment 2.

Cue Characteristics

Cues generated by subjects were moderately associated to the target (M = 0.03); however, the cues had greater target-to-cue associative strength (M = 0.07; t(35) = 13.15) than cue-to-target associative strength (as shown in Appendix 2). The Pearson intercorrelations between all measured cue characteristics are displayed in Table 4. The measures of distinctiveness are all strongly positively correlated (all r > 0.75). The cue-to-target associative strength is positively related to the measures of distinctiveness, but much less so.

Table 4. Intercorrelation matrix of cue characteristics from Experiment 2.

	Cue-to-Target associative strength	Number associated to cue	Cumulative strength from cue
Number associated to cue	0.05		
Cumulative strength associated from cue	0.22	0.79	
Cue in database	0.19	0.85	0.97

Characteristics of effective cues

The cue-to-target associative strength and distinctiveness of effective cues were compared to those of ineffective cues, and all results replicated those found in Experiment 1. The mean values displayed by cue originator are shown in Table 5. Cues generated by oneself benefited from higher cue-to-target associative strength and distinctiveness; cues generated by others benefited only from higher cue-to-target associative strength. Effective cues generated by oneself had higher cue-to-target associative strength (t(29)=5.42)[1], were associated to fewer targets (t(29)=2.52), had a smaller cumulative associative strength to all targets (t(29)=2.89), and were less likely to be in the South Florida database (t(29)=3.52) than ineffective cues. Effective

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[1] Six subjects recalled all of the targets associated with their own cues. Therefore, they contribute no data to the ineffective cue conditions and the degrees of freedom for these analyses are reduced.

cues generated by others had higher cue-to-target associative strengths (t(35)=6.53) than ineffective cues. No measure of distinctiveness differed between effective and ineffective cues: the number of targets associated to a cue (t(35)=1.18; p = 0.24), the cumulative associative strength from a cue to all targets (t(35)=0.85; p=0.40), and the likelihood of being in the South Florida database (t(35)=0.12; p =0.90) did not differ between effective and ineffective cues.

For an analysis of the cue characteristics that support recall using a hierarchical linear model, see Appendix 4. Once again, the central results of the HLM analysis replicate those found in the traditional analysis: cues by self were more beneficial than cues by others, cues with greater cue-to-target associative strength were more beneficial, and cue distinctiveness interacted with cue originator.

Table 5. Characteristics of cues that led to successful and unsuccessful retrieval, split by cue originator in Experiment 2. Significant differences between successful and unsuccessful cues are highlighted by gray backgrounds.
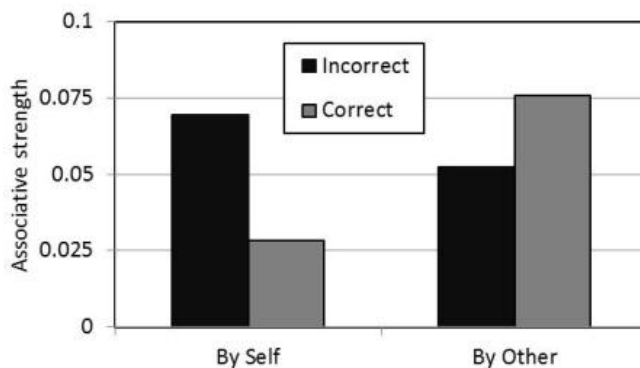
	Cue by oneself		Cue by other	
	Correct	Incorrect	Correct	Incorrect
Cue-to-target associative strength	0.026	0.005	0.076	0.009
Number associated to cue	9.68	11.53	10.06	10.75
Cumulative associative strength from cue	0.56	0.69	0.63	0.61
Cue in the database	0.69	0.86	0.76	0.75

Characteristics of incorrect responses

The characteristics of incorrect responses were examined because they may be informative about the types of cues that effectively support memory. As shown in Figure 3, the associative strength between the cue and the subjects' responses interacted with cue originator and their responses' correctness. A 2 (cue originator: oneself or other) x 2 (correctness) within-subjects ANOVA on the associative strength between test cue and response revealed a

significant interaction (F(1,29) = 12.16), but no main effects of either cue originator

(F(1,29)=2.47; p = 0.13) or correctness (F(1,29)=0.87; p = 0.36) . Post hoc paired t-tests

revealed that the associative strength between cues generated by oneself and incorrect responses

were higher (M $_{incorrect}$ = 0.07) than correct responses (M $_{correct}$ = 0.03; t(29) = 2.76). For

example, a learner that generated the cue "feet" for the target "shoes" (which has a cue-to-target

associative strength of 0.11) might mistakenly recall a word more strongly associated to "feet"

than "shoes" (e.g., "toes" which is strongly associated to "feet" – it has a cue-to-response

associative strength of 0.47). The associative strength between responses and cues generated by

others showed the opposite pattern (M $_{incorrect}$ = 0.05; M $_{correct}$ = 0.08; t(35) = 1.98, p = 0.06).

Figure 3. The mean associative strength between test cue and response as a function of

correctness of response and cue generation condition in Experiment 2.

Discussion

Learners' mnemonic performance, once again, benefited greatly when learners received

their own cues at the time of the test. This suggests the importance of match between encoding

and retrieval contexts and implies that learners' idiosyncratic encoding prevents their cues from

being as beneficial for others.

Further, cue-to-target associative strength and cue distinctiveness significantly moderated the effectiveness of a cue. Cues generated by oneself benefited from both increased cue-to-target associative strength and cue distinctiveness; cues generated by others only benefited from increased cue-to-target associative strength. In Experiment 1, subjects increased the distinctiveness of cues when knowingly generating cues for use in future cued recall, and did so without significantly affecting the cue-to-target associative strength. Cued recall performance might be enhanced if learners were to increase the cue-to-target associative strength than if they were to modify the distinctiveness of cues. In the next two sets of experiments, circumstances prompted learners to modulate the cue-to-target associative strength in addition cue distinctiveness.

Finally, when learners recall the wrong target, their incorrect response is driven by the associative strength between the cue and their response. Cues for incorrect responses were more strongly associated to the learner's response than to the target. When explicit episodic memory for the cue-target pair fails, learners rely upon semantic memory to produce possible target items (in other words, learners generate guesses based upon the cue's associates). This interpretation suggests that cue-to-target associative strength may be very important to support retrieval at long delays when episodic memory has failed and learners need to generate guesses as targets. This idea will be tested more thoroughly in Experiment 4. Further, learners generate different responses when generating cues and when generating descriptions. Learners grasp the importance of distinctiveness when generating cues for future memory performance.

The first two experiments revealed that cues generated by oneself were more beneficial for oneself than for others because learners encoded targets idiosyncratically and generated cues that aligned with that encoding. In the second set of experiments, the ability of learners to

overcome their idiosyncratic encoding of targets in order to generate effective cues for others is examined. When learners are instructed to generate distinctive descriptions of target items, they can avoid temporally unstable interpretations of target items and produce greater consistency between cues generated across a three week delay (Mäntylä & Nilsson, 1988). Learners can step outside of their current cognitive context to produce more temporally stable cues; whether they step outside of their current cognitive context to produce cues helpful for others was tested in the next set of experiments.

PART II: CUES FOR OTHERS

The ability of learners to overcome their idiosyncratic cognitive state in order to take the perspective of others is important for supporting others' cognition. Teachers need to consider what cues will best help their students remember lessons, spouses may need to generate shopping lists that enable their partners to buy specific needed items, and bosses may need to create to-do lists that best elicit desired actions by employees. As shown in Experiments 1 and 2, learners' self-generated mnemonic cues are based upon their own idiosyncratic encoding and personal experiences. Consequently, giving a learner's self-generated cues to a different learner dramatically reduces mnemonic performance. Whether and how learners can overcome idiosyncratic mental states and consider another's knowledge in order to support others' mnemonic performance is unexplored in the memory literature.

Deriving a sense of others' knowledge may rely upon the same fundamental processes required to derive one's sense of self-knowledge (Jost, Kruglanski, & Nelson, 1998), but the available and relevant information used to derive others' knowledge likely differs from that used to determine one's self-knowledge. Learners deduce what others know using three main types of information: projections of personal experiences onto others, generalized statistical knowledge about what people know, and personal interactions with and knowledge about the target individual (Jost et al., 1998). First, learners may determine the beliefs and knowledge of others by extrapolating from their personal experiences and belief structures. Extrapolating from one's personal experiences may result in egocentric biases concerning what others know; such egocentric biases in predicting others' knowledge are found across a variety of situations. For example, people use their own decisions to infer how the majority of other people will act in variety of situations (Ross, Greene, & House, 1977). Learners also predict what others know by

querying their own knowledge. If a learner knows the answer to a general knowledge question, he will estimate that a higher percentage of others will know the answer than if he does not know the answer (Nickerson, Baddeley, & Freeman, 1987). Learners struggle to ignore their own knowledge when anticipating the knowledge of others, a general finding that has been labeled the "curse of knowledge" (Birch, 2005). Both children's and adults' abilities to reason about others' knowledge and behaviors is compromised by their personal knowledge (Birch & Bloom, 2003). Learners cannot, for example, disregard their private knowledge during business negotiations even when in their best interest to do so (Camerer, Loewenstein, & Weber, 1989). Similarly, when told not to reveal some key information, learners actually increased mentions of the secret information compared to when not told to keep the information hidden (Wardlow, Lane, & Ferriera, 2008). If learners cannot distinguish or disregard their private knowledge, learners may not be able to effectively tailor mnemonic cues for others. Learners may create cues for others solely by projecting from their own knowledge, and these cues may be ineffective at supporting others' memory performance.

Second, learners sometimes use statistical information to predict others' cognition. For instance, one might use statistical base rates to predict that an individual woman possesses favorable attitudes towards Obama because most women have a favorable attitude towards Obama (Borgida & Brekke, 1981). Statistical information may be an important and potentially accurate source of knowledge about others' cognitions.

Third, learners use individuating and personal information about the target individual to make judgments about the target's knowledge and behaviors whenever possible (Kahneman & Tversky, 1973). For example, speakers adjust their communication about New York City landmarks based upon whether they believe the addressee is a New York City expert or novice

(Issacs & Clark, 1987). Although there is considerable research on the use of personal

information to predict others' cognitive states (see: Jones, 1990; Heider, 1958; Malle, 1996),

learners throughout our studies had no access to personal information of target individuals and

the use of personal information will be considered no further. Learners must weigh these

different sources of information when predicting the cognitive context of others. If learners can

utilize accurate statistical information about others more than idiosyncratic knowledge, they may

be able to generate cues that are effective at supporting others' memories.

