The Influence of Context Change on Hypermnesia

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Abstract

Hypermnesia refers to the phenomenon of increased recall of items across repeated tests, without additional studying or learning opportunities (Wallner & Bauml, 2018). However, the mechanisms underlying hypermnesia remain unclear. In traditional experiments, participants are not aware that they will be receiving multiple recall tests. This study aimed to investigate whether informing participants in advance about the number of recall tests they will receive influences hypermnesia. Participants were presented with a PowerPoint presentation containing 35 line drawings and were subsequently given three free-recall tests. It was hypothesized that participants who were informed about the number of recall tests they would receive (i.e., no context change group) would exhibit less hypermnesia compared to those who were not informed (i.e., context change group). Surprisingly, the results revealed that informing participants about the number of recall tests did not affect overall item recall, gains, losses, or errors. To further explore these findings, a second experiment was conducted using words instead of line drawings to increase task difficulty. The results of the second experiment were consistent with those of the first, except that a significant difference in item gains was found between the context change and no context change groups. These findings suggest that when using words instead of line drawings, informing participants about the number of recall tests leads to more gains across tests. Overall, our study provides some evidence that not informing participants about the number of recall tests they will receive results in greater reminiscence.

The Influence of Context Change on Hypermnesia

Hypermnesia is the increased recall of items across successive tests. Typical experiments that test hypermnesia expose participants to a set of items, such as words or images, and then participants are asked to recall these items across repeated tests (Wallner & Bauml, 2018). Wallner and Bauml (2018) suggest that there are two overarching processes underlying hypermnesia. Reminiscence occurs when participants are able to recall new items that were not recalled on earlier tests. Intertest forgetting, on the other hand, occurs when participants are able to recall items on the first test, but fail to recall them on subsequent tests (Wallner & Bauml, 2018). Hypermnesia then occurs when the rate of reminiscence exceeds inter-test forgetting.

Although researchers have not yet been able to explain the mechanisms that underlie hypermnesia, a variation of explanations have been suggested. One of the most well-known explanations explaining the effect of hypermnesia is the *cumulative recall hypothesis* (Roediger et al., 1982). This hypothesis would argue that hypermnesia occurs because of the increasing level of recall items, and that when testing conditions are able to produce high levels of recall, hypermnesia is more likely to occur. Roediger et al. (1982) argues that hypermnesia occurs when recall has reached its asymptotic level (i.e. the potential for the maximum level of recall). Subsequent tests allow for items not mentioned previously to be recalled. A number of conditions influence the degree to which the asymptotic levels are achieved (i.e. nature of the test items, length of delays between tests) (Wallner & Bauml, 2018). One implication of this hypothesis is that there is an inverse relationship between the delays between tests and hypermnesia. According to this hypothesis, longer delays should decrease cumulative recall levels and therefore decrease hypermnesia. However, Wallner and Bauml (2018) not only found that hypermnesia was greater in the long delay condition, but also that hypermnesia was non-significant in the short delay condition. This effect was due to a reduction in item losses in the long delay condition.

Other explanations that have emerged include the *changes in cue set hypothesis* and the *retrieval strategy hypothesis* (Wallner & Bauml, 2018). The *changes in cue set hypothesis* states that people may recall more items on later tests because alternative retrieval routes may be used when recalling items on a test, which may lead to the retrieval of items that were not recalled on former tests. However, direct tests of this hypothesis are rarely found in literature on hypermnesia. The retrieval strategy hypothesis states that hypermnesia results from improved retrieval strategies and organization after repeated testing. However, this hypothesis is unable to explain why research has shown that hypermnesia is greater when participants are exposed to images as opposed to words (Wallner & Bauml, 2018).

