Mem Cogn (2015) 43:634–646
DOI 10.3758/s13421-014-0478-y

# Cueing others' memories

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Published online: 7 November 2014


**Abstract** Many situations require us to generate external cues to support later retrieval from memory. For instance, we create file names in order to cue our memory to a file's contents, and instructors create lecture slides to remember what points to make during classes. We even generate cues for others when we remind friends of shared experiences or send colleagues a computer file that is named in such a way so as to remind them of its contents. Here we explore how and how well learners tailor retrieval cues for different intended recipients. Across three experiments, subjects generated verbal cues for a list of target words for themselves or for others. Learners generated cues for others by increasing the normative cue-to-target associative strength but also by increasing the number of other words their cues point to, relative to cues that they generated for themselves. This strategy was effective: such cues supported higher levels of recall for others than cues generated for oneself. Generating cues for others also required more time than generating cues for oneself. Learners responded to the differential demands of cue generation for others by effortfully excluding personal, episodic knowledge and including knowledge that they estimate to be broadly shared.

**Keywords** Metamemory · Cue generation · Perspective taking · Metacognition

Learners frequently create external cues to support future memory performance. Professors create lecture slides to remember what points to make during class, and students take notes during those lectures to help remember what was discussed. These stable external cues may help a learner access a target memory over a long retention interval despite considerable forgetting. People also generate cues to support others' retrieval. Teachers must consider what cues will best help their students remember information, bosses create to-do lists that should remind their employees of desired actions, and friends may cue each other while reminiscing about shared experiences. Learners' self-generated mnemonic cues are based upon their own idiosyncratic encoding and personal experiences (Hunt & Smith, 1996; Mäntylä, 1986; Tullis & Benjamin, under review). Consequently, giving a learner's self-generated cues to a different learner reduces their effectiveness. In our experiments, we explored whether and how learners can overcome the idiosyncrasies of their own knowledge in order to generate cues that support others' mnemonic performance. Learners generated external mnemonic cues for themselves or for others for a list of to-be-remembered target words. We measured the characteristics of these verbal cues and examined whether the cues led to successful retrieval during later cued recall.

Previous research has almost entirely focused on how learners' self-generated *descriptions* of a target word support memory under incidental learning conditions. When learners receive previously generated descriptions of target words as cues during a cued recall test, recall performance is very high (Mäntylä & Nilsson, 1983), even for lists of up to 600 items and for retention intervals as long as 3 weeks (Mäntylä, 1986). Memory performance is even better when learners generate distinctive descriptions of the targets (Hunt & Smith, 1996; Mäntylä & Nilsson, 1988). Only one study, though, has examined the more metacognitively relevant case where learners generate mnemonic cues with the explicit purpose of later cueing memory (Tullis & Benjamin,

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under review). That experiment showed that cued recall is greater when learners generate cues with the explicit purpose of later supporting memory rather than just describing the targets. To do so, learners created mnemonic cues that were more distinctive than descriptions by referencing idiosyncratic knowledge and personal experiences. Using idiosyncratic knowledge renders their cues less useful for other learners who have no access to that private information. Consequently, when a learner receives someone else's cues, performance drops significantly (Andersson & Ronnberg, 1997; Mäntylä, 1986; Tullis & Benjamin, under review; but see Hunt & Smith, 1996). No prior research has examined whether learners can generate mnemonic cues that effectively take the perspective of a different learner. Here we investigated whether learners can tailor their mnemonic cues for others by utilizing shared instead of private knowledge, and we examined if there are mnemonic costs to the generator for doing so.

To generate effective mnemonic cues for others, learners must effectively differentiate between what is private and what is shared. Learners deduce what knowledge is shared by using three sources of information: projections of personal experiences, generalized statistical knowledge, and personal interactions with the target individual (Jost, Kruglanski, & Nelson, 1998). First, learners determine the beliefs and knowledge of others by extrapolating from their personal experiences. For example, if a learner knows the answer to a general knowledge question, he will predict 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 personal knowledge when communicating with others. They do not, for example, disregard their private knowledge during business negotiations even when it is in their best interest to do so (Camerer, Loewenstein, & Weber, 1989). If learners cannot disregard their private knowledge, learners may not be able to effectively tailor mnemonic cues for others.

Second, learners can use statistical information to anticipate others' beliefs or cognitive states. For instance, one might use statistical base rates to predict that an individual woman identifies as a Democrat because most women identify as Democrats (Borgida & Brekke, 1981). Third, whenever possible, learners use personal information about the target individual to make judgments about the target's knowledge and behaviors (Kahneman & Tversky, 1973). For example, speakers adjust their communication about New York City landmarks based upon whether they believe the particular addressee is a New York City expert or novice (Isaacs & Clark, 1987). In general, people must balance these three different sources of information successfully in order to predict the cognition of others.