How and when learners use egocentric knowledge, statistical base rates, and personal

experiences with others during interpersonal communication is described by two competing

models: anchoring-and-adjustment and constraint-based models. In the anchoring-and-

adjustment model, learners go through two distinct phases when producing messages: the first

stage is automatic and egocentric (the anchoring) while the second stage involves effortful

monitoring (the adjustment; Horton & Keysar, 1996; Keysar, Barr, Balin & Paek, 1998; Keysar,

Lin & Barr, 2003). Learners initially automatically consider all the information that is available

to them. Then, through controlled, resource-consuming processes, monitor their message to

make sure the addressee will understand it. This view is largely motivated by the idea that

considering the perspective of others consumes too many mental resources to engage in

constantly. Some evidence supports this view, including evidence that speakers are worse at

perspective-taking in speeded interactions (which leave less time for adjustment: Epley, Keysar,

van Bovan, & Gilovich, 2004) and that happy people are worse at perspective taking (because

they are less likely to monitor their messages; Converse, Lin, Keysar, & Epley, 2008). Further,

learners more successfully consider others' perspective when given a monetary incentive, which

suggests that the monitoring process is somewhat under the control of the learner (Epley et al., 2004).

Alternatively, in the constraint-based view of perspective taking, common ground and others' perspectives are just two of the many linguistic and non-linguistic constraints that constantly impinge on message formation (Hanna, Tanenhaus & Trueswell, 2003; Tanenhaus & Trueswell, 1995). These constraints all have an immediate, but partial, impact on the formed message. Evidence that speakers, even young children, rapidly use common ground information in message formulation supports the constraint-based account (Nadig & Sedivy, 2002). The impact a constraint has on the message is determined by its particular salience and the number of competing constraints. For example, when speakers are asked not to mention a "secret," they are more likely to mention it because the request for secrecy may increase its salience (Wardlow Lane & Ferreira, 2008). Further, consistent with this view, speakers with larger working memories are better able to take perspective of the addressee because they are able to simultaneously consider more constraints (Lin, Keysar, & Epley, 2010).

How effectively learners take the perspective of people with whom they are communicating is still debated. Speakers and listeners both occasionally fail to step outside their perspective and neglect to distinguish between private and shared knowledge (Horton & Keysar, 1996; Keysar, Barr, & Horton, 1998). Listeners consider objects as potential references even when the speaker has no knowledge of the objects (Keysar, Barr, Balin, & Brauner, 2000; Keysar, Lin, & Barr, 2003). Even when listeners use common ground and perspective to help resolve referents, listeners cannot ignore similar, competing information in privileged ground (Hanna, Tanenhaus, & Trueswell, 2003). Speakers also frequently miscalculate how much knowledge a listener has and both under- and over-estimate the common ground in a

conversation (Horton & Gerrig, 2005). Most speakers overestimate whether a listener understands their ambiguous speech (Keysar, 1994; Keysar & Henly, 2002). Some researchers argue that perspective taking in speech production emerges only because of the parallelism between the production and comprehension systems (such as a shared lexicon and the procedures for accessing it) rather than any attempt to consider the perspective of the addressee (Brown & Dell, 1987). Research across a variety of domains suggests that learners sometimes fail to successfully tailor their messages to other learners.

However, other evidence in communication strongly suggests that learners differentiate between common and privileged knowledge. Both listeners and speakers keep track of what knowledge is private and what is shared in order to communicate successfully. Lockridge and Brennen (2002) showed that speakers largely formulate messages that are easiest for themselves to understand (as suggested by Brown & Dell, 1987), but also make non-egocentric adjustments to the particular needs of their partners.   The more time and experience a speaker has interacting with the addressee, the better the speaker becomes at making the non-egocentric adjustments for their partners (Brown-Schmidt, 2009; Brown-Schmidt, 2012; Brown-Schmidt & Shigeta, 2012). Listeners also consider the identity of the speaker and their experiences with the speaker when predicting and interpreting utterances. For example, listeners expect speakers' expressions to refer to common knowledge more than privileged knowledge, even though listeners do not completely disregard privileged knowledge when doing so (Heller, Grodner, & Tanenhaus, 2008). Listeners use information about jointly developed entrained expressions to interpret a specific speaker's utterances (Brown-Schmidt, 2009; Metzing & Brennan, 2003), and these entrained expressions develop as the communicators share more experiences with each other. Further, when asked questions, listeners quickly attend to private knowledge—knowledge that

the questioner does not have and about which they are likely to inquire—more than common

knowledge (Brown-Schmidt, Gunlogson, & Tanenhaus, 2008).

In addition to differentiating between private and common ground when formulating

messages, speakers design their utterances based upon their intended audience (Clark & Murphy,

1982; Fussell & Krauss, 1989; Krauss, 1987). Speakers creating different messages for different

people based upon what they believe people know. For example, when giving driving directions

to strangers who have unfamiliar accents, learners give more detailed directions than when

giving directions to strangers who share their accent (Kingsbury, 1968). This suggests that

direction-givers use the stranger's accent as an indicator of what the stranger knows and how

many details the stranger will need. Further, when learners generate descriptions of ambiguous

stimuli for themselves and for others, the intended recipient alters the type of description utilized.

Learners asked to label an array of colors use lower frequency words when creating labels for

themselves than for others (Kraus, Vivekananthan, & Weinheimer, 1968). Similarly, when

generating descriptions of abstract line drawings, descriptions qualitatively differ depending on

the intended recipient (Danks, 1970). Descriptions for oneself include more metaphors and

figurative language, while those for others include descriptions of basic geometry and shapes.

Learners understand that they may interpret and encode abstract stimuli idiosyncratically and

therefore, create differing types of descriptions for self and others.

Learners accurately distinguish what types of descriptions are beneficial for oneself and

what types of descriptions are beneficial for others. In the color task described above, when

given to others, the descriptions intended for others produce greater matching performance than

descriptions intended for self. The applicability of these results to memory circumstances may

be somewhat limited, however; learners who receive others' descriptions need not rely upon

memory to successfully match descriptions to the ambiguous stimuli. Further, the types of cues used when generating a description of a stimulus differ from the types of cue generated to help remember a stimulus, as shown in Experiment 1. Whether perspective taking happens in memory cuing remains unknown. Further, how the distinctiveness and cue-to-target associative strength of memory cues differ when generated for oneself and for others remains unexplored.

In the next set of experiments, learners created cues for oneself and for others. If learners can overcome their idiosyncratic knowledge to take the perspective of others, the characteristics of the generated cues and final cued recall performance may depend upon the intended recipient. Cues intended for oneself may be based largely upon idiosyncratic encoding and prior experiences, while cues intended for others may be based upon more common knowledge. Relying upon idiosyncratic encoding of the target may be more beneficial to support one's own memory than relying upon cues based upon more shared knowledge. In Experiment 3, learners' abilities to effectively tailor cues for others were analyzed. In Experiment 4, the retention interval was varied to determine if the effectiveness of cues generated for others fluctuates less in time than cues generated for oneself. Finally, in Experiment 5, the mnemonic benefits inherent in generating cues for self were compared to those inherent in generating cues for others.

Experiment 3

In Experiment 3, how effectively learners can tailor cues for oneself and for other learners was examined. Learners generated two cues for each target word: one for themselves and one for another learner. During the memory test, learners received one of four different types of cues for each item: cues generated by oneself and for oneself, cues generated by oneself for others, cues generated by others for oneself, and cues generated by others for others.

Participants

Twenty-four introductory psychology students at the University of Illinois at Urbana-Champaign participated for partial course credit.

Materials

Sixty new words were collected from the University of South Florida Free Association Norms (Nelson et al., 1998). To-be-remembered words were selected that were thought to be relevant to a college student's life, so that subjects could potentially have personal idiosyncratic experiences with each item. Targets included words like "mom," "roommate," "major," and "dog." While some targets overlapped with words used in Experiment 1, most did not.

Method

This experiment was 2 (cue originator: oneself or other) x 2 (intended recipient: oneself or other) crossed, within-subjects design. The cue provided to the learners during the test was generated **by** oneself or another and the cue was generated **for** oneself or another.

Two individual computer rooms were used to run subjects. Instructions about the memory task indicated that subjects would study a list of words and later be asked to recall those words. Subjects were instructed to generate two cue words for each target: one that would help them later retrieve the target and one that would help a "learner very different from you" retrieve the target. For each target item, the target was displayed twice on the right side of the screen and was preceded each time by an empty response box, as shown in Figure 4.

Figure 4. Cue generation screen used in Experiments 3 and 4.

Above the first response box and target, the description "for you" was displayed, while above the second response box and target, the description "for someone else" was displayed. Subjects were required to type a cue for themselves before they could type a cue for someone else. Subjects were instructed that they could use the same cue word for themselves and others, but were instructed to do this only if the cue was beneficial for themselves and others. The computer program did not prevent the same cue from being entered twice.

After creating the cues for all of the items, subjects took the cued recall test. Subjects were informed that sometimes they would receive cues they generated and sometimes they would receive cues that another learner generated. During the test, the cue originator for each cue was not indicated. As during the study list, subjects proceeded through the test at their own rate. Subjects were presented with a single cue on the left side of the screen and were asked to type the corresponding target item into the empty response box on the right side of the screen. The first subject on each computer received all of the cues that they generated, but half of the cues they received were generated for oneself and half were generated for others. All subsequent subjects were yoked to the immediately preceding subject. Cues were randomly divided between the four conditions, such that a fourth of the presented cues were generated by oneself for oneself, a fourth were generated by oneself for others, a fourth were generated by others for oneself, and a fourth were generated by others for others. The targets and cue type were randomly ordered throughout the recall test.

Results

As in the prior studies, only the subjects who received cues from themselves and other learners are included in the following analyses. Therefore, 22 subjects contributed useable data (the first subjects in each of the two rooms were excluded).

Cue Characteristics

The characteristics of the cues generated for oneself differed from those generated for others and are displayed in Table 6. Subjects generated identical cues for self and for others on 48% of the trials. For the remaining 52% of the items, learners generated different cues for oneself and for others. The uniqueness of the cues was measured by counting the number of cues per subject that did not overlap with another subject's cues. Cues were more unique when generated for oneself than for others $(t(59)=6.48)$. For 68% of the targets, a greater variety of cues was generated for oneself than for others; only 17% of the targets elicited a greater variety of cues generated for others than for self.

