The Effects of Control Processes and Continual Distraction on Recall Organization in Categorized Free Recall

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Abstract

This study examined the effects of control processes and continual distraction on semantic and temporal organization of recall. Control processes are memory strategies for memory encoding and retrieval. Participants learned lists that contained items from different taxonomic categories and were given various recall instructions (non-instruction, order-focus, meaning-focus) that manipulated their control processes. Two levels of math task distractors (light vs. heavy) were presented to participants throughout the study phase to disrupt their memory. After learning the list, the participants were asked to recall the items from the list. We discovered that (1) the combination of the list structure that emphasized both semantic and temporal information and the meaning-focus instruction led to the greatest semantic as well as temporal organization, (2) continual distraction levels had little influence on their disruption to recall performance, and (3) there was no significant interaction effect of control processes and continual distraction levels on recall performance.

Introduction

Tulving (1972) proposed that the episodic memory system stores memories of personal experiences associated with a spatiotemporal context — in other words, a particular place and time. Episodic memory is characterized by semantic and temporal organization of the experienced events. That is to say, it can associate autobiographical episodes and store them in an organized way based on their perceptible semantic properties and the temporal relations among them. The organization of memories is essential to memory retrieval, as there has been robust evidence both inside and outside the lab showing that people rely on semantic and temporal organization to recall memories (e.g., Bousfield, 1953; Tulving, 1962; Kahana, 1996; Uitvlugt & Healey, 2019).

Atkinson and Shiffrin (1968) suggested that our memory system sets up control processes that determine how we use semantic and temporal organization during recall. Control processes are memory strategies or retrieval plans used to help search memory, and they influence memory search by constructing a retrieval cue that targets specific memories (Raaijmakers & Shiffrin, 1980). When a memory is retrieved, the retrieval plan could emphasize temporal information in order to retrieve more memories from the same episode, or semantic information to retrieve other memories that are similar in meaning. In Raaijmakers and Shiffrin's model, there are weighting parameters that alter the retrieval cue to control the influence of temporal and semantic organization and stopping criterions that specify how many retrieval failures would cause the memory system to discard a particular retrieval cue. Control processes can also be engaged during study and determine how a studied item is encoded. For instance, they could emphasize the item's category membership in the stored memory trace, which would make it easier to target during memory search using a category-based retrieval cue (and using that cue would be due to a recall period control process).

In this study, we examined how continual distraction tasks affected participants' ability to use control processes. Unlike the classic delayed distraction task that is presented to participants after all stimuli items have been shown, the continual distraction task is presented before and after each item, but not while the item itself is being studied. Earlier research studied the negative effects of delayed distraction tasks on memory retrieval and revealed that they eliminate recency effects, impairing the memories of the last few items on the list (e.g., Postman & Phillips, 1965; Glanzer & Cunitz, 1966). In recent years, researchers have become more interested in continual distraction tasks which usually cause greater disruption to memory. Specifically, recent studies investigated how continual distraction tasks influence how much semantic and temporal organization is shown in recall. However, no studies have looked at the interaction between control processes and continual distraction. Thus, we conducted the current study to see if continual distraction tasks would make control processes harder to engage.

The Past Research

Recall Organization during Memory Search

In the typical categorized free recall paradigm, participants study a list that contains items from different taxonomic categories. Participants are then given standard free recall instructions that ask them to recall as many items as possible in whatever order they come to mind. In a 1953 study, using lists comprised of four distinct categories, Bousfield showed that participants tend to cluster items based on their categories, successively recalling items within a specific category, a phenomenon he termed category clustering. Category clustering represents semantic organization when there exist strong semantic relations among items.

Kahana (1996) discovered that after recalling an item, participants tend to recall another item that has been presented nearby in the list during the learning phase and that the smaller the temporal distance between the two list items, the more likely the transition, and the more rapidly the recall is made. In addition, participants are about twice as likely to recall adjacent items in the forward direction as in the backward direction, which reveals a strong tendency for items to be recalled in the exact same temporal order as they have been learned. Kahana's finding showed that participants rely on temporal associations among items to guide their memory search and successively recall neighboring items more often than temporally remote items. We refer to this phenomenon as the temporal contiguity effect (TCE), or temporal clustering.