How effectively learners take the perspective of other people is still debated. Research across a variety of domains shows that learners often fail to successfully tailor their messages to other learners. For example, 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). Similarly, listeners cannot ignore competing information in privileged ground even though they can use common ground to resolve referents (Hanna, Tanenhaus, & Trueswell, 2003). Other evidence in communication shows that sometimes speakers effectively take into account their intended audience when producing messages. For example, when generating descriptions of abstract line drawings, descriptions qualitatively differ depending on the intended recipient (Danks, 1970). Descriptions for self include more metaphors and figurative language, while those for others include more descriptions of basic geometry and shapes. Similarly, people asked to label an array of colors use more common words when creating labels for others than when creating labels for themselves (Kraus, Vivekananthan, & Weinheimer, 1968). Whether and how learners can take perspective in memory cueing remains unknown.

In this set of experiments, learners created cues for themselves and for others. If learners can take the perspective of others, the characteristics of the generated cues and final cued recall performance should depend upon the intended recipient. In order to determine if learners differentiated among cues based upon the intended recipient, three main characteristics of cues were analyzed, as in Tullis and Benjamin (under review). First, the cue-to-target associative strength, as indexed by the South Florida Free Association Norms (Nelson, McEvoy, & Schreiber, 1998), was examined. Higher cue-to-target associative strength normally supports cued recall performance (Feldman & Underwood, 1957; Koriat & Bjork, 2006). Second, cue overload, which refers to the number of targets or associations subsumed by a cue, was measured (Earhard, 1967; Nairne, 2002; Watkins & Watkins, 1975). Cue overload was measured in three ways: (1) by counting the number of targets associated with the cue in the South Florida Free Association Norms,(2) by totaling the cumulative cue-to-all-normed-targets' associative strength, and (3) by indicating if the cue is present in the database at all. The greater number of targets associated with a cue, the greater cumulative cue-to-all-normed targets' associative strength, and the cue being in the database all suggest a greater cue overload. Overloaded cues usually lead to poor memory performance because they do not sufficiently restrict the possible search space (Nairne, 2002; Watkins & Watkins, 1975). Finally, the match between encoding and retrieval was manipulated. During retrieval, learners received some of their own cues (which match their own encoding) and some of the cues generated by other learners (which likely do not match their encoding). A greater match between encoding and retrieval supports higher memory performance (Tulving & Thomson, 1973).

## Experiment 1

In Experiment 1, we examined how effectively learners tailor cues for themselves and for other learners. Learners generated two mnemonic cues for each to-be-remembered 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 but for someone else, cues generated by someone else for themself, and cues generated by someone else for someone else.

### Method

#### *Participants*

Forty-three introductory psychology students at the University of Illinois at Urbana-Champaign participated for partial course credit. The first subject in each testing room only received cues from themselves and was therefore not included in any statistical analyses. Therefore, 41 subjects contributed useable data.

#### *Materials*

Sixty 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 "roommate," "haircut," and "fad."

#### *Procedure*

This experiment utilized a 2 (cue originator: oneself or other) ×2 (intended recipient: oneself or other) crossed, within-subjects design. The cue provided to the learners during the test was generated *by* oneself or someone else and the cue was generated *for* oneself or someone else. 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. This latter instruction is similar to those used in other perspective-taking tasks (e.g., Danks, 1970), and intentionally avoids undue specification of the alternative learner. For each of the 60 target items, the target was displayed twice on the right side of the screen and an empty response box, as shown in Fig. 1, preceded each instance. Above the first response box and target, the description "for you" was displayed, while

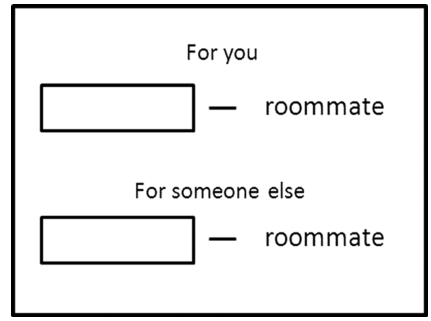


**Fig. 1** Cue generation screen used in Experiments 1 and 2

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 so only if the cue was beneficial for themselves and others. In order to restrict generated cues to single words, subjects were not allowed to use the space bar; if a subject pressed the space bar, a warning message appeared asking learners to generate only single words.

Immediately after creating 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, but 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 only cues that they generated (and was omitted from analysis). All subsequent subjects were yoked to the immediately preceding subject. Cues were randomly divided between the conditions and were randomly ordered throughout the recall test.

### Results

#### *Cue characteristics*

The characteristics of the cues generated for self differed from those generated for others and are displayed in Table 1. Subjects generated identical cues for self and for others on 55 % of the trials. Examples of cues generated are displayed in Table 2.

We analyzed all cues, regardless of whether the subject generated the same cue for self and for other, unless otherwise specified. Cues generated for others had greater cue-to-target associative strength than cues generated for self ($t(40) = 4.58$, $p < 0.001$, Cohen's $d = 0.72$). Cues generated for self were associated to fewer target items ($t(40) = 5.30$, $p < 0.001$, $d = 0.84$), showed smaller cumulative associative strength to all