The cue distinctiveness and cue-to-target associative strength for cues generated for oneself and for others was also analyzed using the University of South Florida Free Association Norms (Nelson et al., 1998). Cues generated for others were more strongly associated to the targets than cues generated for oneself $(t(24) = 4.08)$. Cues generated for oneself were more distinctive than cues generated for others. A smaller proportion of the cues generated for oneself was listed in the University of South Florida Free Association Norms than cues generated for others $(t(24) = 3.61)$. Cues generated for oneself were associated to fewer target items than cues generated for others $(t(24) = 3.11)$. Similarly, cues generated for oneself showed smaller cumulative associated strength to all items in the database than cues generated for others $(t(24) = 3.64)$.
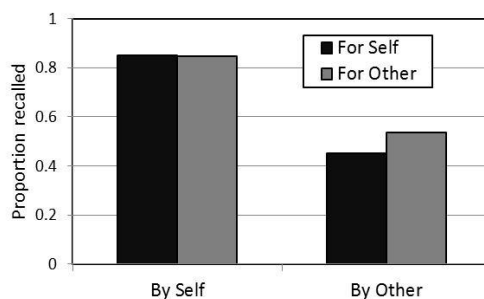
Table 6. Characteristics of cues generated for oneself and others across Experiments 3, 4, & 5.

		Exp. 3	Exp. 4	Exp. 5
Proportion of targets that were unique	For others	0.58	0.48	0.62
	For oneself	0.68	0.62	0.72
Cue-to-target associative strength	For others	0.06	0.06	0.08
	For oneself	0.03	0.05	0.06
Proportion of cues in the South Florida Database	For others	0.65	0.62	0.67
	For oneself	0.54	0.51	0.55
Number of targets in database associated to cues	For others	8.67	8.47	8.98
	For oneself	7.36	6.64	7.54
Cumulative cue-to-target associative strength for all possible targets	For others	0.51	0.49	0.54
	For oneself	0.43	0.40	0.44

Memory Performance

Cued recall performance is displayed in Figure 5. A 2 (cue originator: oneself or other) x 2 (intended recipient: oneself or other) repeated measures ANOVA on cued recall performance revealed a significant interaction between the cue originator and the intended recipient $(F(1,21)=4.44)$. Follow up paired t-tests show that the intended recipient variable influenced performance when given to others $(t(21) = 2.01, p = 0.06)$ but not when given to self $(t(21) = 0.14, p = 0.87)$. Further, the ANOVA revealed a significant main effect of the cue originator variable, such that self-generated cues resulted in greater recall than other-generated cues $(F(1,21)=177.89)$.

Figure 5. Cued recall performance as a function of who generated and who received the cue in Experiment 3.

Characteristics of effective cues

Replicating the prior two studies, the effectiveness of a cue depended upon the cue-to-target associative strength and distinctiveness of cues. The mean values displayed by cue originator are shown in Table 7. Higher cue-to-target associative strength and greater distinctiveness were characteristics of effective cues generated by oneself. Cues generated by others benefited from higher cue-to-target associative strength and lower distinctiveness. Effective cues generated by oneself had higher cue-to-target associative strength ($t(19)=2.27$), were associated to fewer targets ($t(19)=1.85$, $p = 0.08$), had a smaller cumulative associative strength to all targets ($t(19)=1.42$; $p = 0.17$), and were less likely to be in the South Florida database ($t(19)=1.67$; $p = 0.11$) than ineffective cues. Effective cues generated by others had higher cue-to-target associative strengths ($t(21)=6.86$) than ineffective cues. Effective cues generated by others were less distinctive than ineffective cues. While the number of targets associated to effective and ineffective cues did not differ ($t(21)=0.29$; $p = 0.77$), the cumulative associative strength from a cue to all targets ($t(21)=2.31$), and the likelihood of being in the South Florida database ($t(21)=2.10$) were higher for effective cues generated by others.

Table 7. Characteristics of cues that led to successful and unsuccessful retrieval, split by cue originator in Experiment 3. Gray boxes indicate significant differences between effective and ineffective cues. Numbers in parentheses indicate standard deviations of the mean.

	Cue by oneself		Cue by other	
	Correct	Incorrect	Correct	Incorrect
Cue-to-target associative strength	0.05 (.02)	0.02 (.05)	0.08 (.04)	0.02 (.02)
Number associated to cue	7.45 (2.38)	9.49 (4.20)	8.15 (2.56)	7.98 (2.81)
Cumulative associative strength from cue	0.44 (.13)	0.52 (.21)	0.50 (.14)	0.43 (.15)
Cue in the database	0.55 (.16)	0.67 (.26)	0.63 (.17)	0.54 (.19)

Discussion

When generating cues, learners effectively tailored their cues for an intended recipient. Cues generated for oneself were more idiosyncratic and variable than cues generated for others, as shown by the greater uniqueness of cues generated for oneself and by the smaller number of cues located in the South Florida database. Similarly, cues for oneself were more distinctive than cues generated for others. Cues for oneself were associated to fewer items in the database and had smaller cumulative forward associative strength to all possible items. However, the cue-to-target associative strength was greater when the cue was generated for someone else. Learners reduced distinctiveness of the cues and increased the cue-to-target associative strength when generating cues for others.

When cues are given to others, the intended recipient of that cue is important. Cues generated for others led to better cued recall performance for others than cues generated for oneself. Learners took the perspective of others to generate cues that effectively improved others' memory performance. Because cues generated for oneself were idiosyncratic and more variable, they were less beneficial for others' retrieval than were cues generated for others. Cues intended for oneself relied upon idiosyncratic encoding and personal knowledge, while cues intended for others relied more upon shared knowledge. Cues intended for others did not decrease the match between encoding and retrieval contexts for the cue originator, but increased the match between encoding and retrieval for other learners.

Relying upon idiosyncratic knowledge to generate cues for oneself did not increase learners' mnemonic performance. Whether learners received self-generated cues intended for oneself or for others did not impact how many targets were recalled. The reduced distinctiveness and increased cue to target strength for cues generated for others may have produced an

equivalently effective cue as those more distinctive cues generated for oneself. The absence of an effect on intended recipient when a learner receives his own cues is analogous to the prior literature on description formation (Fussell & Krauss, 1989).

Experiment 4

When given back to oneself, cues generated for oneself (the more idiosyncratic cues) were not more beneficial than those generated for others in Experiment 3. At longer delays, cues generated for oneself may actually be less beneficial for oneself than cues generated for others because the cues for oneself may rely more upon unstable, temporally changing, personal cognitive contexts. As these contexts change with increasing retention intervals, cues for oneself may quickly become less beneficial. Cues generated for others, however, may rely less upon idiosyncratic encodings and more upon stable, shared semantic knowledge. As contexts change, then, cues generated for others may still support memory performance. Additionally, learners who fail to recall the correct target may rely upon a pair's associative strength to try to guess the target, which implies that cue-to-target associative strength will be very important at longer retention intervals (when recall fails more often). Evidence supports this claim, as errors of commission have higher cue-to-response associative strength than cue-to-target associative strength (as shown in Figure 2). This idea is explored in Experiment 4 by introducing a 2-day retention interval between cue generation and memory test. Subjects were tested on half of the items immediately and on the other half after a two day delay. By varying the retention interval in this experiment, the long-term effects of cues for self and others will be compared.

Participants

Forty-four introductory psychology students at the University of Illinois at Urbana-Champaign participated for partial course credit across six different computer rooms. Once

again, only the subjects who received cues generated by themselves and others will be included in the analyses to follow, which includes data from 38 subjects.

Materials

Four new words, collected from the University of South Florida Free Association Norms (Nelson, et al., 1998), were added to the Experiment 2 list, for a total of 64 to-be-remembered words. These words were added to allow for equal numbers of items across eight different experimental conditions.

Method

This experiment utilized a 2 (cue originator: oneself or other) x 2 (intended recipient: oneself or other) x 2 (retention interval: no delay or 2 day delay) fully crossed, within-subjects design. The procedure was identical to that of Experiment 3, with the addition of the retention interval variable. Half of the items in each condition were tested immediately and half were tested after a 2 day retention interval. Subjects were not informed about the retention interval at the beginning of the experiment, but were told at the end of the first day that they would continue the experiment when they returned to the lab two days later.
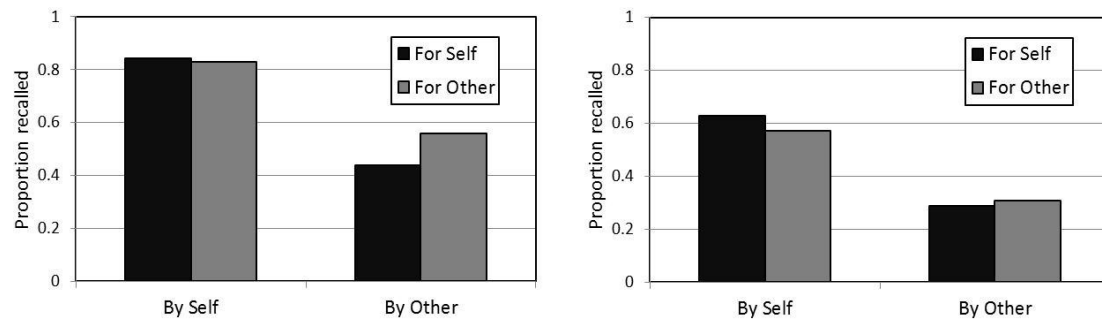
Results

Cue Characteristics

All the differences between the cues generated for others and for oneself found in Experiment 3 replicated in this experiment and are displayed in Table 6. Learners generated the same cues for oneself and for others for 50% of the targets, which is similar to the 48% overlap found in the prior study. Cues generated for others were less variable, had greater cue-to-target associative strength, and were less distinctive than cues generated for oneself. Cues intended for oneself were, once again, more unique than cues generated for others, as there were a greater

proportion of cues for oneself that were not repeated across subjects compared to cues for others

(t(63)=9.81). For 89% of the targets, a greater variety of cues was generated for oneself than for

others; only 6% of the targets showed greater variety of cues generated for others than for self.

Cues generated for others were more strongly associated to the targets than cues generated for

oneself (t(37) = 6.21). Measures of distinctiveness showed the same pattern as prior studies:

cues for others were less distinct than cues for oneself. A greater proportion of the cues

generated for others were listed in the University of South Florida Free Association Norms

(Nelson et al., 1998) than cues generated for oneself (t(37) = 5.51), were associated to fewer

target items than cues generated for others (t(37) = 5.57), and had smaller cumulative strength

from the cue to all possible targets (t(37) = 5.58).

