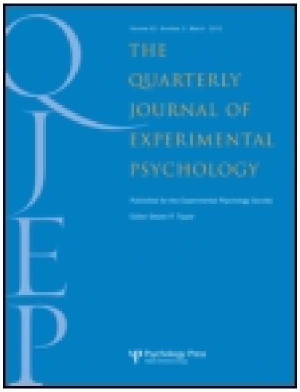

The Quarterly Journal of Experimental Psychology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pqje20

Your words are my words: Effects of acting together on encoding

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Accepted author version posted online: 03 Sep 2012.Published online: 04 Oct 2012.

THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 2013
Vol. 66, No. 5, 1026–1034, http://dx.doi.org/10.1080/17470218.2012.725058

Your words are my words: Effects of acting together on encoding

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Social influences on action and memory are well established. However, it is unknown how acting together affects the incidental encoding of information. The present study asked whether coactors encode information that is relevant to a partner's task, but irrelevant to their own task. In Experiment 1, participants performed a categorization task alone and together, followed by a surprise free recall test where they were asked to recall items from the categorization task. Recall was better not only for items that participants had responded to themselves, but also for items that their coactor had responded to, than for items that had not required a response. The same results were found in Experiment 2, even though financial incentives motivated participants to only encode words they had responded to themselves. Together, the findings suggest that performing tasks together can modulate how information relevant to coactors is processed. Shared task representations may act as a vehicle for establishing shared memories.

Keywords: Joint action; Task sharing; Collaborative memory; Memory encoding; Observation inflation.

Studies on action and studies on memory suggest that the human mind is attuned to others. Previous research on action has shown that individuals take into account each other's tasks even when they perform independent reaction time tasks alongside each other (e.g., Atmaca, Sebanz, & Knoblich, 2011; Milanese, Iani, & Rubichi, 2010; Sebanz, Knoblich, & Prinz, 2003, 2005; Welsh et al., 2005). For instance, a response selection conflict between a left and a right response was observed in participants who only controlled a right response option when they were sitting next to a person taking care of the left response (Sebanz et al., 2003). Such effects of "task sharing" have been found regardless of whether or not the other's actions can be observed. The mere belief to be acting together with an intentional agent can be sufficient (Atmaca et al., 2011; Ruys & Aarts, 2010; Stenzel et al., in press; Tsai, Kuo, Hung, & Tzeng, 2008).

It has been suggested that people form a representation of their coactor's task that specifies

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which events require the other to act (Wenke, Atmaca, Hollaender, Liepelt, Baess, & Prinz, 2011, so that seeing stimuli that are potentially task relevant for the other activates a representation of the other's task and thereby induces a response selection conflict (Kiernan, Ray, & Welsh, in press; Milanese et al., 2010; Welsh, 2009; but see Guagnano, Rusconi, & Umilta, 2010, for an alternative spatial coding account, and Liepelt, Wenke, & Fischer, in press; Liepelt, Wenke, Fischer, & Prinz, 2011, for a feature binding account). Recent findings show that a coactor's task can also change stimulus processing even when there is no response conflict (Boeckler, Knoblich, & Sebanz, in press).

Studies on social influences on memory suggest that people cannot help taking into account others' memories when recalling information together. For example, when collectively retrieving material that had been learned individually, people tend to forget information that their partner has omitted (Coman, Manier, & Hirst, 2009; Cuc, Koppel, & Hirst, 2007). By the same token, people report information that their retrieval partners produced, as if it were part of what they had learned alone (for a review, see E. F. Loftus, 2005). For instance, when participants were asked to watch different versions of a story and were then tested individually following a collective recall protocol, they remembered items from both versions (Gabbert, Memon, & Allan, 2003). This effect of sharing of memory persists even when people are warned against it (ibid.). The effect is more pronounced when the novel information is injected by another person than when it is presented as written text (Maede & Roediger, 2002), together suggesting that there are mechanisms of social interaction that foster the involuntary sharing of memories.

The above studies demonstrate social effects on retrieval by showing that collective retrieval affects subsequent recall of information that has previously been encoded individually (Roediger, Maede, & Bergman, 2001). Studies on transactive memory have investigated how pairs of people memorize information when asked to later recall it together (Wegner, 1986; Wegner, Erber, & Raymond, 1991). However, it is largely unknown how acting together affects the way information is incidentally encoded when there is no intention to perform a joint memory task. When performing a task together with another, does representing the coactor's task affect the way information relevant to the coactor is processed and consequently how it is later recalled? Do people encode information that requires their partner to act, but not themselves? If coactors take each other's tasks into account, representing which stimuli call for an action by the other (see Knoblich, Butterfill, & Sebanz, 2011, for a review of the evidence), then memory should be improved not only for items that require oneself to act (Nilsson, 2000; Noice & Noice, 2001), but also for items that require the other to act. Accordingly, information that is task relevant for one's partner should be better recalled than information irrelevant to one's own or the other's task.