**Table 1** Characteristics of cues generated for self and others across Experiments 1, 2, and 3. Numbers in parentheses indicate standard deviations of the mean. All comparisons between "for others" and "for oneself" are significant at a $p < 0.001$ level

| | | Exp. 1 | Exp. 2 | Exp. 3 |
|---|---|---|---|---|
| Cue-to-target associative strength | For others | 0.06 (0.02) | 0.06 (0.03) | 0.08 (0.04) |
| | For oneself | 0.04 (0.02) | 0.05 (0.03) | 0.05 (0.03) |
| Proportion of cues in the South Florida Database | For others | 0.66 (0.12) | 0.62 (0.18) | 0.67 (0.13) |
| | For oneself | 0.55 (0.17) | 0.51 (0.16) | 0.55 (0.17) |
| Number of targets in database associated to cues | For others | 9.01 (1.96) | 8.47 (2.75) | 9.03 (2.04) |
| | For oneself | 7.52 (2.56) | 6.64 (2.32) | 7.50 (2.54) |
| Cumulative cue-to-target associative strength for all normed targets | For others | 0.52 (0.10) | 0.49 (0.15) | 0.54 (0.11) |
| | For oneself | 0.44 (0.13) | 0.40 (0.13) | 0.44 (0.14) |
| Proportion of targets that were unique | For others | 0.50 (0.14) | 0.56 (0.15) | 0.59 (0.15) |
| | For oneself | 0.59 (0.16) | 0.71 (0.15) | 0.70 (0.16) |

normed targets ($t(40) = 5.79$, $p < 0.001$, $d = 0.92$), and were less likely to be listed in the University of South Florida Free Association Norms ($t(40) = 5.80$, $p < 0.001$, $d = 0.92$) than cues generated for others.

Finally, we measured the diversity among the generated cues. We counted the total number of different cues supplied for each target and divided that by the number of subjects in that condition. For each target item, more unique cues were generated for self than for others ($t(59)= 8.97$, $p < 0.001$, $d = 1.17$). For 85 % of the targets, a greater variety of cues was generated for self than for others; only 13 % of the targets elicited a greater variety of cues generated for others than for self.

### *Memory performance*

Cued recall performance is displayed in Fig. 2. A 2 (cue originator: oneself or other) ×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 ($F(1,40)= 5.55$, $p = 0.02$, $\eta^2_{partial} = 0.12$) . Follow-up paired t-tests showed a marginal effect of intended recipient when the cues were given to others ($t(40) = 1.83$, $p = 0.07$, $d = 0.29$) but not when given to self ($t(40) = 1.15$, $p = 0.26$, $d = 0.18$). 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 ($F(1,40) = 143.34$, $p < 0.001$, $\eta^2_{partial} = 0.78$).

**Table 2** Illustrative examples of cues generated

| | Cue for self | Cue for other | Target |
|---|---|---|---|
| Differentiated between self and other | superman | villain | hero |
| | francis | football | team |
| | indiana | evil | enemy |
| | dwight | work | office |
| | reading | models | hobby |
| | ecuador | sacrifice | volunteer |
| Did not differentiate between self and other | trend | trend | fad |
| | vacation | vacation | holiday |
| | piano | piano | instrument |
| | representative | representative | senator |
| | meal | meal | breakfast |

### *Memory performance by cue differentiation*

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, and learners did this for 55 % of the targets. We conditionalized further tests upon whether learners provided the same cue for themselves as they did for others. When learners differentiated cues based upon the intended recipient, a repeated measures ANOVA on cued recall performance indicated an interaction between cue generator and intended recipient ($F(1, 31) = 17.72$, $p < 0.001$, $\eta^2_{partial} = 0.36$), and a main effect of cue generator ($F(1, 31) = 118.32$, $p < 0.001$, $\eta^2_{partial} = 0.79$). When cues were generated by a different learner, cues intended for others led to better recall

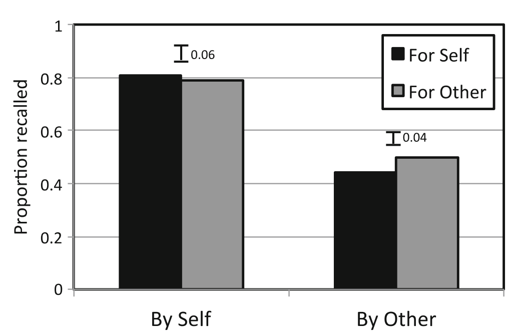


**Fig. 2** Cued recall performance as a function of who generated and who received the cue in Experiment 1. Error bars (and corresponding number labels) indicate the width of the 95 % confidence interval of the difference between intended recipients (Loftus & Masson, 1994)

(M = 0.52) than cues intended for self (M = 0.30; t(35) = 4.49, p < 0.001, d = 0.77). When cues were generated by self, cues intended for self led to greater recall (M = 0.82) than cues intended for others (M = 0.74), but this difference did not reach significance (t(36) = 1.62, p = 0.11, d = 0.28).

*Characteristics of effective cues*

Cues were considered effective if they led to successful recall of the appropriate target. The characteristics of effective and ineffective cues as a function of cue originator are shown in Table 3. Effective cues generated by self had higher cue-to-target associative strength (t(38) = 4.20, p < 0.001, d = 0.68), were associated to fewer targets (t(38) = 4.30, p < 0.001, d = 0.70), had a smaller cumulative associative strength to all normed targets (t(38)= 1.93; p = 0.002, d = 0.54), and were less likely to be in the South Florida database (t(38) = 2.69, p < 0.001, d = 0.64) than ineffective cues. Effective cues generated by others had higher cue-to-target associative strength (t(40) = 6.45, p < 0.001, d = 1.02). No differences were found between effective and ineffective cues in the number of targets associated (t(40) = 0.97; p = 0.34, d = 0.15), the cumulative associative strength from a cue to all normed targets (t(40) = 0.93, p = 0.36, d = 0.15), or the likelihood of being in the South Florida database (t(40) = 0.71, p = 0.48, d = 0.11).