Memory Performance

Cued recall performance is displayed in Figure 6, and the results at the short retention

interval closely replicate those from Experiment 3. A 2 (cue originator: oneself or other) x 2

(intended recipient: oneself or other) x 2 (retention interval: no delay or 2 day delay) repeated

measures ANOVA on recall performance revealed significant main effects of cue originator and

retention interval. Cues generated by oneself resulted in higher performance than cues generated

by others (F(1,37) = 160.70). Further, performance declined as retention interval increased

(F(1,37) = 119.27). Cue originator interacted with intended recipient (F(1,37) = 10.11), such that

the intended recipient only mattered when the cue originator was a different learner. No

evidence was found that retention interval interacted with the cue originator (F(1,37) = 0.21; p =

0.65), intended recipient (F(1,37) = 2.27; p = 0.14), or both originator and recipient (F(1,37) =

0.97; p = 0.33).

Figure 6. Cued recall performance for immediate retention (left graph) and at a 2 day delay (right graph), as a function of cue originator and intended recipient in Experiment 4.

Characteristics of effective cues

A 2 (retention interval) x 2 (cue originator) x 2 (correct or incorrect) repeated measures ANOVA was performed on cue-to-target associative strength, the number associated from the cue, the total cumulative associative strength from the cue, and the percent of cues in the database. No main effect or interactions with retention interval were found, so the cue characteristics were averaged across retention interval. The mean values of effective and ineffective cues divided by cue originator are displayed in Table 8. First, effective cues generated both by oneself ($t(37) = 4.90$) and others ($t(37) = 5.30$) had higher cue-to-target associative strength than ineffective cues. Second, greater distinctiveness was effective for cues generated by oneself, but had no effect on cues generated by others. Effective cues generated by oneself had a smaller number of targets associated from the cues ($t(37) = 4.29$), a smaller cumulative cue-to-target associative strength ($t(37) = 3.34$), and were less likely to be in the South Florida Free Association Norms ($t(37) = 3.44$) than ineffective cues. Effective cues generated by others were not more distinctive than ineffective cues: effective and ineffective cues had a similar number of targets associated from the cue ($t(37) = 1.09$; $p = 0.28$), similar cumulative cue-to-target associative strength ($t(37) = 1.26$; $p = 0.22$), and were equally likely to be in the database ($t(37) = 0.94$; $p = 0.36$).
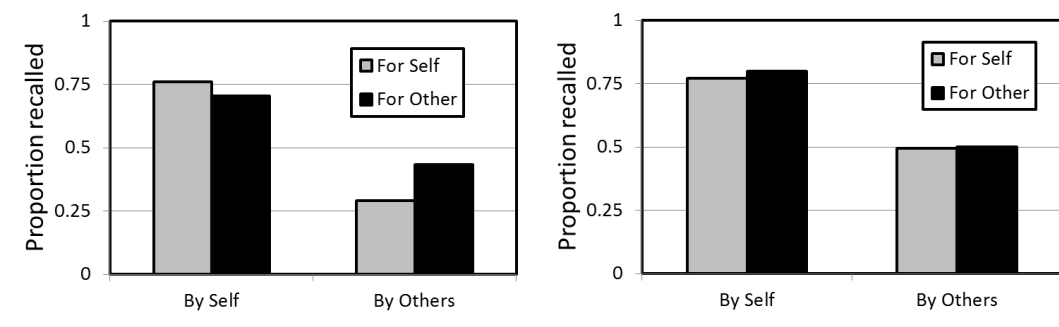
Table 8. Characteristics of cues that led to successful and unsuccessful retrieval, split by cue originator from Experiment 4. Gray boxes indicate significant differences between successful and unsuccessful cues. Numbers in the parentheses indicate standard deviations of the means.

	Cue by self		Cue by other	
	Correct	Incorrect	Correct	Incorrect
Cue-to-target associative strength	0.07 (.04)	0.03 (.03)	0.10 (.08)	0.03 (.03)
Number associated to cue	7.05 (2.52)	9.53 (3.53)	7.00 (3.05)	7.55 (3.2)
Cumulative associative strength from cue	0.43 (.14)	0.54 (.18)	0.47 (.20)	0.43 (.17)
Cue in the database	0.54 (.18)	0.68 (.22)	0.58 (.25)	0.54 (.22)

Memory performance as a function of cue differentiation

In the prior two experiments, learners generated cues for themselves and cues for others. Learners were explicitly told that they could use the same cue for themselves and for others if the cue was effective for both themselves and others. Learners used the same cue about 50% of the time. Analysis of cue effectiveness was conditionalized upon whether a learner provided the same cue for themselves as they did for others. As shown in Figure 7, the proportion learners recalled did not differ based upon intended recipient when the cue originator did not provide different cues for self and for others: the interaction between cue originator and intended recipient did not reach significance ($F(1, 53) = 0.83$; $p = 0.37$). When the cue originator provided different cues for self and other, the cue originator interacted with intended recipient ($F(1,50) = 17.77$). Post-hoc paired t-tests show that cues for others were better at supporting memory when given to others than cues for self ($t(54) = 3.76$) and cues for self were numerically better at supporting memory when given to self than cues for others ($t(64) = 1.64$; $p = 0.11$).

Figure 7. Cued recall performance as a function of cue originator and intended recipient, conditionalized upon when cue originator provided different cues for self and other (left graph) and when cue originator did NOT provide different cues for self and other (right graph). Both graphs show data combined across Experiments 3 & 4.

Discussion

Learners once again differentiated between the cues intended for oneself and for others. First, cues intended for others were more homogenous than cues intended for oneself. Second, cues for others showed greater associative strength to the target. Third, cues intended for oneself were more distinctive than cues intended for others: they were associated to fewer targets, had smaller cumulative strength to all possible targets in the database, and were less likely to be in the normed database.

Cued recall performance across both retention intervals replicated results from Experiment 3. When the cues were generated by oneself, performance did not differ as a function of the intended recipient. However, when the cues were generated by others, performance was better when the cues were intended for others. Learners effectively tailored their cues to support the memory of other learners. Learners do this by generating cues that are more strongly associated to the target and less distinctive, as discussed above. No meaningful interactions between retention interval and cue originator or intended recipient were found. The ordering of performance in conditions at short lags remained consistent across the two day

retention interval. The different types of cues experienced similar amounts of forgetting across the two days. Two possible explanations may underlie why retention interval did not impact the ability of different cues to support memory differentially. The retention interval might have been too short for the cognitive context to shift substantially between encoding and retrieval. Therefore, the cues generated for oneself during encoding still matched the cognitive context at retrieval and successfully triggered recall of the target. Alternatively, the cues utilized by learners for oneself might be stable over very long periods of time. For instance, "Rosemary" as a cue for "mom" will likely remain stable across a lifetime. Prior research shows that learners can distinguish between descriptions of target items that will be stable over time (Mäntylä & Nilsson, 1988); learners may select stable descriptions of the targets for their mnemonic cues.

When learners distinguished between the cues generated for themselves and for others, a slight numeric advantage was found for producing cues for oneself (but this difference did not reach significance even when data were collapsed across the prior two experiments). Even though a slight mnemonic advantage was found for producing cues for oneself, a large mnemonic advantage was found for creating cues intended for others. When others receive cues intended for others, they recall more. Since there appears to be minimal mnemonic cost to generating cues intended for others, learners could support higher levels of mnemonic performance by always generating cues useful for others. The procedure utilized in the two prior experiments limited the ability to discover the costs of creating cues for others by requiring learners to consistently generate two cues for each target: a cue for oneself before generating a cue for others. Experiment 5 moved away from this contrastive cue generation process and required learners to generate only one cue per target. In doing so, Experiment 5 measured the

time needed to generate cues for self and for others to determine if generating cues for others requires more time (and, by inference, more effort) than generating cues for oneself.

Experiment 5

Learners differentiate between the types of cues they provide for themselves and for others. In Experiment 5, the processes utilized to tailor cues for intended recipients are analyzed more closely. Theory suggests that learners utilize a negative feedback loop when creating descriptions of ambiguous stimuli for themselves and others (Mäntylä, 1986). Learners generate an initial description of a stimulus and judge whether it will reasonably support their future matching performance. If the cue does not meet the criteria, learners generate a new description until they create a description that meets their criteria. This model of description generation is analogous to the anchoring-and-adjustment model of perspective taking. When speakers generate messages for listeners, the anchoring-and-adjustment model of audience design suggests that speakers initially produce messages from an egocentric perspective; only after the message has been produced does a monitoring process check for violations of common ground and adjust the initial message accordingly (Keysar et al., 1998). The monitoring process proposed in the anchoring-and-adjustment model is much like the negative feedback loop proposed by Mäntylä (1986) during cue generation.

Generating cues to support future mnemonic performance may engender similar processes as generating messages for others. Learners may free associate from a target to generate potential cues. Learners then judge whether the candidate cue will adequately support future retrieval. If the cue does not meet the criteria, learners will reject that cue and freely associate another cue. Fewer (or laxer) constraints should exist for cues that will be beneficial for oneself than for others. For example, cues for oneself can utilize personal idiosyncratic

knowledge that effective cues intended for others cannot. Generating a cue for oneself should require less iteration through the negative feedback cycle than generating a cue for someone else, and consequently, should require less time than creating cues for others. This prediction is investigated in the current experiment.

The quality of generated cues and the mnemonic benefits resulting from the cue generation process were also deconfounded in the current experiment. Cues intended for others may not be as beneficial for one's own memory performance because they cannot rely upon idiosyncratic, distinctive, useful cues. However, the more complex process of generating a cue for someone else may increase the retrievability of that target independent of the cue. When generating cues for others, a learner may have to generate several candidate cues, most of which get rejected by the negative feedback loop, before finding a suitable cue. A greater number of cues attempted could create greater variability in how the target is encoded, increase the amount of retrieval routes to that target later, increase the amount of time studying the target, and engender better memory for the target (Estes, 1955; Bower, 1972; Belleza & Young, 1989). For example, generating cues for others may enhance target memory because a learner might encode a target that fits both with his idiosyncratic perspective and another learner's perspective. Alternatively, generating cues for oneself only requires that learners encode a target that fits with their own idiosyncratic perspective.

In order to measure the influence of cue generation processed on subsequent memory performance without the confound of cue quality, memory for targets was compared between intended recipient conditions using either a free recall test or a cued recall test with experimenter-chosen cues. By disregarding the cues that learners generated during the memory test, memory performance should not be impacted by the quality of the cues the learners

generated; rather, only the differential processing that the learners engage in during cue generation should affect later recall.