The present study examined how well individuals are able to recall information that required their own action, a coactor's action, or no action during an earlier performed categorization task. In Experiment 1, participants performed the categorization task alone and together without knowing that their memory would later be tested. In Experiment 2, participants believed that they would be rewarded for recalling items they had responded to themselves, thus creating a strong incentive to focus on their own items and to ignore the other's items.

EXPERIMENT 1

This experiment tested whether people performing independent categorization tasks show improved memory performance for items that require their coactor's response. Participants first performed a categorization task alone and together. In the joint condition, each participant in a pair responded to words of one category (e.g., one person responding to animals, the other to household items). Words of a third category (e.g., fruit and vegetables) did not require a response and served as a control. In the individual condition, participants responded to words from their own category and not to words from the other two categories (e.g., responding to animals, but neither to household items nor to fruit/vegetables). Following the individual and joint categorization tasks, participants were asked in a subsequent individual surprise test to recall as many items as possible, regardless of whether they had encountered them alone or together, and regardless of whether they, their coactor, or nobody had responded to them.

In line with previous findings, we expected recall to be best for those items that required the participants to act themselves (Nilsson, 2000; Noice & Noice, 2001). The main question, however, was whether acting together would improve recall for items that did not require participants' own action, but required their partner's action. This can be tested in two ways. First, words that required the partner to act (joint condition, "other") should be better recalled than words of the same category that were encountered alone (individual condition, "other"). Secondly, words that required the partner to act (joint condition, "other") should also be remembered better than words from a different category that did not require anyone to act (joint condition, "no one"). If participants generally recalled more (or less) items from the joint task than from the individual task, regardless of whether an item required their own response, the coactor's response, or no response, this would suggest a more general effect of acting together, known as social facilitation (Aiello & Douthitt, 2001).

Method

Participants

A total of 48 participants from Rutgers University, USA, took part in this experiment in exchange for course credit or monetary compensation.

Materials and procedure

Participants were recruited as pairs and received instructions together. In the first part, participants performed a categorization task alone (individual condition) and together in a pair (joint condition). Each participant was assigned one of three word categories (animals, fruit/vegetables, household items) and was instructed to respond only to items belonging to their assigned category by pressing the indicated key (e.g., Participant A responded to animals, Participant B to household items). The order of conditions was counterbalanced, so that half of the participants performed the individual condition first, and half performed the joint condition first. Participants were told to do nothing in response to items of the other, unassigned categories. All categories were mentioned equally often in the individual and in the joint condition.

The stimulus materials comprised a total of 192 word items that were divided into two sets. Half of the experimental sessions used one set; the other half used the second set. In each experimental session, 96 stimuli were shown. The stimuli for each of the three word categories consisted of 32 items that were matched for frequency (Kucera & Francis, 1967). Half of the items of each category were presented in the individual condition, and half were presented in the joint condition. Throughout the experiment, the item category and the response key assigned to each participant remained the same (e.g., Participant A responded to animals with key "z" in both conditions). An equal number of participants was assigned to each of the three categories, and all combinations of categories across participant pairs (e.g., Participant A responding to animals, Participant B responding to household items) occurred equally often. For instance, for Pair 1, Participant A and Participant B were assigned to animal and fruit/vegetable items, respectively, and household items were not assigned, whereas for Pair 2, Participant A and Participant B were assigned to fruit/vegetable and household items, and animal items were not assigned. Two keys on the computer keyboard were assigned for making the responses, one for each participant. The response key–category pairings were counterbalanced across participant pairs so that, for instance, half of the participants responding to animals used the key "z", and half used the key "m". The experiment was run on an Apple Power PC using PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993).

Participants in the joint condition sat next to each other on chairs that were at fixed positions to the left and right of the computer screen and used the same keyboard to respond. In the individual condition, one of the chairs remained empty. Each trial commenced with a 500-ms fixation cross, followed by the stimulus presented for 1,500 ms. Participants pressed a key as quickly as possible if an item of their assigned category was displayed and did not press a key for any other items (performing a go/no-go task). From the perspective of each participant, one third of the trials required a response ("self"), one third of the trials never required a response ("no one"), and one third required a response from the other in the joint condition and no response in the individual condition ("other"). In the second part of the experiment, participants performed a surprise free recall test. They were tested alone and were asked to write down as many of the previously encountered items as possible (regardless of category) within 2 minutes. A pilot study had shown that this provided ample time.