Discussion

When generating cues, learners 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 those cues. Similarly, cues for oneself were less likely to be in the normed database, were associated with fewer items in the database, and had lower cumulative associative strength with all normed targets. However, the cue-to-target associative strength was greater when the cue was generated for someone else. In sum, learners increased the cue-to-target associative strength at the expense of the number of cues associated with the cues when generating cues for others.

In sum, Experiment 1 hints that learners took the perspective of others to generate cues that effectively improved others' memory performance. When cues were given to others, especially when the cue originator differentiated between the cues for self and for other, the intended recipient of that cue was important. Because cues generated for oneself were more variable and idiosyncratic, they were less beneficial for others' retrieval than cues generated for others. This effect was also revealed in the analysis of *which* cues led to successful recall: when receiving one's own cues, both associative strength and amount of cue overload influenced memory, but when receiving someone else's cues, only associative strength helped. Experiment 2 replicated and extended the results of Experiment 1 by including a longer retention interval.

## Experiment 2

Although the intended recipient did not impact cued recall when the cue originator received their own cues at the short retention intervals implemented in Experiment 1, the intended recipient may matter more at longer retention intervals. Learners often believe that their current cognitive state will persist longer than it actually does (Kornell & Bjork, 2009). Therefore, learners may generate cues for themselves based upon an unstable cognitive state, believing that it will be long lasting. If cognitive contexts fluctuate, idiosyncratic cues may become less supportive of memory across long retention intervals. However, cues generated for others, which rely less upon idiosyncratic encodings and more upon stable, shared semantic knowledge, may be less deleteriously affected by the passage of time and changing context. If learners' cues intended for self rely upon less stable cognitive contexts than cues intended for others, an interaction between retention interval and intended recipient may hold. We tested the stability of cues based upon intended recipient by introducing a

**Table 3** Characteristics of cues that led to successful and unsuccessful retrieval, split by cue originator in Experiment 1. 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 (0.03) | 0.02 (0.05) | 0.08 (0.02) | 0.02 (0.06) |
| Number associated with cue | 7.45 (2.46) | 11.09 (4.84) | 8.55 (3.03) | 7.81 (2.76) |
| Cumulative associative strength from cue | 0.44 (0.13) | 0.60 (0.20) | 0.47 (0.16) | 0.48 (0.15) |
| Cue in the database | 0.55 (0.16) | 0.77 (0.26) | 0.60 (0.18) | 0.59 (0.20) |

2-day retention interval between cue generation and memory test in Experiment 2.

## Method

### *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 by others were included in the analyses to follow, which include data from 38 subjects.

### *Materials*

Four new words from the University of South Florida Free Association Norms were added to the list from Experiment 1, 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.

### *Procedure*

This experiment utilized a 2 (cue originator: oneself or other) ×2 (intended recipient: oneself or other) ×2 (retention interval: no delay or 2-day delay) fully crossed, within-subjects design. The procedure was identical to that of Experiment 1, 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 2 days later.

## Results

### *Cue characteristics*

All differences between the cues generated for others and for self found in Experiment 1 were replicated in this experiment and are displayed in Table 1. Learners generated the same cues for self and for others for 50 % of the targets. Cues generated for others had greater cue-to-target associative strength ($t(37) = 6.21$, $p < 0.001$, $d = 1.05$), were more likely to be listed in the University of South Florida Free Association Norms ($t(37) = 5.51$, $p < 0.001$, $d = 0.93$), were associated with more target items ($t(37) = 5.57$, $p < 0.001$, $d = 0.94$), and had greater cumulative strength from the cue to all possible targets ($t(37) = 5.58$, $p < 0.001$, $d = 0.94$) than cues generated for self. Cues for self were more unique than cues generated for others ($t(63) = 9.81$, $p < 0.001$, $d = 1.24$). For 89 % of the targets, a greater variety of cues was generated for oneself than for others; only 6 % of the targets showed a greater variety of cues generated for others than for self.