Participants

Thirty eight introductory psychology students at the University of Illinois at Urbana-Champaign participated for partial course credit.
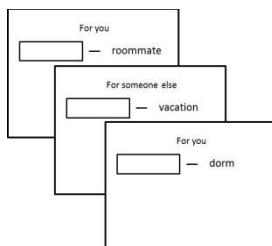
Materials

New items were collected from the University of South Florida Free Association Norms in order to specifically include targets with a large number of associated cues. Increasing the number of possible associated cues may allow learners more variability in the types of cues they generate. Targets were selected to be unassociated to each other. Further, the experimenter selected a single cue for each target item, which had a medium forward association to one target (M = 0.05) and was used only during the cued recall test.

Method

Subjects completed the experiment on PCs in six individual testing rooms. Subjects were given cue generation instructions utilized in all prior studies. Additional instructions were added that asked subjects to "generate beneficial cues but to generate them as quickly as possible because the time you take will be recorded." Subjects were also told that they would sometimes generate cues for themselves and sometimes generate cues for a learner who is very different than they are. The procedure is displayed in Figure 8.

Figure 8. The experimental procedure of Experiment 5.

Unlike the previous two experiments, learners only generated one cue for each item. Prior to each target item appearing on screen, the directive "for yourself" or "for someone else" was displayed on the screen for one second. Then a single response box and target were displayed on screen until a subject entered their cue. Subjects completed the cue generation phase and took the memory test immediately. Twenty-two subjects took the cued recall test, while sixteen subjects completed a free recall test. In the free recall test, subjects were asked to type in all of the targets that they could remember from the study list until they could remember no more. In the cued recall test, a single experimenter-chosen cue was presented on screen and subjects typed the corresponding target item. Subjects were told that the cues given to them at the time of the test were chosen by the computer and were unlikely to overlap with any of the cues they actually generated. The experimenter selected the cues that were used during the cued recall test to have a small forward association to a single target item. The cues were selected before any subjects participated in the study and were identical for all subjects.

Results

Cue Characteristics

Characteristics of the generated cues were analyzed across subjects from both test conditions since the experiments did not differ until the cue generation phase was complete and are displayed in Table 6. Subjects generated cues for oneself faster (M = 6.25 sec) than cues for others (M = 7.25 sec; t(37) = 3.13). Even though the cue generation process no longer required a cue for oneself and for others for each target, the differences in cue characteristics based upon intended recipient in this experiment replicated the prior two studies. A greater consensus developed for cues intended for others than for oneself. A greater proportion of cues were unique (did not overlap with any other subjects') when generated for oneself than for others

(t(59)=3.67). For 56% of the targets, a greater variety of cues was generated for oneself than for others; 33% of the targets showed greater variety of cues generated for others than for self. Assocations between cues and targets were stronger when cues were intended for others than for oneself. Cues for others had greater cue-to-target associative strength than cues intended for oneself (t(37) = 4.05). Cues for others were also less distinct than cues for oneself. Cues for others were more likely to be included in the South Florida Free Association Norms (t(37) = 5.45), were associated to more targets (t(37) = 4.46), and had higher cumulative associative strength from the cue to all possible targets than cues for oneself (t(37) = 5.45).
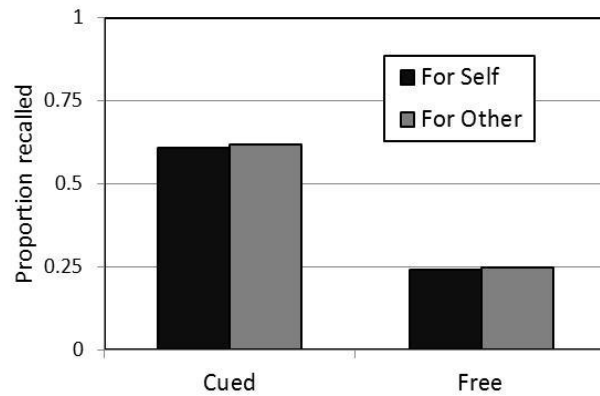
Memory Performance

Recall performance for each type of test is displayed in Figure 9. Intended recipient did not impact free recall of targets (t(15) = 0.80, p = 0.26). For only 3% of the test cues, the experimenter-chosen cue matched the subject-generated cue. Performance on the cued recall test was significantly higher when subject-generated cues matched the experimenter-chosen test cues (M = 0.90) than when they did not match (M = 0.60; t(18) = 4.78). All analyses include both matched and non-matched data since they show the same patterns of memory performance. Intended recipient did not affect cued recall of targets (t(21) = 0.68, p = 0.41). Even when combined across the type of memory test, intended recipient did not alter final memory performance for the target (t(37) = 0.63, p = 0.49).

A hierarchical multi-level model was fit to the data to ascertain the role that time needed to generate the cue had on final memory performance. The models used to fit the data included subjects and items as random variable and time needed to generate the cue as a fixed effect. For free recall, the seconds used to generate the cue had a positive effect on final recall performance (β= 0.062); the model including the time fit the data significantly better than the model excluding

this variable ($X^2(1) = 15.04$). For cued recall, the seconds used to generate the cue showed a small positive effect on performance ($\beta = 0.02$), but did not significantly improve the fit of the model ($X^2(1) = 2.14$, p = 0.14).

Figure 9. Proportion recalled as a function of intended recipient and type of memory test in Experiment 5.

Series of Cues

The anchoring-and-adjustment account of perspective taking (Epley et al., 2004) suggests that the initial adjustment away from one's own perspective may be a difficult, time-consuming process. A possible prediction of this viewpoint is that, if a learner consistently generated cues for others, the learner would adjust away from his perspective during the first cue generation and would not need to adjust away from their perspective after that. If consistently generating cues for others, learners would become faster at generating cues because the initial adjustment process would only need to be accomplished once. Therefore, if learners in this experiment generated multiple cues for another learner in a row, their cue generation for others may speed up across successive cue generation for other trials. Table 9 shows the properties of cues generated for oneself and for others as a function of how many cues for others (or for themselves) they have consistently generated in a row. Contrary to predictions, learners are slower at generating cues for another learner for the second cue in row than for the first cue in a row (t(37) = 2.14). The

increase in time needed to generate the second cue for another learner does not increase the effectiveness of the cue. Cues have less cue-to-target associative strength and become more distinctive across the repetition in a series. This same pattern is not evident for cues generated for self. In fact, learners are faster at generating the second cue for themselves in row than for the first (t(37) = 2.34). Further, there seems to be no consistent pattern for the characteristics of cues generated consecutively for oneself.

Table 9. Characteristics of cues generated in Experiment 5 as a function of the number of same intended recipient preceding it.

	For Other			For Self		
NUMBER IN A ROW	**1**	**2**	**3**	**1**	**2**	**3**
Cue time (sec)	7.18	7.55	6.78	6.51	5.81	5.71
Cue-to-target assoc strength	0.09	0.08	0.06	0.06	0.05	0.07
Number associated to cue	9.03	8.97	8.73	7.46	7.65	7.76
Cumulative strength from cue	0.55	0.53	0.51	0.43	0.46	0.45
Cue in database	0.68	0.66	0.64	0.55	0.58	0.55

Discussion

As in Experiments 3 and 4, learners generated different types of cues for oneself and for others. Even though the cue generation procedure was changed in this experiment and learners were instructed to generate cues as quickly as possible, learners tailored cues for the intended recipients in the same way as the prior two experiments. Learners generated more common cues for others than for oneself. Further, learners generated cues for others that were less distinct but had higher cue-to-target associative strength than cues for themselves.

This experiment revealed a significant cost of generating cues for others compared to generating cues for oneself: generating cues for others required more time than generating cues for oneself. This difference is consistent with the idea that learners execute a negative feedback cycle to disqualify candidate cues until one meets the requisite criteria. Because their criterion

for others is higher than the criterion for themselves, learners must spend more time in the negative feedback loop for others.

Theory in language production suggests that a tradeoff exists between the efficiency of a message (the length and time needed to generate the message) and its probability of successful communication (Clark, 1984). Here, learners may spend more time generating cues for others because they want to ensure a greater probability of its successful communication with others. Learners may minimize cognitive effort by spending less time generating cues for themselves because they believe they are likely to retrieve the target even with poorer quality cues. Poor quality cues may be easy for learners who generated them to understand, but very difficult for others to understand. Learners can, then, minimize cognitive effort (and time spent) while still supporting high levels of mnemonic performance by accepting poorer cues for oneself than for others. Evidence suggests that learners accept poorer quality cues for themselves than for others, as cues for oneself have smaller cue-to-target associative strength.

Even when assessed with tests that should not be dependent on the quality of memory cues, mnemonic performance for the targets did not differ as a function of the intended recipient of the cue. Neither free recall nor cued recall revealed differences in the recall of the targets based upon the intended recipient. Mnemonic performance, then, did not differ as a function of the processes used to generated cues for differing intended recipients. Specifically tailoring a cue for a different recipient, and taking more time to do so, did not result in greater memory performance for the corresponding target. The lack of difference suggests that differential processing induced by the intended recipient does not yield large differences in memory for the targets.

Across the prior three experiments, learners generated different types of cues for different intended recipients. When generating cues for others, learners created less distinctive cues with higher cue-to-target associative strength than when generating cues for self. Cues intended for others support others' cued recall more than cues intended for oneself. Learners effectively overcome their idiosyncratic encoding and knowledge, take the perspective of others, and generate cues that are more compatible with others' perspectives. However, learners show a significant cost to overcoming personal knowledge and taking another's perspective. This cost does not show up in reduced cued recall performance for these learners; rather, it shows up as an increase in the time needed to generate cues for others compared to the time needed to generate cues for oneself. The additional time needed to generate cues for others is consistent with suggestion that learners free associate cues to a target and reject each until a cue meets some criterion of fitting with others' knowledge. Learners must cycle through the generation and criterion check more often when generating cues for others than for oneself.

Cue characteristics change as learners generate cues for the same learner successively. Learners were slower to generate the second cue in a row for another learner than for the first cue in a row. This may suggest that for every cue generated, learners cannot remain anchored in another's perspective. Learners must anchor in their own perspective and anchor away from it on every trial. In fact, adjusting away from one's perspective may take effort, doing so repeatedly in a row may be cognitively tiring, and it may slow down cue generation processes. This effect stands in contrast to the fact that learners become faster at generating the second cue in a row for themselves than for the first cue in a row.