Control Processes and Recall Organization

Atkinson and Shiffrin (1968) suggested that we can manipulate participants' control processes by giving them different recall instructions because specifying how to retrieve memories directly changes their memory strategies. On the basis of this, Healey and Uitvlugt (2019) studied if control processes affect the encoding of temporal and semantic information during the learning phase and the organizational phenomena during memory search. They asked participants either to focus on the serial order of items to learn and recall items (order-focus instruction), to focus on items' meanings to learn and recall items (meaning-focus instruction), or to learn and recall items in whatever way they liked (free-recall instruction). Healey and Uitvlugt hypothesized that the order-focus instruction would strengthen temporal organization, increasing the TCE, whereas the meaning-focus instruction would strengthen semantic organization. The results were that semantic organization was the most significant under the meaning-focus instruction and that the size of the TCE was the greatest under the order-focus instruction and significantly lower under the meaning-focus instruction.

Therefore, Healey and Uitvlugt demonstrated that control processes modulate temporal and semantic organization.

Interestingly, when further examining the data of the meaning-focused condition, Healey and Uitvlugt found that the participants used temporal information to decide which same-category items they would recall next. That is to say, though same-category items were separated by different-category items in the study list, participants encoded serial order of same-category items and followed the serial order to search items within the same category. It seems that even when the meaning-focus instruction is given, participants still encode temporal order information and show temporal organization. This finding is similar to that of an early study by Tulving and Pearlstone (1966) in which they discovered that participants tended to recall items in the same order as they appeared in the original list when given category names as retrieval cues. Healey and Uitvlugt finally suggested that control processes determine how much temporal information is used during memory search but they do not prevent this information from being registered in the memory system.

Memory Models Account for Recall Organization and the Role of Control Processes

Retrieved context models provide an account of the cognitive mechanisms responsible for recall organization (Howard & Kahana, 2002; Sederberg, Howard, & Kahana, 2008; Polyn, Norman, & Kahana, 2009). These theories propose that the process of memory search is driven by associations between studied items and internally maintained contexts that are formed during the study of items, and that contexts are used to probe memory. The mental contexts are either temporal contexts or semantic contexts. When participants begin memory search, the first item recalled reinstates its context that cues the next recall, which then reinstates its context, and so on. The cued recall is usually one of the neighbors of the last recalled item. Temporal contexts support retrieval of temporal neighbors (i.e., items learned nearby in time), whereas semantic contexts support retrieval of semantic neighbors (i.e., items that are semantically related). If the memory search process uses these contexts to guide memory retrieval, then memory search shows temporal and semantic organization.

The retrieved context models have not yet explored whether control processes are important in memory dynamics between instruction conditions. In comparison, the traditional dual-storage models emphasize the essential role of control processes in memory encoding and memory retrieval (Atkinson & Shiffrin, 1968; Raaijmakers & Shiffrin, 1980). The dual-storage models posit that control processes can selectively rehearse particular items in a "rehearsal buffer" during memory encoding. Items rehearsed simultaneously are associated and their associations are stored in the long-term memory (LTM). Hence, when given meaning-focus instruction, our control processes will selectively rehearse items that have similar semantic meanings and our memory search will then show strong semantic organization because we have associated them in the LTM.

Continual Distraction Affects Recall Organization

Continual distraction has been shown to disrupt semantic organization while has no impact on temporal organization. In the continual distraction free recall paradigm, participants are asked to perform a distractor task between each two list items. Morton & Polyn (2017) used math tasks of different length of time (short vs. long) as inter-item distractors and showed that continual distraction tasks decreased category clustering of the studied materials without affecting their temporal organization, regardless of how long the distraction was. The work by Lohnas and Kahana (2014) also discovered similar results and pointed out that their participants even exhibited strong long-range contiguity effects, which means that participants manifested the TCE even when substantial temporal gaps (i.e., increased amount of inter-item distraction) separated one item from another. The finding that temporal organization was not disrupted is consistent with what the retrieved context models would predict, for they suggest that the recalled item reinstates its context that cues the recall of its nearest neighbors and that this process cannot be significantly modified by inter-item distractors (Kahana, 2014). This is because even though the nearest neighbors are pushed further away by the inter-item distractors, they are still the closest, as the other items on the list have been pushed even further away. Consequently, the recall of neighboring items are still well supported. Nevertheless, in one study of our lab, Cutler, Jeon and Polyn (2020) used math task distractors of different levels (light vs. heavy) to study the effects of continual distraction and found that participants' temporal organization was disrupted by heavy distraction compared to light distraction, potentially posing a challenge to the retrieved context models.

The Present Study

The present study built upon previous research on the effects of control processes and continual distraction on recall organization, and how memory theories, particularly the retrieved context models, account for them. The first goal was to replicate Healey and Uitvlugt's (2019) findings that different control processes led to different recall organization. Second, we wished to reconcile the conflicting findings regarding whether increased continual distraction disrupted temporal organization. Finally, we examined if the effects of control processes on memory performance would be modified by continual distraction levels.