### *Memory performance*

Cued recall performance is displayed in Fig. 3, and the results at the short retention interval closely replicate those from Experiment 1. A 2 (cue originator: oneself or other) ×2 (intended recipient: oneself or other) ×2 (retention interval: no delay or 2 day delay) repeated measures ANOVA on recall performance revealed a significant interaction of cue originator with recipient ($F(1,37) = 10.11$, $p < 0.003$, $\eta^2_{partial} = 0.22$). Follow-up t-tests indicated that the intended recipient mattered when the cue originator was a different learner ($t(37) = 3.06$, $p < 0.005$, $d = 0.50$), but not when the cue originator was oneself ($t(37) = 1.03$, $p = 0.31$, $d = 0.15$). This interaction replicates the pattern found in Experiment 1. Further, the ANOVA revealed significant main effects of originator and retention interval. Cues generated by oneself resulted in higher performance than cues generated by others ($F(1,37) = 160.70$, $p < 0.001$, $\eta^2_{partial} = 0.81$), and the proportion recalled declined as retention interval increased ($F(1,37) = 119.27$, $p < 0.001$, $\eta^2_{partial} = 0.76$). No evidence was found that retention interval interacted with the cue originator ($F(1,37) = 0.21$, $p = 0.65$, $\eta^2_{partial} = 0.01$), intended recipient ($F(1,37) = 2.27$, $p = 0.14$, $\eta^2_{partial} = 0.06$), or both originator and recipient ($F(1,37) = 0.97$, $p = 0.33$, $\eta^2_{partial} = 0.03$).

When learners differentiated between cues for self and for others, memory performance was greater when they received

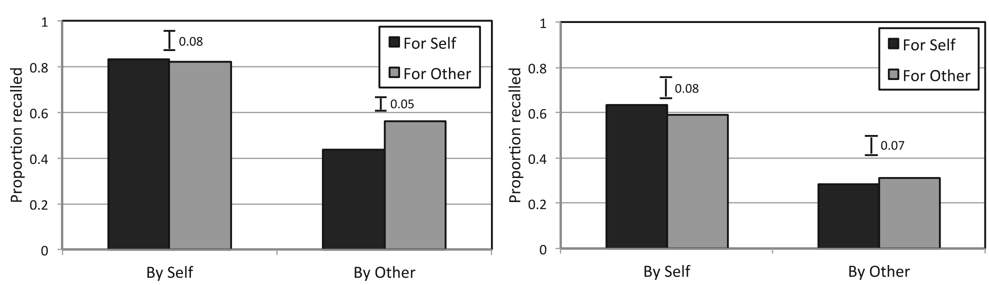


**Fig. 3** Cued recall performance for immediate retention (left graph) and at a 2-day delay (right graph), as a function of cue originator and intended recipient in Experiment 2. Error bars (and corresponding number labels) show the width of the 95 % confidence intervals of the differences between intended recipient for each pair of bars

cues intended for themselves (M = 0.79 [SD = 0.19]) than cues intended for others (M = 0.70 [SD = 0.24]; t(37) = 2.23, p = 0.03, d = 0.37). Further, memory performance was greater when learners differentiated between cues intended for self and others and received cues intended for themselves than when learners did not differentiate between cues intended for self and others (M = 0.70 [SD = 0.15]; t(37) = 2.95, p = 0.006, d = 0.48).

### *Characteristics of effective cues*

A 2 (retention interval) ×2 (cue originator) ×2 (correct or incorrect) repeated measures ANOVA was performed on cue-to-target associative strength, the number associated with the cue, the total cumulative associative strength from the cue, and the percentage 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 as a function of cue originator are displayed in Table 4. First, effective cues generated both by self (t(37) = 4.90, p < 0.001, d = 0.81) and others (t(37) = 5.30, p < 0.001, d = 0.87) had higher cue-to-target associative strength than ineffective cues. Second, the efficacy of overloaded cues depended upon the cue originator. Effective cues generated by self had a smaller number of targets associated with the cues (t(37) = 4.29, p < 0.001, d = 0.70), had a smaller cumulative cue-to-target associative strength (t(37) = 3.34, p = 0.002, d = 0.55), and were less likely to be in the South Florida Free Association Norms (t(37) = 3.44, p = 0.002, d = 0.57) than ineffective cues. Effective and ineffective cues generated by others had a similar number of targets associated with the cue (t(37) = 1.09; p = 0.28, d = 0.18), similar cumulative cue-to-target associative strength (t(37) = 1.26; p = 0.22, d = 0.22), and were equally likely to be in the database (t(37) = 0.94; p = 0.36, d = 0.15).

## Discussion

Learners once again provided different types of cues for themselves and for others. First, cues intended for others were more homogeneous than cues intended for oneself. Second, cues for others showed greater cue-to-target associative strength than cues for oneself. Third, cues intended for others were connected to more possible targets than cues intended for oneself: they were associated with more targets, had greater cumulative strength with all possible targets in the database, and were more likely to be in the normed database.

Cued recall performance across both retention intervals replicated the results from Experiment 1. Cues generated for others and given to others were more supportive of others' memories than cues generated for self but given to others. No meaningful interactions between retention interval and cue originator or intended recipient were found, and the ordering of performance in conditions remained consistent across the 2-day retention interval. There are at least two reasons 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 guided 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 and those that are more ephemeral (Mäntylä & Nilsson, 1988). When generating mnemonic cues, learners may select only stable descriptions of the targets for their mnemonic cues.

When learners provided different cues for themselves and for others, a significant mnemonic advantage was found when learners received cues produced by and intended for oneself, as discussed in Appendix A. Cues intended for oneself are more helpful to cue one's own memory than cues intended for others because learners can rely upon rich, idiosyncratic knowledge to support memory more than general, semantic knowledge. This is likely because their idiosyncratic knowledge allows for cues that better restrict the search space.