Finally, these three experiments show that learners can expertly rely upon statistical information to infer others' knowledge. Since learners have no knowledge or personal

interaction with the learner that is receiving their cues, they must base their conception of what others know solely on what they believe most learners know. Learners effectively tailor their cue generation based upon the intended recipient by shifting away from personal, episodic knowledge and to more semantic knowledge.

These results may be limited by the type of other learner that was invoked by the instructions. Across each experiment, the instructions asked the learners to generate cues for learners that are "very different from you" or "for someone else." This was intended to prompt learners to differentiate between the cues they generated for themselves and for others as much and as frequently as possible. However, by leaving this other learner vague and indistinct, learners may struggle to generate cues for them. Prior research suggests that learners approach communication with specific addresses differently than if they are addressing a general learner (Brown & Dell, 1986). If the instructions throughout the experiments asked learners to generate mnemonic cues for a specific addressee instead of a general addressee, their cue generation tactics and effectiveness may differ dramatically. Learners who are addressing a specific listener could rely upon personal knowledge or personal interactions they have had with the intended recipient when generating cues. This possibility is open for future exploration.

Part III: CUES FOR COMPETING TARGETS

Learners often need to recall information in the face of distracting competitors. Cueing memory to distinguish between similar targets may be an essential skill to successfully navigate around the target's competitors. If a cue leads to recall of a competing item, negative consequences may ensue. For instance, a cue to pick up your daughter from soccer practice that does not distinguish between the array of possible practice fields may fail as an effective cue and produce an angry daughter. Similarly, notes about applying permutations and combinations that do not clearly delineate the circumstances under which each is applicable may not enhance learners' later math grades. In the next pair of experiments, learners generated cues for a set of targets that included similar, competing targets.

Speakers consistently consider competing referents when generating messages for others. In fact, the contrast set may have one of the largest influences on the nature of communication, as speakers need to identify a referent uniquely (Olson, 1970), even when referents are spaced apart in time (van der Wege, 2009; Yoon & Brown-Schmidt, submitted). For example, speakers provide subordinate level categorical information (e.g., collie) only when referents have competitors at the basic level (e.g., other dogs; Sedivy, 2003). Similarly, learners contrast a locally unique referent against previously referenced items from the same category (van der Wege, 2009). Speakers also use scalar adjectives (modifiers that reference an object's size) when drawing contrasts among competing referents. When communicating about a circle when it is the only circle present, speakers refer to the referent as "the circle." However, when a smaller circle is also present, speakers refer to the referent as "the larger circle" (Brown-Schmidt & Tanenhaus, 2006). If competitors exist in the array, but the speakers do not notice them, speakers do not use modifying adjectives; only when speakers notice the competitors do they use

specific adjectives to distinguish among referents (Brown-Schmidt & Tanenhaus, 2006).

Speakers deliberately generate messages that distinguish among the known competitors in a set

in order to effectively communicate with others. Whether consideration of competitors plays a

similar role in generating cues to communicate with a future self was explored in this set of

experiments.

Across the next two experiments, learners generated cues to remember sets of related

triplets. Learners read a set of three words and then generated a cue for each specific item in the

set. To manipulate whether learners were likely to notice the relationships among competing

targets, related triplets were either presented simultaneously (together condition) or spaced out in

time (apart condition). These conditions were varied within-subjects in Experiment 6 and

between-subjects in Experiment 7. I examined how effectively learners generated cues to

differentiate among related targets, as well as the characteristics of the cues and the resultant

cued recall performance.

Experiment 6

Participants

Thirty-four introductory psychology students at the University of Illinois at Urbana-

Champaign participated for partial course credit.

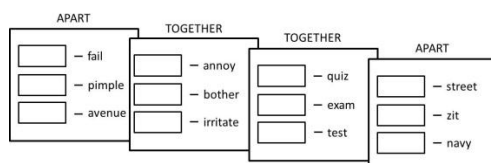### Materials

Twenty triplets of synonyms were collected from the South Florida Free Association

Norms (Nelson et al., 1998). Each to-be-remembered target then had two related to-be-

remembered competitors. The triplets included both nouns (e.g., quiz, exam, test) and verbs

(e.g., irritate, annoy, bother). The average associative strength among the members of each

related triplet was 0.18.

Method

This experiment utilized a within-subjects design, with related triplets presented on the same screen simultaneously or presented across three different sets of items. Subjects completed the experiment on PCs in individual testing rooms. Subjects were given the same cue generation instructions that were utilized in all prior studies. Unlike all previous experiments, however, three target items were displayed on the screen at once as shown in Figure 10. The three different targets appeared in a column in random order on the right hand side of the screen for 6 seconds before any subject response was allowed. Presenting the targets together for six seconds before responses could be made was done to encourage subjects to read all three targets before generating cues. After six seconds, the first response box appeared next to the top target item and subjects typed in the first cue. Subjects then entered a cue for the middle target and finally entered a cue for the final target.

Three target items were always presented on each cue generation screen. In the together condition, the three target items came from the same related triplet. In the apart condition, three random unrelated target items were presented on screen together and the related triplet items were randomly distributed across three different screens. Conditions were randomly assigned across presentation screens. After subjects completed the cue generation phase, they immediately took the cued recall memory test. The cues were presented on the left side of the screen in a random order and subjects typed in their response in a box on the right hand side of the screen.

Figure 10. The cue generation procedure screens utilized for Experiment 6 and 7.

Results

Cue Characteristics

The characteristics of the cues generated as a function of generation condition are displayed in the pink columns of Table 10. Subjects took more time to generate cues when related triplets were presented together than when presented apart ($t(33) = 2.85$). Subjects used the other items from the related triplet as cues for 28% of the targets when the triplets were presented apart, and for only 10% of the targets when triplets were presented together ($t(33) = 6.69$). The cue-to-target associative strength was greater in the apart condition than in the together condition ($t(33) = 4.39$). The associative strength between a cue and the two wrong (but related) targets was also greater in the apart condition than in the together condition ($t(33) = 4.75$). Further, the cues generated in the together condition were associated to fewer other targets in the database than those generated in the apart condition ($t(33) = 3.59$). The number of cues which a subject used for more than one target was calculated. In the apart condition, subjects repeated cues more frequently (4%) than in the together condition (2%; $t(33) = 2.23$).
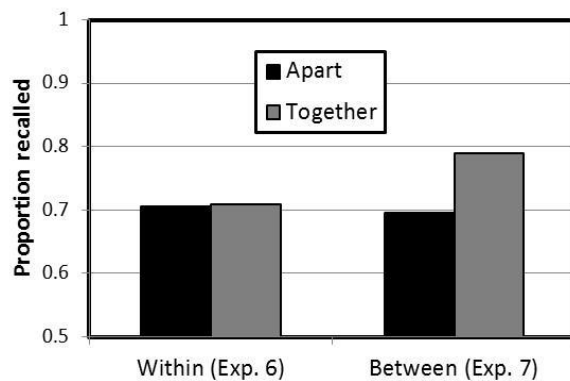
Table 10. Dependent measures across experiments 6 (pink, within) and 7 (blue, between).

	Apart (within)	Together (within)	Apart (between)	Together (between)	Together (all)
Time to generate cue (sec)	7.37	10.19	6.00	8.96	9.30
Assoc strength from cue to target	0.10	0.05	0.13	0.05	0.05
Number of items associated from cue	7.94	6.45	9.45	6.91	6.78
Proportion of cues that were competitors	0.28	0.07	0.41	0.10	0.09
Assoc strength from cue to competitors	0.05	0.02	0.08	0.03	0.02
Proportion of cues repeated in list	0.04	0.02	0.07	0.01	0.02
Number of confusions	2.35	1.95	7.79	1.38	1.59

Memory Performance

Cued recall performance did not differ between the together and apart conditions (t(33) = 0.86, p = 0.17) and is displayed in Figure 11. The number of confusions within each condition and within each subject was also calculated. An incorrect response was considered a confusion when the response was a competing target from the related triplet. Subjects made more confusions when cues were generated in the apart condition (u = 2.53) than when cues were generated in the together condition (u = 1.38; t(33) = 2.19).

Figure 11. Cued recall performance for Experiment 6 and 7.

Proportion recalled — Apart, Together — Within (Exp. 6), Between (Exp. 7)

Discussion

When learners were likely to notice the competing target items, learners generated different cues than when they were not likely to notice the competing target items. For items presented with their competitors, learners took more time to generate cues, used fewer competitors as cues, used cues with smaller cue-to-target associative strength to the competitors, and generated cues that were associated to fewer possible target items. Learners recognized the difficulty of generating an effective cue for the competing items when presented together and altered their cue generation process for these items. Although simultaneous and sequential presentation of the triplets changed the cue generation process, final cued recall performance did not benefit—though I will revisit this finding in Experiment 7.

Memory performance did not differ between the together and apart condition, despite the fact that the number of confusions between target items was reduced in the together condition. Cues generated when the targets are presented together increased the learners' abilities to reject incorrect potential targets without increasing their ability to recall the correct target.

The comparisons between the together and apart conditions may be artificially reduced because the manipulation was entirely within-subjects. Learners may have become aware of the high degree of association between items in the together condition and applied somewhat stricter cue generation criteria to all potential targets. Further, after viewing related triplets presented simultaneously on screen, learners may have noticed the relationships among the triplets presented sequentially. Adjusting their cue generation strategies and applying stricter criteria for cues across both conditions may have eliminated performance differences between together and apart items. To reduce the risk of this homogenization of cue generation processes across conditions, the together and apart conditions were varied between-subjects in the following experiment.

Experiment 7

In the previous experiment, learners may have noticed the relationships among the target items, even in the apart condition, because the manipulation was entirely within-subjects. This could homogenize the strategies used among the different conditions and eliminate expected differences in performance. In Experiment 7, triplets were either presented together or apart, as in Experiment 6, but the presentation condition was manipulated between subjects. The between-subjects manipulation should reduce the likelihood that subjects in the apart condition notice the relationships among related triplets because related items never appear simultaneously on the same screen. Consequently, the between subjects manipulation utilized in this experiment

should increase the differences between conditions and should provide a stronger test of the effects of that manipulation on accuracy.

Participants

Thirty-nine introductory psychology students at the University of Illinois at Urbana-Champaign participated for partial course credit.

Materials

The twenty triplets utilized here were the same as those in Experiment 6.

Method

The only change between the procedure utilized here and that of Experiment 6 was that the together and apart conditions were varied between-subjects. Subjects were alternatively assigned to the together and apart conditions.   For subjects in the together condition, all related triplets were presented simultaneously on the screen. For subjects in the apart condition, related triplets were always distributed across three different screens.