Methods

Participants

We recruited 96 participants via Amazon Mechanical Turk. After we filtered out participants who used paper or electronic aids to do our memory tasks and who did not follow our instructions strictly, the sample size was 65. The sample consisted of 43 male participants and 22 female participants ranging in age from 23-67 years old (*M* = 38.200, *SD* = 11.036). Participants completed our experimental tasks using a browser-based experiment hosted on a server and received monetary payment for their completion. Participants were randomly assigned to one of the three instruction groups: the non-instruction group (*n* = 25), the order-focus group (*n* = 21), and the meaning-focus group (*n* = 19).

Design

Our experiment was built in lab.js and conducted online. The experiment consisted of a 3 (control processes: non-instruction, order-focus, meaning-focus) x 2 (continual distraction levels: light, heavy) mixed factorial design with control processes as a between-participants factor and continual distraction levels as a within-participants factor. Instructions were presented to participants at the beginning of each trial. The meaning-focus instruction group was instructed to use the semantic associations of the list items to memorize and recall items. The order-focus instruction group was instructed to rely on the original order of the list items to memorize and recall items. The non-instruction group was not given any specific instructions regarding memorization and recall. All the participants completed four trials of study and recall. For the first and third trials, participants were asked to do a light distractor task every time after studying a list item; for the second and fourth trials, participants were asked to do a heavy distractor task every time after studying a list item. The level of distractor task remained consistent for each trial. The dependent variable is participants' recall performance. We measured recall performance by examining recall accuracy, primacy and recency effects, semantic organization, and temporal organization.

Materials

List construction. Each word list was composed of three distinct taxonomic categories which each contained nine items. Twelve categories and their exemplars were chosen from the word pool used in Polyn, Erlikhman, and Kahana (2011). The word pool had been originally developed by Battig and Montague (1969) and Van Overschelde, Rawson, and Dunlosky (2004). It was constructed through asking participants to write down any category exemplars they could think of when given a particular category name.

We used the list construction method from Cutler et al.'s (2020) study. We further divided each category into three sets which were each composed of three category exemplars in a fixed order. The sets of category exemplars were interwoven in the list, with the constraint that no sets of the same category were presented next to each other. As an example, one short word list would be: *grape*, *tangerine*, *apricot* (*category A*); *folk*, *punk*, *pop* (*category B*); *Sweden*, *Brazil*, *Switzerland* (*category C*); *soul*, *opera*, *blues* (*category B*); *Japan*, *Iceland*, *Australia* (*category C*); *mango*, *raspberry*, *pear* (*category A*).

Distractor tasks. A series of single-digit numbers appeared on the screen. After three numbers appeared, the next number would have a question mark next to it. For the light distractor task, participants were asked to press the 'N' key when seeing the number with the question mark appear on the screen. For the heavy distractor task, participants were asked to determine whether the sum of the three single-digit numbers equaled to the number with the question mark. Specifically, they were asked to press the 'N' key if it was correct and to press the 'M' key if it was incorrect.

Procedure

To begin with, participants were told that in each trial they would learn a list of words and recall as many words as possible after the study of the list. They were then randomly assigned to one of the three instruction groups.

Order-focus group. Participants were instructed to use the temporal order of the list items to study items and to guide recall. Specifically, they were told: "Memory search is helped by the order in which you memorize the words. Remembering one word might remind you of its neighboring words in the list. When studying the lists, try to use the order to help you remember words. During the recall period, try to use the original order of the list items to guide your memory search."

Meaning-focus group. Participants were instructed to use the semantic associations of the list items to study items and to guide recall. Specifically, they were told: "Memory search is helped by the meaning of the word. Remembering one word might remind you of another word that is semantically related. For example, APPLE → ORANGE → BANANA. When studying the lists, try to use the semantic associations of the items to help you remember words. During the recall period, try to use the semantic associations of the list items to guide your memory search."

Non-instruction group. Participants were not told that semantic associations among list items and the temporal order could help memorization and recall. They started studying the list items directly.

After learning the instructions (or not learning any instructions), participants were told that during the trials they would need to do a distractor task every time after a list item was presented. They were also told that the distractor task would be either an easy (light) task or a hard (heavy) task, and that the level of task would remain consistent for each trial.

During the study phase, list items were presented one at a time on the computer screen for 2.5 seconds. Participants were asked to press the SPACE bar when the list items came up on the screen to keep attentive. Each item presentation was followed by a distractor task that lasted for 5 seconds. Following the final item presentation and a 5-second pause, the recall period began. Participants were given 90 seconds to recall list items by typing in all the words they could remember from the list. After the recall period, participants were able to choose if they wanted to take a break or directly start the next trial. Participants completed 4 trials. At the end of the experiment, participants were asked if they used any electronic or paper aid to remember the items. Participants' recall were not considered if they answered 'Yes' to the question.