**Table 4** Characteristics of cues that led to successful and unsuccessful retrieval, split by cue originator from Experiment 2. Gray boxes indicate significant differences between successful and unsuccessful cues. Numbers in 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 with 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) |

In the next experiment, we questioned how the act of generating cues for others differs from the act of generating cues for self. The procedure utilized in the two prior experiments limited our ability to evaluate the resources involved in cue construction for the two intended-recipient conditions because each subject generated two cues for each target, and in a confounded order. Experiment 3 moved away from this contrastive cue generation process and required learners to generate only one cue per target. We 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 3

In Experiment 3, the processes utilized to tailor cues for intended recipients were analyzed more closely. Theories about how learners generate descriptions of targets and how learners generate messages for others provide starting points to explore how learners tailor mnemonic cues for others. According to some theories (Mäntylä, 1986), learners utilize a negative feedback loop when creating descriptions of ambiguous stimuli. They first generate an initial label of a stimulus and judge whether it reasonably describes the target. If the description does not meet the criteria, learners generate a new description until they create a one that meets their criteria. This model of description generation is similar to the anchoring-and-adjustment model of perspective taking (Horton & Keysar, 1996; Keysar, Barr, Balin & Paek, 1998; Keysar et al., 2003). 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 message accordingly.

Generating cues in support of future mnemonic performance may entail similar processes to generating messages for others. Learners may free associate from a target to generate potential cues. If the candidate cue does not meet some criteria, learners will reject that cue and choose another. Fewer (or laxer) constraints should exist for cues that will be more beneficial for oneself than for others because cues for oneself can utilize personal knowledge that effective cues intended for others cannot. Generating a cue for oneself should require fewer iterations 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 was investigated in the current experiment.

The quality of generated cues and the mnemonic benefits resulting from different cue generation processes 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, as suggested in our discussions of the earlier experiments. However, the more complex process of *generating* a cue for someone else may increase the accessibility 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, increase the amount of time studying the target, and enhance memory for the target independent of the cue (Estes, 1955; Bower, 1972; Belleza & Young, 1989). In other words, the process of cue generation can have an impact on later memory for the target independent of the cue. For example, the process of generating distinctive cues results in better free recall of targets than generating shared cues (Hunt & Smith, 1996). Here, we investigated whether generating a cue for someone else enhances memory for the target, independent of the cue.

In order to measure the influence of cue generation processes 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 with no cues or a cued recall test with experimenter-chosen cues. By disregarding the cues that learners generated during encoding, recall should not be impacted by the quality of the cues the learners generated. Recall should only be affected by learners' differential processing during cue generation.

### Method

#### *Participants*

Fifty-five introductory psychology students at the University of Illinois at Urbana-Champaign participated for partial course credit. All participants contributed usable data because participants never received other- (or own-) generated cues at test.

#### *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. The experimenter selected a single cue for each target item, which had a medium forward association to one target ($M = 0.05$), to be used only during the cued recall test.

*Procedure*

Subjects completed the experiment on PCs in six individual testing rooms. Subjects were given cue generation instructions utilized in 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 different to them. The cue generation screens are displayed in Fig. 4.

Unlike the previous two experiments, learners only generated one cue for each target. 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-five subjects took the free recall test, and thirty subjects completed the cued 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, the experimenter-chosen cues were presented in a random order on-screen and subjects entered a response. 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 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. These statistics are displayed in Table 1. The differences in cue characteristics based upon intended recipient in this experiment replicated the prior two studies. Cue-to-target associative strength was greater when cues were intended for others than for self ($t(54) = 4.91$, $p < 0.001$, $d = 0.88$). Cues for others were more likely to be included in the South Florida Free Association Norms ($t(54) = 6.45$, $p < 0.001$, $d = 0.67$), were associated with more targets ($t(54) = 5.65$, $p < 0.001$, $d = 0.77$), and had higher cumulative associative strength from the cue to all possible targets than cues for self ($t(54) = 6.46$, $p < 0.001$, $d = 0.88$). Finally, a greater proportion of cues were unique when generated for self than for others ($t(59)= 4.08$, $p < 0.001$, $d = 0.53$). For 70 % of the targets, a greater variety of cues was generated for self than for others; 22 % of the targets showed greater variety of cues generated for others than for self.

*Cue generation time*

Subjects entered the first letter of cues intended for themselves faster ($M = 4.77$ sec) than the first letter of cues intended for others ($M = 5.56$ sec; $t(54) = 3.69$, $p < 0.001$; $d = 0.50$). Similarly, subjects submitted the entire cues for self faster ($M = 6.57$ sec) than cues for others ($M = 7.40$ sec; $t(54) = 3.42$, $p = 0.001$, $d = 0.46$).

*Memory performance*

Recall performance for each type of test is displayed in Fig. 5. The intended recipient did not impact free recall of targets ($t(24) = 0.94$, $p = 0.36$, $d = 0.19$) or cued recall of targets ($t(29)= 1.44$, $p = 0.16$, $d = 0.27$). Even when combined across the type of memory test, the intended recipient did not alter final memory performance for the target ($t(54) = 0.56$, $p = 0.58$, $d = 0.08$).