Results

Cue Characteristics

The characteristics of the cues generated as function of condition are displayed in the blue columns of Table 10, and entirely replicate the differences found between conditions in the prior experiment. Subjects took more time to generate cues when related triplets were presented together than when presented apart (t(37) = 3.68). Subjects used the other items from the related triplet as cues for 41% of the targets when the triplets were presented apart, and for only 7% of the targets when triplets were presented apart (t(37) = 7.39). The associative strength between a cue and the correct target was greater in the apart condition than in the together condition (t(37) = 5.99). However, the associative strength between a cue and related (but wrong) targets was

greater in the apart condition than in the together condition (t(37) = 8.30). Cues generated in the together condition were associated to fewer items in the database than those generated in the apart condition (t(37)=4.05). The number of cues which a subject used for more than one target was calculated. In the apart condition, subjects repeated cues more frequently (7%) than in the together condition (1%; t(37) = 5.80).

Memory Performance

Cued recall performance is displayed in Figure 11. Learners in the together condition recalled significantly more targets than learners in the apart condition (t(37) = 2.08). Further, as in the prior experiment, subjects made more confusions when cues were generated in the apart condition (M = 7.79) than when cues were generated in the together condition (M = 1.95; t(37) = 7.13).

Discussion

When information about the competitors was available, learners effectively generated cues to prevent confusions among targets and improved cued recall performance. As in the prior experiment, the characteristics of the cues differed between the apart and together conditions. In order to prevent confusions among targets, learners in the together condition spent more time generating cues than learners in the apart condition. Cues generated by the learners in the together condition were less likely to be competing targets and were less strongly associated to the competing targets. Further, cues in the together condition were less strongly associated to the target item than cues in the apart condition. Awareness of competitors led learners to decrease the cue-to-target associative strength in order to improve performance. Differences in the cues led learners in the together condition to correctly recall more items and have fewer confusions than those in the apart condition. Learners were better able to tailor their cues to distinguish

among competitors when knowledge of the competitors was simultaneously present and to recall more of the correct targets.

The between-subjects manipulation in Experiment 7 revealed a significant difference in cued recall performance, while the within-subjects manipulation in Experiment 6 did not. To determine why performance differences arose in the between-subjects manipulation, but not in the within-subjects manipulation, the characteristics of the cues generated across these conditions were compared. The cue characteristics across the between-subjects apart condition, the within-subjects apart condition, and the together condition combined across experiments were compared in Table 10. All relevant dependent measures for the within-subjects apart condition fall between the measures from the other two groups. This order of conditions suggests that learners in the within-subjects apart condition may be using a mixture of strategies from the between-subjects apart group and the together group, which allows them to create only mildly beneficial cues. The subjects in the within-subjects apart condition were likely aware that there were relationships among apart targets, but did not effectively improve their cued recall performance for these items. With the related triplets presented across three different screens, learners likely knew that there would be related competitors for each target but could not exactly predict what the competitors would be. Not knowing what the competitors would be prevents these learners from generating cues as beneficial as in the together condition.

As when communicating with others, learners consider the context of the to-be-remembered items when communicating with their future self. Learners recognize the difficulty inherent in creating cues that differentiate among related targets and alter their cue generation strategies in response to it. When aware of the competitors, learners spent more time generating cues, utilized fewer cues that were competing targets, and generated cues that were less strongly

associated to the competing targets. These tactics prevented confusions among the competing

targets and improved cued recall performance.

GENERAL DISCUSSION

Across the entire set of experiments, learners used sophisticated tactics to generate cues that effectively supported consistently high levels of cued recall performance. Learners generated cues that were compatible with their own rich, idiosyncratic knowledge. The high levels of performance elicited by those cues reflected the effectiveness of this strategy. Learners thrived when they received self-generated cues during the test, but stumbled when they received cues generated by others. This difference reveals the importance of the match between encoding and retrieval; when the test cue was compatible with the learner's interpretation during encoding, recall was enhanced. Evidence across all experiments suggests that cue-to-target associative strength, cue distinctiveness, and the match between encoding and retrieval play significant roles in fostering future retrieval.

Regularities emerged in the types of cues learners utilized. When generating cues for oneself, learners generated distinctive cues that were associated to the target item. When generating cues for others, learners sacrificed cue distinctiveness in order to increase the cue-to-target associative strength. Conversely, when learners were aware of related competitors in the to-be-remembered list, they increased the distinctiveness of the cues at the expense of the cue-to-target associative strength. Learners flexibly modulated the characteristics of generated cues to fit the particular demands of the task, and by doing so, bolstered their memory performance.

Cues generated by oneself are best at supporting one's own memory, regardless of the intended recipient. Cues generated for others are superior for promoting recall in others and yield little impairment for oneself. The principal cost to generating cues intended for others is the extra time needed to generate those cues. Finally, learners consider a target's competitors when generating cues. When aware of competing targets, learners spend more time generating

cues that distinguish among the related targets, reduce confusions among targets, and enhance cued recall performance.

In cases of real-life prospective memory, the factor that may most influence success or failure is the quality of the cue. In many such cases, the cue may be self-generated, like it is in the tasks presented here. Across almost all real-world prospective memory tasks, people generate their own cues to support future retrieval. People write the dates of dissertation defenses in calendars, take notes during preliminary oral defenses, and create lists of potential experiments to conduct in the future. It is the quality of these cues that largely determines how much a learner will successfully recall. Yet, no prior prospective memory task has allowed learners control over the types of cues utilized. Cue generation, a new dimension of prospective memory, was analyzed across these experiments. These experiments show that learners intentionally generate cues to effectively support effective memory performance, and the specific instructions and circumstances affect both the type and effectiveness of the cues generated. When learners know their cues are going to be used during a later memory test, they create more distinctive cues, and those cues are more mnemonically beneficial than prior descriptions of targets. Allowing learners to control their own cues in memory tasks dramatically enhances performance and may more closely simulate real life prospective memory situations. Further, by allowing learners to choose the cues they utilize during prospective memory tasks, a set of different and meaningful questions can be asked about successful prospective memory.

This approach, however, is unlike some kinds of real-world prospective memory in one major respect. In many real-world perspective memory tasks, people generate conceptual cues (like shopping lists, which include things like "celery") which map onto actions (buy celery). Rather than mapping cues onto actions, the series of prospective memory tasks outlined here

maps a conceptual cue (e.g., "shoe") onto a different concept (e.g., "feet"). In some real-world prospective memory undertakings, people generate cues that map directly and singularly from ideas to other ideas. For instance, when taking notes in a history class, learners may write notes that read "Napoleon: 1769-1821" which maps onto the concept of the birth and death years of Napoleon Bonaparte. This mnemonic cue exists only to support the conceptual memory of the time period of Napoleon's life; it is not created in the service of any specific performable action. Further, naming a computer file "cuegen.docx" maps directly onto the concept of a "cue generation dissertation" and not an action. While many kinds of prospective memory map conceptual cues to actions, other kinds exist only to help a learner remember concepts in the future.

Learners effectively considered another learner's perspective when generating cues. Learners generated cues for others that had higher cue-to-target strength but were less distinctive than when generating cue for themselves. These cues were more beneficial for others than cues that learners generated for themselves. Generating cues for others took significantly longer than generating cues for oneself. This time requirement aligns well with the perspective-taking literature, which shows that learners need significant time to consider common ground in message formation; when under time pressure, learners fail to consider common ground. Considering another's perspective when generating mnemonic cues is a slow, resource-consuming process. This may be most consistent with the anchoring-and-adjustment view of perspective taking. In this view, a learner must first consider his own egocentric perspective before adjusting away from it. According to a free association-driven, negative feedback model, a learner can only "shift away" from his own egocentric perspective by restricting the types of cues he uses. He does this by excluding the egocentric cues he generates and by selecting the

cues that could plausibly apply to others' knowledge. "Shifting away" from his egocentric perspective might, then, be the wrong metaphor. A learner can only generate cues that somehow fit with his own perspective, but must selectively choose which ones of those he uses for others through the use of the negative feedback loop. Interestingly, by restricting the types of cues they use for others, learners produce more homogenous cues. As shown throughout Experiment 3-5, learners generated cues for others that overlapped to a greater extent than cues generated for oneself. Learners can restrict the cues they output for others and this produces greater consistency across cues.

Further, according to this anchoring-and-adjustment view, a learner may take longer to generate cues for people that are significantly unlike her, as the negative feedback loop should have a higher criterion for intended recipients that are dramatically unlike the cue originator. The cue originator, then, must execute the negative feedback loop more times for people that are more unlike her. For example, a college subject who is generating cues for her best friend may have a lower criterion for cues than when generating cues for her grandmother. This prediction remains to be tested.

Generating effective cues for your future self is analogous to communicating with someone else. Learners need to consider the perspective of their future self when generating cues, much like speakers need to consider the perspective of their addressee to communicate effectively. Evidence for learners effectively taking the perspective of the future self appears in two significant ways. First, learners generate different types of cues if they are told they are generating mnemonic cues or generating descriptions of the target (Exp. 1-2). Learners effectively take the perspective of their future self to generate mnemonic cues that will be more beneficial in the future than just descriptions. Second, learners take the perspective of their

future self by generating cues that effectively disambiguate among competing targets (Exp. 6-7). When learners can notice the relationships among competing targets, they are more likely to generate cues that effectively point to only one target item. Learners recognize the difficulty that their future selves will have in connecting the appropriate target with the appropriate cue, and generate cues to help them overcome this difficulty even though doing so requires significantly more time. Learners actively use cognitive resources to take the perspective of their future selves.

Taking the perspective of the future self, like taking the perspective of others, may be deliberate and resource-consuming. The effect of a dual-task on cue generation could be explored to determine how cues change when learners' resources are devoted elsewhere. Without full attention and resources, learners' cues may revert back to basic descriptions of the target items and cued recall performance could suffer. Learners may struggle to effectively take the perspective of their future self when generating cues. Accurately predicting the future self's perspective is likely impossible, as unpredictable life events may drastically alter the future self. Evidence further suggests that learners significantly underestimate how much their personality will change in the next decade (even though they recognize how much they have changed in the prior decade; Quoidbach, Gilbert, & Wilson, 2013). If learners cannot estimate how much their personality will change, regardless of predicting the ways in which it will change, their ability to take the perspective of their future self across long time spans may be very limited.