Results and discussion

We analysed the number of items that were recalled (see Figure 1, Table 1). First, to analyse recall for items that had required the participant to respond, a 2 × 2 analysis of variance (ANOVA) with the within-subjects factors condition (individual vs. joint) and category ("self" vs. "no one") was conducted. There was no main effect of condition,

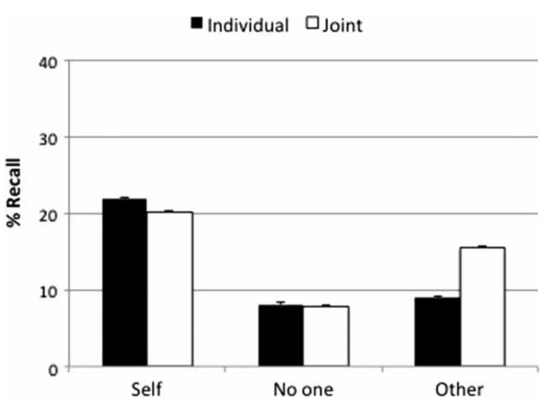

Figure 1. *Mean percentage of words recalled in Experiment 1. Words belonging to a coactor's category were recalled more frequently when participants had performed a joint task rather than an individual task. Error bars reflect within-subject confidence intervals (G. R. Loftus & Masson, 1994).*

but the main effect of category was significant, $F(1, 47) = 88.0, p < .001, \eta_p^2 = .65$. The interaction was not significant, $F(1, 47) = 0.24, p = .63, \eta_p^2 = .005$. Participants recalled more of the items they had responded to than of items no one had responded to, regardless of whether these items had been encountered individually or jointly.

Our main prediction was that words that required a coactor to respond (joint, "other") should be recalled better than the words that required no one to respond (individual, "other"; individual, "no one"; joint, "no one"). To test this, a 2 × 2 ANOVA with the within-subjects factors condition (individual vs. joint) and category ("other" vs. "no one") was performed. Both main effects and the interaction were significant [condition: $F(1, 47) = 4.1, p < .05, \eta_p^2 = .8)$; category: $F(1, 47) = 16.6, p < .001, \eta_p^2 = .26$; interaction: $F(1, 47) = 11.2, p < .01, \eta_p^2 = .19$]. Two-sided t tests confirmed that participants recalled significantly more items from the category assigned to the coactor when the coactor had responded to these items (joint condition, "other") than when the coactor was absent and had not responded to them (individual condition, "other"), $t(47) = 3.07, p < .01$. Recall for items that the other had responded to (joint condition, "other") was also significantly better than recall for "no one" items in the joint condition, $t(47) = 4.58, p < .001$, and in the individual condition, $t(47) = 3.59, p < .001$. The order in which the individual and the joint condition had been performed did not affect the results (no significant main effect of order and no significant interactions involving order). Taken together, the results of Experiment 1 show that surprise free recall of a coactor's items was improved.

Table 1. *Mean percentages for recalled items for Experiment 1 and Experiment 2*

	Experiment 1		*Experiment 2*	
Items	*Individual (%)*	*Joint (%)*	*Individual (%)*	*Joint (%)*
Self	21.8	20.2	37.5	37.8
No one	8.0	7.8	7.0	8.9
Other	8.9	15.5	7.6	16.4

EXPERIMENT 2

Experiment 2 tested whether better recall for items requiring a coactor's response would still occur when it pays off to focus on one's own task. To create a strong motivation for participants to encode only items of their own category, they were led to believe that they would be paid for each word recalled from their own category. However, after the categorization part of the experiment they were asked to recall any item previously encountered, just like in Experiment 1.

Method

Participants

A total of 24 participants were recruited from the University of Birmingham in exchange for course credit or monetary compensation.

Materials and procedure

This experiment differed from Experiment 1 only in terms of instructions. Participants were told at the beginning of the experiment that there would be a free recall test after the categorization tasks and that they would be tested only on the items they had responded to—that is, items from their own category. They were explicitly instructed to focus on these items, and they were told that they would receive 10p for each correctly recalled word. However, after participants had completed the categorization task (individually and jointly), they were asked to recall as many items as possible from any of the three categories. They were paid 10p for each word they could recall from any category, in addition to the fixed compensation rate. Finally, participants were debriefed. All participants reported that they had initially believed that they would only be paid for recalling items from their own category.