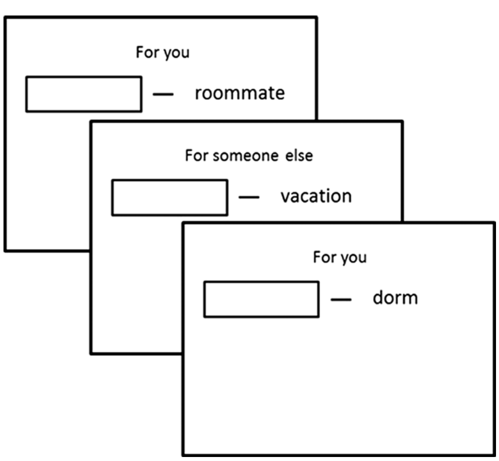


**Fig. 4** The cue generation procedure in Experiment 3

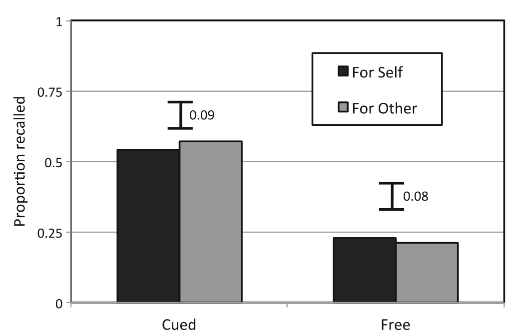


**Fig. 5** Proportion recalled as a function of intended recipient and type of memory test in Experiment 3. Error bars (and corresponding number labels) show the width of the 95 % confidence intervals

### Discussion

As in Experiments 1 and 2, learners generated different types of cues for self 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 cues for others that had higher cue-to-target associative strength but had stronger connections to other words than cues for themselves. Further, learners generated a greater number of unique cues for self than for others.

This experiment revealed a significant cost of generating cues for others compared to generating cues for self: generating cues for others required more time than generating cues for self. 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.

When assessed with tests that are not dependent on the quality of memory cues, mnemonic performance for the targets did not differ as a function of the intended recipient. Neither free nor cued recall revealed differences in memory for the targets based upon the intended recipient. 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 may suggest that differential processing induced by differing intended recipients did not yield large differences in memory for the targets.

## General discussion

Across the three experiments reported here, learners effectively tailored their mnemonic cues based upon the intended recipient. When generating cues for others, learners created cues with higher cue-to-target associative strength but stronger connections to other words than when generating cues for self. Cues intended for others supported others' cued recall more than cues intended for self. Learners effectively overcame their idiosyncratic encoding and knowledge, took the perspective of others, and generated cues that were more compatible with others' perspectives. However, learners show a significant cost to overcoming personal knowledge and taking another's perspective. This cost shows up both as a loss in the cue's ability to support one's own recall, as discussed in Appendix A, and as an increase in the time needed to generate cues for others. For a learner who received her own cues during the test, the exclusion of idiosyncratic knowledge in the cue generation process impaired memory performance. Using idiosyncratic knowledge allows learners to craft more distinctive, meaningfully connected cues that benefit their own memory performance.

Considering another's perspective when generating mnemonic cues is a slow, resource-consuming process. Evidence suggests that learners free-associate cues to a target and effortfully reject each cue until it meets a criterion of fitting with others' knowledge. This view appears to be most consistent with the anchoring-and-adjustment view of perspective taking and suggests that a learner first considers 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 until he generates a cue that could plausibly fit with others' knowledge. Restricting the cues generated for others produces a greater consistency in cues across subjects.

Across Experiments 1 and 2, learners generated the same mnemonic cue for self and others on about 50 % of the trials. Being an effective and efficient cue generator is knowing when memory will be better served by a common, semantic cue or by an idiosyncratic, personal cue. Often, a shared semantic cue may better support memory than a personally unique cue. For example, if a learner does not have a strong, personal experience with the common one-word target, they are likely to use a common, semantic cue for themselves. When a learner uses a common, semantic cue for themselves, they do not need to generate a different cue for a different learner. By giving the same cue for others as used for themselves, learners are exercising supremely efficient and effective metacognitive control over cue generation. Learners judiciously take the perspective of the cues' intended recipient and only expend extra effort to differentiate cues when they believe their cue for themselves will not support another's memory.

Effectively generating mnemonic cues for others reveals a social aspect of successful metacognition that has not yet been explored. Learners can effectively tailor their metacognitive control over memory by considering others' perspectives. In order to effectively control others' memories, learners must accurately monitor others' memories—that is, they must first predict what others will know before choosing cues that will benefit others' memories. This study reveals that learners can successfully use social monitoring (see Jost et al., 1998) to inform metamnemonic control choices.