Individual differences that predict the ability of learners to take perspective should also predict how effective learners are at generating cues for their future selves if cue generation is similar to perspective taking. For instance, mood (Converse, Lin, Keysar, & Epley, 2008), culture (Wu & Keysar, 2007), intoxication (Monahan & Samp, 2007), need for cognitive closure

(Webster & Kruglanski, 1997), and working memory capacity (Lin, Keysar, & Epley, 2010) all influence perspective-taking in communication. These individual differences should also predict the ability of learners to create cues for their future selves. Another individual difference in cue generation that should be explored is impact of age on cue generation. Effective cue generation (especially when generating cues for others) may rely upon learners rejecting or inhibiting cues that do not meet certain criteria. Older learners may have fewer cognitive resources to inhibit the ineffective or inappropriate cues that come to mind first, and therefore, may be unsuccessful at generating effective cues for their future selves and for others. Alternatively, older learners may have more experience generating cues for themselves because of a longer history of working with one's own memory, particularly as it fails. Older learners may stand to benefit to an even greater extent when using self-generated cues in memory.

These results add to the growing literature that suggests that learners expertly utilize metacognitive control beyond control of encoding to improve their learning. Learners who have control over their learning use study time, study schedules, and study activities to boost their mnemonic performance. Similarly, learners can generate retrieval circumstances that effectively support their memory performance. As shown throughout these experiments, learners can also effectively offload cognition to the environment to improve their mnemonic performance. Learners can utilize metacognitive control over study effectively because they base study choices upon their idiosyncratic cognitive environment and personal metacognitive monitoring of their learning. Learners' metacognitive monitoring of their own learning is often more accurate than an outsider's (Jameson, Nelson, Leonisio, & Narens, 1993). Learners have privileged access to their idiosyncratic mental states that allows them to make more effective choices for themselves than could be determined by an outsider or aggregate data. Creating effective retrieval cues is an

example of how learners successfully use privileged access to their mental states and

metacognitive control to flexibly offload cognitive demands onto the environment.

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Appendix A

Strategies of learners

Analyses of the types of strategies learners utilized when generating cues was completed. Six distinct categories were created after an initial overview of the cues utilized across all experiments. The categories used included one-word cues, two-word cues, the targets in foreign languages, rearrangement of the letters in the target (ie, "honep" as a cue for "phone"), the beginning of the target (but not the entire word: e.g., "pos" as a cue for "positive"), and adding a letter to the end of the target (e.g., "shoes" as a cue for "shoe"). Cues were coded blind to their condition. As shown in Table A1 below, learners almost exclusively generated one-word cues across all experiments.

There are two interesting patterns of data. First, in Experiment 1, learners in the description condition used almost exclusively one-word cues, while learners in the cue generation condition relied upon one-word cues less. When trying to remember targets, learners may rely upon more strategic processing than when trying to describe the items. Second, in Experiment 7, learners relied upon one-word cues less when generating cues for the competing targets when they were aware of the competitors than when they were less away of the competing targets. Learners may shift cue generation strategies when recognizing the inherent difficulty of distinguishing among three related concepts.

Table A1. Proportion of strategies utilized across Experiments 1 – 7.

	One-word cues	Two-word cues	Foreign translation of targets	Rearranged letters from targets	Beginning of target	Target with extra letter
Exp 1 (Cue Gen)	0.90	0.05	0	0.04	0	0
Exp 1 (Description)	0.99	0.01	0	0	0	0
Exp 2	0.93	0.02	0	0	0	0.05
Exp. 3(For oneself)	0.94	0.06	0	0	0	0
Exp. 3(For others)	0.95	0.05	0	0	0	0
Exp. 4 (For oneself)	0.90	0.07	0	0.01	0.01	0
Exp. 4 (For others)	0.90	0.05	0	0.02	0.01	0
Exp. 5 (For oneself)	0.97	0.02	0	0	0	0
Exp. 5 (For others)	0.96	0.03	0.01	0	0	0
Exp. 6 (Together)	0.83	0.03	0	0.03	0.11	0
Exp. 6 (Apart)	0.85	0.03	0	0.03	0.10	0
Exp. 7 (Together)	0.89	0.09	0	0.01	0.01	0
Exp. 7 (Apart)	0.98	0.01	0	0	0	0

Appendix B

Target-to-cue associative strength

Across the first five experiments, the cue-to-target associative strength was compared to the target-to-cue associative strength. Cue-to-target associate strength reflects the probability of freely associating from the cue to the target, while the target-to-cue associate strength reflects the probability of freely associating from the target to the cue. Take, for example, the cue-target pair "pair-shoes." When given the cue "pair", the likelihood that learners freely associate the target "shoes" is the cue-to-target associative strength. Alternatively, when given the target "shoes", the likelihood that learners will freely associate the cue "pair" is the target-to-cue associative strength.

Learners received only the cue and had to retrieve the target during the cued recall test. Under these circumstances, only the cue-to-target associative strength impacts retrieval; target-to-cue associative strength has no influence (Feldman & Underwood, 1957; Koriat & Bjork, 2005). Learners, when generating cues for targets, may ignore the direction of the association between cue and target, and value cues with target-to-cue associative strength even though it does not influence recall. The failure of learners to discount target-to-cue associative strength when monitoring learning has been shown (Koriat & Bjork, 2005). When learners make judgments about the memorability of items, they overweight the perceived association between cue and target when both are present and under-utilize the probability with which a cue, when presented alone, will elicit the corresponding target. Generating cues with greater the target-to-cue than cue-to-target associative strength result may reflect this metacognitive illusion. However, no systematic relationship between target-to-cue associative strength and cue-to-target associative strength was found across the five experiments. As shown in Table A2, two

experiments showed higher cue-to-target than target-to-cue associative strength while two

showed higher target-to-cue associative strength.

Table B1. The cue-to-target and target-to-cue associative strength for cues generated across five experiments as a function of intended recipient and experiment. Orange rows indicate significantly greater cue-to-target strength, while blue rows indicate significantly greater target-to-cue strength.

	For self		For others	
	Cue-to-target	Target-to-cue	Cue-to-target	Target-to-cue
Exp. 1 (cue gen.)	0.059	0.047		
Exp. 1 (description)	0.048	0.051		
Exp. 2	0.027	0.072		
Exp. 3	0.041	0.050	0.053	0.060
Exp. 4	0.047	0.049	0.064	0.063
Exp. 5	0.084	0.069	0.055	0.044

Appendix C

The log odds of a correct recall on each trial were predicted by the different stimulus characteristics using a multi-level logit model. The model included the fixed effects of instruction condition and the simple interactions of cue originator condition with each of the following for variables: cue-to-target associative strength, number associated from cue, total cumulative strength from cue, and cue in database. These were crossed with random intercepts for subjects and items. The model was fit in the R software package (R Development Core Team, 2008) with Laplace estimation using the *lmer()* function of the *lme4* package (Bates, Maechler, & Dai, 2008). Using backward elimination, interactions and variables that were least influential in the model were removed until removing predictors produced a model that fit the data significantly worse. The parameters of the least-complex best fitting model are displayed below. The beta-weights (and corresponding Z values) are shown in Table C1.

Table C1. Beta weights from the logit model.

	β	Z value
Intercept	-0.16	0.70
Cue originator	2.58	15.06
Instructions	-0.53	4.45
Cue-to-target associative strength	4.59	9.36
Total strength	-0.39	2.10
Cue originator * total strength	-1.12	4.39

This model of performance shows that cue originator has a very strong effect on recall. If a learner receives their own cues, they are 13.2 times more likely to recall the target than if they receive another's cues. Additionally, the instructions given to the cue originator make a significant difference in the probability of recall. Instructions to generate a cue are 1.67 times more likely to lead to recall than instructions to generate a description. Further, the stronger the

cue-to-target associate strength, the more likely the target is recalled. The cue originator interacts with the cumulative total strength from the cue, which suggests that when the cue was created by another learner, total cumulative strength is less important than when it was created by oneself. When it was created by oneself, lesser cumulative associative strength promotes higher memory performance.

A major difference between the HLM and the standard prior analysis is the influence of whether a cue is in the database and the raw number of potential targets associated to the cues (two measures of distinctiveness). The HLM shows that the number of targets associated to the cues did not contribute to the model's ability to predict memory performance. These two variables likely overlap largely with the other measures of distinctiveness (cumulative total strength); therefore, they did not contribute new information to the model and do not appear in it. The HLM does corroborate some major results from the traditional analyses: cue generation instructions influence recall, self-generated cues show a higher likelihood of recall than other-generated cues, greater cue-to-target associative strength enhances likelihood of recall regardless of cue originator, and the influence of cue distinctiveness depends upon cue originator.

Appendix D

The log odds of a correct recall on each trial were predicted by the different stimulus characteristics using a multi-level logit model in Experiment 2. The model included the fixed effects of simple interactions of cue originator condition with each of the following for variables: cue-to-target associative strength, number associated from cue, total cumulative strength from cue, and cue in database. These were crossed with random intercepts for subjects and items. The model was fit in the R software package (R Development Core Team, 2008) with Laplace estimation using the *lmer()* function of the *lme4* package (Bates, Maechler, & Dai, 2008). Using backward elimination, interactions and variables that were least influential in the model were removed until removing predictors produced a model that fit the data significantly worse. The parameters of the least-complex best fitting model are displayed below. The beta-weights (and corresponding Z values) are shown in Table D1.

Table D1. Beta weights derived from the logit model.

	β	Z value
Intercept	-0.34	1.61
Cue originator	3.08	10.78
Cue-to-target associative strength	16.14	6.71
Cue in database	-1.79	2.64
Total strength	1.54	1.85, p = 0.07
Cue originator * total strength	-1.06	2.72

As the prior hierarchical model showed, this model of performance shows that cue originator has a very strong effect on recall. If a learner receives their own cues, they are 21.76 times more likely to recall the target than if they receive another's cues. Further, the stronger the cue-to-target associate strength, the more likely the target is recalled. Measures of distinctiveness have a more complex relationship to recall. When the cue is located in the

database, learners are less likely to recall the target. Further, the cue originator interacts with the cumulative total strength from the cue. When the cue was created by another learner, total cumulative strength is less important than when it was created by oneself. When it was created by oneself, lesser cumulative associative strength promotes higher memory performance.

As in the prior heirachical model, learners are more likely to recall the targets when they generated the cue than when someone else did. Further, increased cue-to-target strength is beneficial to recall. As in the prior model, the effects of distinctiveness interact with cue originator. Finally, the number associated from the cue has no significant impact on probability of recalling the target. Once again, the information contained in this variable likely largely overlap with the other measures of distinctiveness. The one difference in this model contrasted with the prior one, is that whether the cue is in the database or not impacts the probability of recall significantly.