Results

How did control processes and continual distraction affect general recall performance?

We begin by examining how the recall instructions and continual distraction influenced the recall accuracy (Fig. 1). We found that participants showed the strongest recall performance when they were told to focus on the semantic meaning of the study items. Means and standard deviations of recall accuracy (averaged across the two distraction levels) by instruction condition are presented in Table. 1. The meaning-focus instruction significantly improved the participants' recall accuracy compared to the non-instruction ($t(42) = 2.188$, $p < .05$). The difference between the meaning-focus and the order-focus instruction was tending towards significance ($t(38) = 2.018$, $p = .051$). There was no significant difference between the non-instruction and the order-focus instruction ($t(44) = .212$, $p > .05$). Within each of the three instruction conditions, the recall accuracy did not differ between the light and heavy distraction (non-instruction: $t(24) = -.149$, $p > .05$; order-focus: $t(20) = -.340$, $p > .05$; meaning-focus: $t(18) = -1.226$, $p > .05$).

The finding that the meaning-focus instruction led to significantly better recall performance than the non-instruction while the order-focus instruction did not suggest two interesting things about control processes. First, participants were able to create retrieval plans that could easily help them recall more items using semantic information; they simply needed the recall instruction that could remind them of the availability of the control processes that emphasized semantic information. Second, it seemed very likely that participants in the non-instruction condition used the temporal order information even without the order-focus instruction so that their performance did not significantly differ from those in the order-focus condition. This finding may provide further support for the previous theory that no matter what control processes are employed, temporal information is always encoded and more or less used (Healey & Uitvlugt, 2019).

Table. 1 Means and standard deviations of recall accuracy (averaged across the two distraction levels) by instruction condition

	Non-instruction	Order-focus	Meaning-focus
Mean	.332	.324	.416
Std. Deviation	.109	.142	.146

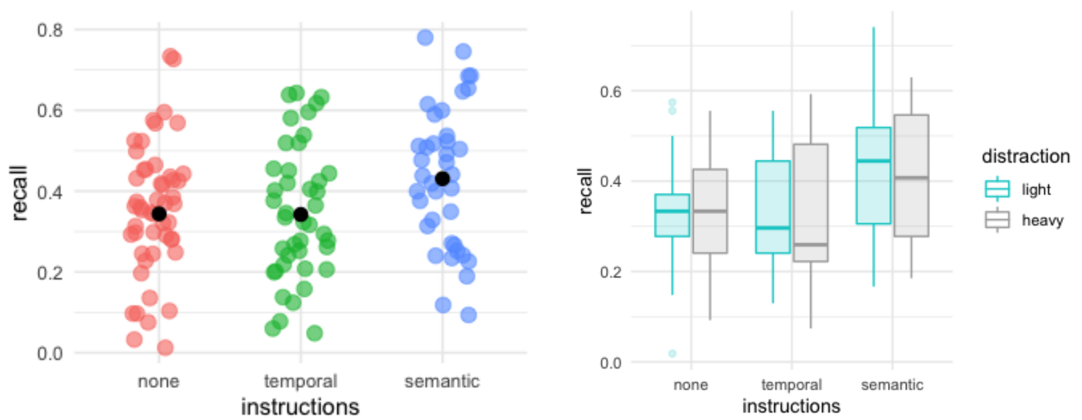


Fig. 1 Recall accuracy by instruction condition (left, not averaged across the two distraction levels) and by distraction level (right)

The results of a two-way ANOVA (Table. 2) confirmed that there was a significant main effect of instruction conditions on recall accuracy ($F(2, 7014) = 24.813$, $p < .01$) but there was no significant main effect of distraction levels ($F(1, 7014) = 1.696$, $p > .05$). The interaction between instruction conditions and distraction levels was not significant ($F(2, 7014) = .217$, $p > .05$), suggesting that distraction levels did not modify the influence of control processes on recall accuracy.

Table. 2 Two-way ANOVA

	Df	Sum Sq	Mean Sq	F value	Sig
Instruction	2	11.300	5.634	24.813	.000*
Distraction_Level	1	.400	.385	1.696	.193
Instruction* Distraction_Level	2	.100	.049	.217	.805

We then examined the recall dynamics with the serial position curve (SPC). SPCs show the probability of recalling an item as a function of its serial position in the list. In immediate free recall, a typical SPC is U-shaped, meaning that the first few items and the last few items in the list are more likely to be recalled by participants. In other words, the SPC is characterized by the primacy effect and recency effect (Kahana, 2014). Previous studies have discovered that the recency effect is usually larger than the primacy effect in immediate free recall (Healey & Kahana, 2014). None of our SPCs by instruction condition were consistent with this pattern; in fact, none of our SPCs showed strong recency effects (Fig. 2). The results implied that our data was noisy, yet they might also support Healey and Uitvlugt's (2019) theory that the control processes that emphasized temporal order and semantics encouraged participants to give up the traditional memory strategy of holding the last few list items in the short-term memory to ensure that these items could be well recalled and to focus on strengthening the recall organization instead.