Results and discussion

The analyses were the same as those in Experiment 1. To analyse recall for items that had required participants' own response, a 2 × 2 ANOVA with the within-subjects factors condition (individual vs. joint) and category ("self" vs. "no one") was performed (see Figure 2, Table 1). It showed a significant main effect of category, $F(1, 23) = 126.4$, $p < .001$, $\eta_p^2 = .85$. As in Experiment 1, participants recalled more of the items they had responded to than of words no one had responded to. The interaction was not significant, $F(1, 23) = 0.06$, $p = .81$, $\eta_p^2 = .002$.

To analyse recall for items that the coactor had responded to, a further 2 × 2 within-subjects ANOVA with the factors condition (individual vs. joint) and category ("other" vs. "no one") was conducted. It revealed a significant main effect of condition, $F(1, 23) = 10.5$, $p < .005$, $\eta_p^2 = .31$, and category, $F(1, 23) = 6.3$, $p < .05$, $\eta_p^2 = .21$, as well as a significant interaction, $F(1, 23) = 4.8$, $p < .05$, $\eta_p^2 = .17$. Replicating the results of Experiment 1, participants recalled more items when the other had responded to these items than when no one had responded to them. Two-sided t tests confirmed that participants recalled more items of the other's category when they had appeared in the joint condition than when they had appeared in the individual condition, $t(23) = 3.77$, $p < .001$. Recall for items that the other had

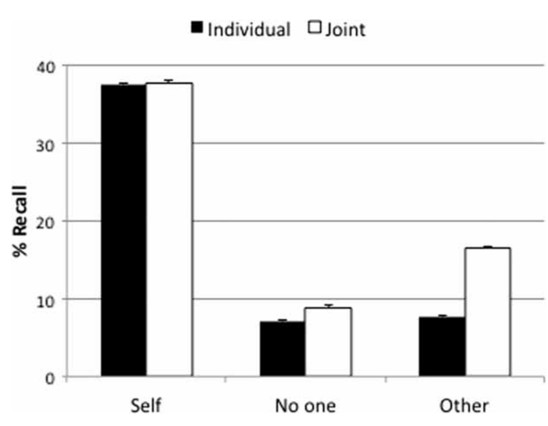

Figure 2. *Mean percentage of words recalled in Experiment 2. Words belonging to a coactor's category were recalled more frequently when participants had performed a joint task rather than an individual task, despite the monetary incentive to focus on one's own category and ignore the coactor's category. Error bars reflect within-subject confidence intervals (G. R. Loftus & Masson, 1994).*

responded to was also significantly better than recall for "no one" items in the individual condition, $t(23) = 3.65$, $p < .001$, as well as in the joint condition, $t(23) = 2.9$, $p < .01$. There was no significant main effect of order, and none of the interactions involving order reached significance.

GENERAL DISCUSSION

Two experiments confirmed the prediction that joint task performance modulates the encoding of information that is task relevant to a coactor. Participants were better at recalling items that their partner had responded to than information that their partner had not responded to. Recall of the partner's items was improved even though participants were unaware that their memory of the other's items would be tested. Improved recall for the coactor's items was observed not only when participants did not expect a memory test at all (Experiment 1) but also when they expected to be tested on and rewarded for recalling their own items (Experiment 2). Interestingly, in both experiments, improved recall for the coactor's items did not seem to come at the cost of reduced recall for items relevant to oneself. Although the joint categorization task resulted in improved recall of the coactor's items, participants recalled an equal number of their own items regardless of whether they had responded to these items alone or in the coactor's presence.

The finding of improved recall for items that participants had responded to themselves generalizes previous findings on the role of enactment, suggesting that performing a task involving particular items enhances recall of these items even when the link between items and actions is arbitrary (Noice & Noice, 2001; Noice, Noice, & Kennedy, 2000). Generating an action plan in relation to a particular item, and monitoring whether the planned action has been correctly executed, may serve to process task-relevant information more deeply and to contribute to episodic memories that later facilitate free recall.

We think it is likely that improved recall for items that were relevant to the coactor is due to similar mechanisms. Previous research on task corepresentation suggests that people form representations of their coactor's task that specify which items require the other's response (Knoblich et al., 2011; Wenke et al., 2011). When participants perceive a stimulus that requires the coactor's response (Sebanz, Knoblich, Prinz, & Wascher, 2006; Tsai et al., 2008) or a stimulus that shares features with the stimuli requiring the coactor's response (Atmaca et al., 2011; Sebanz et al., 2003, 2005; Vlainic, Liepelt, Colzato, Prinz, & Hommel, 2010), an action plan relating to the other's task is activated. Accordingly, when participants saw stimuli requiring the coactor to respond in the joint categorization task, this probably triggered the activation of an action plan and possibly ensuing monitoring processes (de Bruijn, Schubotz, & Ullsperger, 2007).