These results further add to the growing literature that suggests how learners expertly utilize metacognitive control beyond just that exercised during encoding to support memory. During encoding, learners make effective choices about what to study (Kornell & Metcalfe, 2006; Metcalfe, 2002; Nelson, Dunlosky, Graf, & Narens, 1994; Tullis & Benjamin,

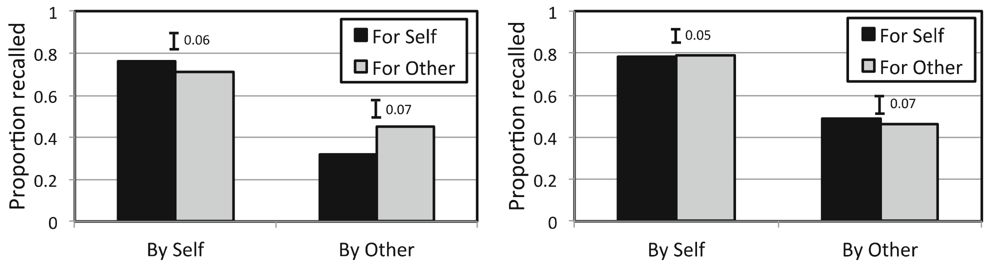


**Fig. 6** Cued recall performance as a function of cue originator and intended recipient, conditionalized upon whether the cue originator provided different cues for self and other (left graph) or did NOT provide different cues for self and other (right graph). Error bars (and corresponding number labels) show the 95 % confidence intervals of the difference between intended recipients for each pair of bars. Both graphs show data combined across Experiments 1 and 2

2012), how long to study (Ariel, Dunlosky, & Bailey, 2009; Koriat, Ma'ayan, & Nussinson, 2006; Son & Metcalfe, 2000; Thiede & Dunlosky, 1999; Tullis & Benjamin, 2011; Tullis, Benjamin, & Liu, in press), study schedules (Benjamin & Bird, 2006; Son, 2004; Toppino, Davis, Cohen, & Moors, 2009), how to accommodate an anticipated test (Finley & Benjamin, 2012), and study activities (Kornell, & Son, 2009; Tullis, Benjamin, & Fiechter, in prep). Cue generation lies at the intersection of encoding and retrieval. Learners generate cues during encoding, but do not reap the benefits of those cues until retrieval—and only do so if the effectiveness of those cues persists through the intervening retention interval. Learners are thought to make effective metacognitive choices because they can base their decisions upon their idiosyncratic cognitive environment and personal monitoring of their learning. Here, we showed that learners can also exhibit effective metacognition by disregarding that privileged access to their idiosyncratic mental states to make more effective choices for others.

Across three experiments, learners used sophisticated tactics to flexibly generate cues across a variety of different situations and, by doing so, effectively supported future retrieval. Learners did not just seek to maximize the cue-to-target associative strength and reduce cue overload of their cues, but rather modulated these characteristics to fit the demands of a particular situation. When generating cues for others, learners increased the cue-to-target associative strength of cues but also increased cue overload. When disambiguating among related targets, learners decreased cue overload and the cue-to-target associative strength (Tullis & Benjamin, under review). Learners recognize the benefits and limitations of each of these characteristics, and expertly exploit each under differing circumstances. The ability to adapt their tactics to a wide variety of situations reveals sophistication in how learners control their own memories—and those of others.

**Author Note** This research was funded in part by grant R01 AG026263 from the National Institutes of Health. The first author was supported by a graduate fellowship from the National Science Foundation.

## Appendix A

We combined the cued recall performance data across Experiments 1 and 2 to analyze the pattern of data across all subjects, and the results are shown in Fig. 6. A repeated measures ANOVA on cued recall revealed a significant interaction between cue originator and intended recipient ($F(1, 78) = 14.82$, $p < 0.001$, $\eta^2_{partial} = 0.16$), and a main effect of cue originator ($F(1, 78) = 304.05$, $p < 0.001$, $\eta^2_{partial} = 0.80$). Follow-up t-tests show that when the cue originator is a different learner, cues intended for others led to better memory ($M = 0.47$) than cues intended for self ($M = 0.40$; $t(79) = 3.28$, $p = 0.002$, $\eta^2_{partial} = 0.37$). When the cue originator is oneself, cues intended for others led to numerically worse recall ($M = 0.75$) than cues intended for self ($M = 0.77$), but this difference did not reach significance ($t(79) = 1.55$, $p = 0.12$, $d = 0.18$).

We further analyzed cued recall performance combined across Experiments 1 and 2 based upon whether the learner provided different cues for self and for other. Cue originators differentiated between cues for self and for others on approximately 50 % of the trials. For the subset of trials on which the cue originator provided different cues for self and other, the cue originator interacted with intended recipient ($F(1,54) = 17.61$, $p < 0.001$, $\eta^2_{partial} = 0.25$), as shown in the left graph in Fig. 6. T-tests showed that cues for others were better at supporting memory than cues for self when given to others ($t(60) = 4.44$, $p < 0.001$, $d = 0.57$) and cues for self were better at supporting memory than cues for others when given to self ($t(78) = 2.01$, $p = 0.05$, $d = 0.24$). As shown in the right graph of Fig. 6, the proportion of targets that learners recalled did not differ based upon intended recipient when the cue originator did *not* provide different cues for self and for others ($F(1, 62) = 1.08$; $p = 0.30$, $\eta^2_{partial} = 0.02$), as recall could only differ through the random assignment of items to conditions. When learners distinguished between cues for self and cues for others, learners' own cues intended for themselves were more beneficial than learners' cues intended for others. When learners relied upon idiosyncratic information in generating their cue, it supported their own future memory performance better than shared, common cues.

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