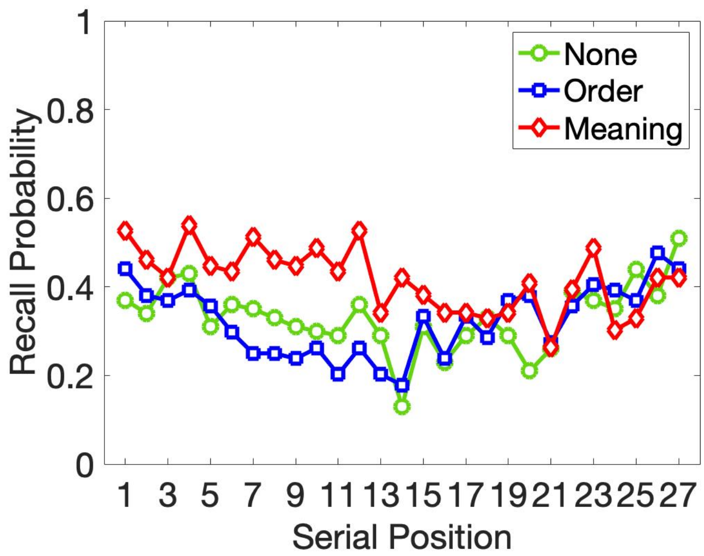
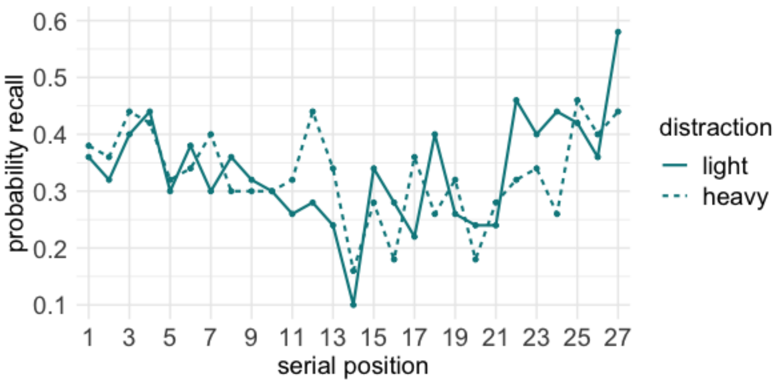
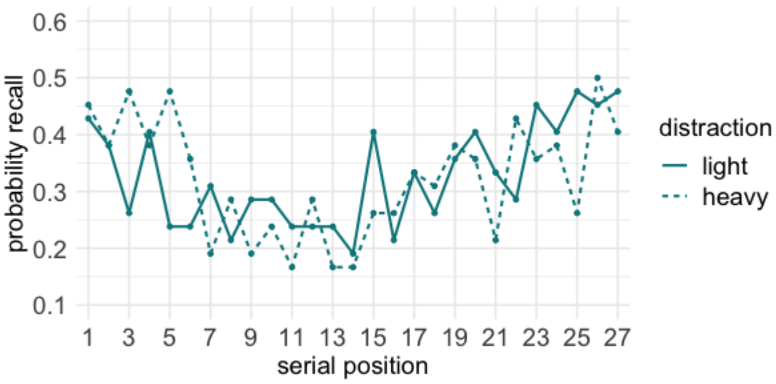


Fig. 2 Serial position curves by instruction condition

The SPCs by distraction showed that distraction levels did not significantly influence the primacy and recency effects (Fig. 3). The results were different from Cutler et al.'s (2020) finding that heavy distraction decreased the size of the primacy effect. This might pose a challenge to Cutler et al.'s predictions with the retrieved context models, as they suggest that intense distraction modifies temporal context at an accelerated rate, causing the context of the items at the beginning of the list to be dissimilar from the context at the time of recall such that the items lose their primacy advantage. However, as mentioned above, our data was noisy and our failure to replicate Cutler et al.'s finding might be caused by situation noise. Since this was an online study and participants completed our experimental tasks outside the lab, the less controlled environment might have distracted participants from focusing on our tasks and consequently obscured the true difference.