An open question is whether participants actually engaged in a motor simulation of the actions to be performed by the coactor. It has recently been shown that seeing someone performing an action can lead to false memories of having performed this action, both in children (Sommerville & Hammond, 2007) and in adults (Lindner, Echterhoff, Davidson, & Brand, 2010). This phenomenon, known as "observation inflation" is thought to be due to motor simulation, where seeing someone else performing an action activates corresponding motor programmes in the observer (Grezes & Decety, 2001; Jeannerod, 2001). If participants in our study simulated performing the coactor's actions this may have increased the accessibility of items for recall in a similar way as items they responded to themselves. Given that task corepresentation effects tend to occur even when the coactor cannot be seen (Atmaca et al., 2011; Ruys & Aarts, 2010; Tsai et al., 2008; Vlainic et al., 2010), it will be interesting to explore in future studies whether the present effect depends on the observation of the partner's actions or occurs even when people merely believe that they are performing the categorization task together (Shteynberg, 2010). In the latter case, imagining the other's actions might lead to similar effects as observing them.

We cannot fully rule out the possibility that the coactor's response provided additional retrieval cues that enhanced recall for the coactor's items (Craik & Tulving, 1975). Although, to eliminate response feedback, all stimuli remained on screen even after a response by either actor was recorded, key presses could still be seen and heard. These perceptual effects could have potentially increased saliency and/or modulated participants' attention, thus enhancing encoding for a coactor's items. However, previous studies found preserved task corepresentation effects in conditions where participants did not see or hear their coactor's response (Sebanz et al., 2005: Vlainic et al., 2010) and even when participants just believed that there was a coactor (Atmaca et al., 2011; Ruys & Aarts, 2010; Tsai et al., 2008). Findings from other studies have also demonstrated that neither the mere presence of a coactor (Sebanz et al., 2003; Tsai et al., 2008) nor receiving the instructions for a potential coactor's task (Boeckler et al., in press) is sufficient for inducing effects of task corepresentation. Future studies will be needed to determine the role of online feedback about the other's actions in the present paradigm.

It is unlikely that encoding for the coactor's items was enhanced because participants suspected that they would have to recall these items. The effect occurred when participants were oblivious to the upcoming free recall test (Experiment 1). One could argue that in Experiment 2, paradoxical effects (Wegner, Ansfield, & Pilloff, 1998) may have occurred, such that participants focused on nonself words because they were instructed to focus on their own words. However, if that were the case we should also have found improved recall for "no one" items, which was not observed.

Our findings contribute to the understanding of social influences on memory, providing a new link between collaborative memory research (e.g., Barnier, Sutton, Harris, & Wilson, 2008) and joint action research (Knoblich et al., 2011; Sebanz, Bekkering, & Knoblich, 2006). Previous studies on collective recall (e.g., Basden, Basden, & Henry, 2000) demonstrated how remembering information together with others reshapes memories. The present study, by manipulating the social context during encoding of information, demonstrates that effects of social interaction on memory are not restricted to retrieval, but also affect encoding. The fact that participants' memory changed as a function of the coactor's task in a context that did not involve verbal communication (Shteynberg, 2010) and did not require collaboration indicates that social effects on memory occur even when people do not intend to encode information together (as in transactive memory paradigms; Wegner, 1986; Wegner et al., 1991) or retrieve information together (as in collaborative recall; Basden et al., 2000; Rajaram & Pereira-Pasarin, 2007; Weldon & Bellinger, 1997; or memory conformity studies; Wright & Schwartz, 2010). In line with findings in the domain of retrieval (Coman et al., 2009; Cuc et al., 2007), our results suggest that processes occurring within individuals may also occur across people, whether this be retrieval-induced forgetting as in the studies by Hirst and colleagues, or improved recall following categorization as in the present case. Most importantly, we show that even when the participant's task does not require paying attention to the coactor, a coactor's task can affect memory performance. It has been suggested that information experienced by those who are socially relevant to us earns prominence and is thus better remembered; this in turn may affect the formation of shared knowledge systems (Shteynberg, 2010). The present findings indicate that people's proneness to represent others' tasks may constitute a possible mechanism for the formation of such shared knowledge systems.

Original manuscript received 9 January 2012
Accepted revision received 21 August 2012
First published online 4 October 2012

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