(a)



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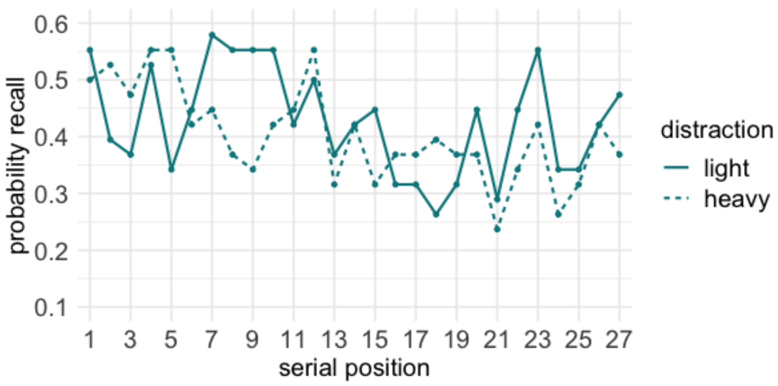


(c)

Fig. 3 Serial position curves by distraction. (a) Non-instruction; (b) order-focus instruction; (c) meaning-focus instruction

How did control processes and continual distraction affect semantic and temporal organization?

To measure semantic organization of recall, we used list-based semantic clustering (LBC_{sem}). LBC_{sem} measures the extent to which participants exhibit semantic organization during learning and use it to retrieve list items during recall (Delis et al., 2010). LBC_{sem} indices quantify how many observed clusters have occurred in recall beyond what would be expected if list items were recalled randomly; positive indices indicate occurrence of semantic organization, whereas negative indices indicate that other forms of organization besides semantic organization (e.g., temporal organization) predominate the recall organization (Stricker et al., 2002).

To measure temporal organization of recall, we used temporal factor scores, or temporal organization scores. The temporal organization score is computed by ranking each actual lag transition with respect to all possible lag transitions and then averaging the results (Sederberg et al., 2010; Healey & Uitvlugt, 2019). Lag is the difference between two recalled list items' serial positions. As an example, if one recalls the item from serial position 4 and then recalls the item from serial position 6, the lag = +2. However, if the recall of the item from serial position 4 is followed by the recall of the item from serial position 2, then lag = -2. The actual lag means the absolute value of the lag. Temporal organization scores > 0.5 indicate temporal clustering.

The LBC_{sem} (averaged across the two distraction levels) by instruction condition and the temporal organization scores (averaged across the two distraction levels) by instruction condition were shown in Fig. 4. We found that the size of category clustering was the greatest under the meaning-focus condition, suggesting that meaning-focus instruction strengthened semantic organization. The results of two sample t-tests revealed that category clustering of the meaning-focus condition was significantly greater than that of the non-instruction condition ($t(70.204) = 2.133$, $p < .05$). There were no significant differences between the non-instruction condition and the order-focus condition ($t(81.805) = -.446$, $p > .05$), and between the order-focus condition and the meaning-focus condition ($t(75.965) = -1.571$, $p > .05$).

Regarding the temporal organization, we discovered that the meaning-focus instruction led to the largest temporal clustering and that the temporal organization scores varied significantly across the three instruction conditions (non-instruction vs. order-focus: $t(86.854) = -2.110$, $p < .05$; non-instruction vs. meaning-focus: $t(76.991) = -4.133$, $p < .05$; order-focus vs. meaning-focus: $t(75.919) = -2.086$, $p < .05$).

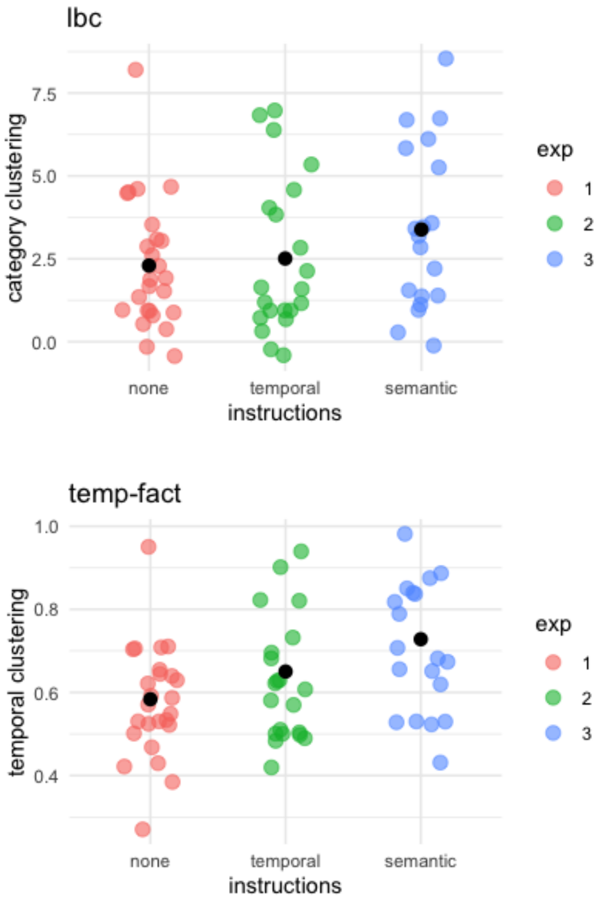
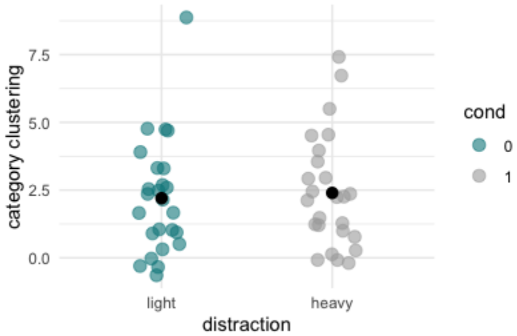
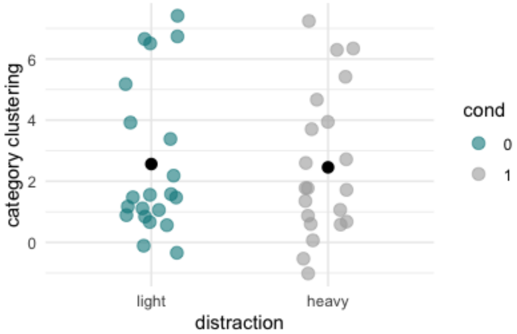


Fig. 4 Category clustering (LBC_{sem}) by instruction condition (top, averaged across the two distraction levels) and temporal clustering (temporal organization scores) by instruction condition(bottom, averaged across the two distraction levels)

While different instruction conditions more or less affected the recall organization, continual distraction levels had little influence on both semantic and temporal organization (Fig. 5 and Fig. 6). Within each of the three instruction conditions, both the category clustering (non-instruction: $t(24) = -.619$, $p > .05$; order-focus: $t(20) = .382$, $p > .05$; meaning-focus: $t(18) = .171$, $p > .05$) and the temporal clustering (non-instruction: $t(24) = -.502$, $p > .05$; order-focus: $t(20) = .224$, $p > .05$; meaning-focus: $t(18) = 1.350$, $p > .05$) did not differ between the light and heavy distraction (Fig. 5 and Fig. 6).



(a)



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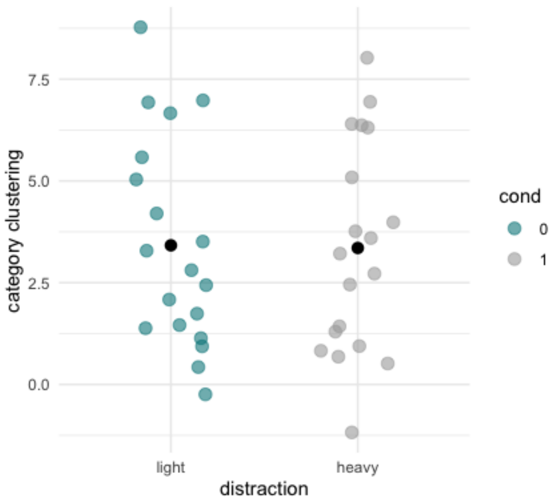

(c)

Fig. 5 Category clustering (LBC_{sem}) by distraction. (a) Non-instruction; (b) order-focus instruction; (c) meaning-focus instruction

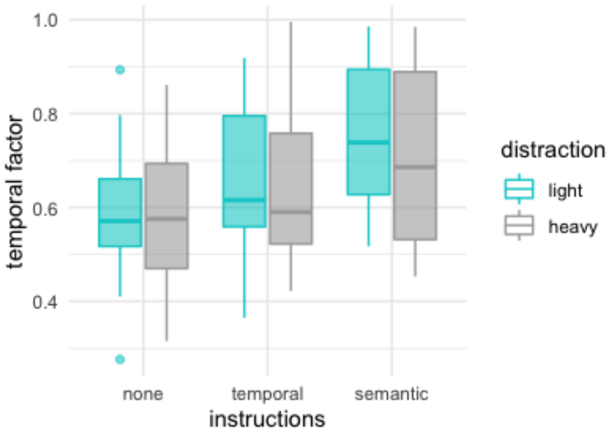

Fig. 6 Temporal clustering (temporal organization scores) by distraction

Discussion

We had three main study goals. First, we attempted to replicate Healey and Uitvlugt's (2019) finding that control processes modulated the size of semantic and temporal organization. Second, we wanted to know if different levels of continual distraction would disrupt temporal and semantic organization differently. Third, we went beyond earlier work to investigate if there would be an interaction between control processes and continual distraction levels with regard to memory accuracy.

Our results only supported parts of Healey and Uitvlugt's (2019) finding. While we did discover that meaning-focus instruction led to the greatest semantic organization, we failed to show that the temporal organization was the largest under the order-focus instruction. We tend to think that the failure to replicate the effects of order-focus instruction was caused by the difference in the list structure. In Healey and Uitvlugt's categorized lists, members of the same semantic cluster were never presented in adjacent serial positions such that temporal and semantic information was placed in opposition. That is to say, any increase in semantic organization would by necessity decrease temporal organization, and vice versa. In contrast, our lists had three items from the same category presented to participants successively as a set, which encouraged participants to group the same-category items together while also enhancing the temporal clustering because the semantically associated items were temporal neighbors. Therefore, in the meaning-focus condition, though participants were not told to focus on the temporal information to memorize items, their semantic clustering helped them build strong temporal organization. The combination of the list structure that emphasized both semantic and temporal information and the meaning-focus instruction led to the cooccurrence of significant semantic and temporal organization. Atkinson and Shiffrin (1968) suggested that besides the nature of the instructions, factors influencing control processes also include the meaningfulness of the material. Healey and Uitvlugt's comparison of random lists (lists that lack consistent semantic structure) to categorized lists have proved this theory to be true. Here, we show that how the meaningful material is structured also matters.

We also found that continual distraction levels did not affect their disruption to recall organization. Our finding is therefore consistent with the results of some earlier studies (Morton & Polyn; Lohnas & Kahana, 2014) and provides support for the retrieved context models which would predict that increased inter-item distractors do not affect temporal organization. Finally, we found that the effects of control processes on recall accuracy were robust and insensitive to the levels of continual distraction. This suggests that when continual distraction presents, intervention in control processes at encoding can consistently enhance memory performance regardless of whether the distraction is light or heavy.

This study has a few limitations. Since the experiments were conducted online, we could not control participants' experimental environment and thus our data was noisy. Some participants did not pay full attention to our experimental tasks and some did not follow our instructions strictly. We also could not monitor if participants used any electronic or paper aid to complete our memory tasks; even though we asked them a question to check on this issue and told them that their payment would not be affected by their answers to the question, they might still have answered untruthfully. Another problem was related to our manipulations of continual distraction. We did not include a non-distraction condition so we could not contrast effects of "some distraction" to those of "no distraction". We only compared the effects of "some distraction" to those of "more distraction" (light vs. heavy). We considered this as a flaw in our experimental design because a non-distraction condition would have allowed us to find out whether participants would show substantially different performance when there is nothing distracting them from implementing control processes.

Future research should therefore further investigate the interaction between control processes and continual distraction by comparing how control processes would affect recall organization when there is no distraction to when there is distraction. In addition, future research can look at if changing the type of distractor tasks will lead to different results. Most of the recent studies on continual distraction used math tasks as distractors so it remains to be seen how continual distractors that require different types of cognitive processing may influence recall organization. We originally planned to expand upon Petrusic and Jamieson's (1978) finding that various types of delayed distractors, particularly the music-listening task (listening to music) and shadowing task (to say the name of a two-digit number when it is presented on the screen), led to different recall decrements, and to examine what would happen if these distractors were continual. However, since we transferred our study to online settings due to the COVID pandemic, we have had difficulty coding these two distractor tasks in the new online research tools within a limited time. Consequently, we were unable to study this research question and we hope to examine it in the future.

Conclusion

We extended Healey and Uitvlugt's (2019) study by incorporating continual distraction as a factor and by using a new list construction method. We showed that list composition influenced control processes, and specifically, list structure that emphasized both semantic and temporal information led to large temporal organization even when the instruction only emphasized semantic organization. We also reconciled the conflicting findings about whether continual distraction levels have influence on their disruption to temporal organization by demonstrating that the influence was minimal. Therefore, we argue that the retrieved context models are still a compelling theory. We finally found that a transition from light to heavy distraction did not change participants' control processes at study. However, since we did not include a non-distraction condition, further studies are needed to investigate the effects of control processes when there is no distraction compared to when there is some distraction. Together with Healey and Uitvlugt's study, we have shown that control processes play an important role in memory encoding and retrieval. Hence, we wish that future research can extend our understanding of control processes and how they interact with distraction so that we can help people memorize things more effectively and efficiently.

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