Wallner and Bauml (2018) also examined hypermnesia using different recall methods, including free recall and forced recall. Forced recall methods included giving participants a page of blank lines and asking them to write down every item that they saw while leaving no lines blank. If they forgot an item, they were to fill it in with a guess (Wallner & Bauml, 2018). Free recall methods, on the other hand, involved asking participants to list as many items as they could remember without putting a constraint on how many items they had to list (Wallner & Bauml, 2018). Participants in each condition underwent repeated testing. It was found that hypermnesic effects were found in the free recall condition, but not in the forced recall condition when a longer delay between tests was used. It is suggested that hypermnesia was present in the free-recall condition because participants were not expected to recall a certain number of items, but rather as many items as they could remember (Wallner & Bauml, 2018). However, hypermnesia was equivalent between the free and forced recall formats when the delay was shorter (Wallner & Bauml, 2018). Wallner and Bauml (2018) suggest that recall format as well as other factors (i.e. length of delay) mediate hypermnesia.

Current Study

The dependent variables in the present study are free recall over tests, measures of recovery, and intertest forgetting. Free recall over tests is the number of items that are recalled over tests; recovery refers to items not recalled on previous tests but recalled on subsequent tests. Intertest forgetting is when earlier recalled items are forgotten on later tests. The study will be looking at how context change affects hypermnesia. Participants are going to be shown a number of items and will be told to recall as many items as possible.

What will be manipulated in the present study is whether or not people are going to be told that they will be receiving three tries to recall the items. When participants suddenly find out that they have a second test, this is a change in context. Bauml and Schlichting (2014) observed that retrieval of items can have adverse effects on hypermnesia after a short retention interval and similar context between encoding and test. However, when there were changes in the social and spatial context between encoding and the test, as well as a longer retention interval, the retrieval of items were improved. Bauml and Schlichting (2014) believed that this effect was because changing the social and spatial locations mimicked the way participants retrieve information in everyday life; in different locations, around different people, and when internal emotions states are different.

Predictions

We can hypothesise that when participants are given a change in context, they are more likely to exhibit greater hypermnesia (i.e. higher recall and less intertest forgetting of items across subsequent tests) than when participants are not given a change in context. The presentation of an unexpected second test changes the testing context (i.e. people are expecting one memory test and then they are surprised with multiple memory tests), and such changes may have a number of effects on information processing and recall. At the end of our present experiment when our participants will be asked if they were expecting there to be multiple tests. We would expect that people in the traditional hypermnesia experiment, where the context is violated, would say that they only expected to have one test. Based on the idea of an unexpected second test, it might be that context change is the norm for hypermnesia research. For example, in Mulligan (2006), and Roediger and Payne (1985) participants were not told that there would be a second recall test prior the administration of the first recall test. Further, this context change forces the participant to search for new retrieval routes on an unexpected second and then third memory test.

Context Change Group

Participants use these new retrieval routes to bring them back to the original episodic trace, while potentially retrieving previously unrecalled items in the process of doing so (Mulligan, 2006). For example, a context change changes the strategies that people use to sample and recover items. This in turn may lead to participants using additional alternative retrieval routes, which may increase item gains and therefore increase hypermnesia. Therefore, we may expect that the search for new retrieval routes serves to help people increase their item gains across tests (Mulligan, 2006). Wallner and Bauml (2018) found that after a delay-induced context change, hypermnesia increased. However, it was found that this effect was driven by a reduction in item losses, and there were no increases in item gains. Wallner and Bauml (2018) suggested that the recall performance is improved because the retrieval of the first few items reactivates the item’s study context, which acts as a retrieval cue for the other items. On the other hand, the no-context change group still presented hypermnesia, but to a lesser extent as there was no delay-induced contextual change. Wallner and Bauml (2018) discovered that item losses in the no delayed-induced context change group exceed item losses in the delay induced context change group. There were also no significant item gains across tests in either group that contributed to hypermnesia effects.

Additionally, for both groups there were more item losses between the first and second test than the second and third test.

Therefore, in our study we expect that participants that are in the context change group will show increased hypermnesia due to increased item gains and minimal item losses across subsequent tests. Participants will be unaware that three tests are coming, and as a result, participants will be less likely to manage their efforts across tests and have the cognitive resources to focus on finding alternative retrieval routes for the second and third tests.

No Context Change Group

On the other hand, those in the no-context change group should show reduced hypermnesia as they are more likely to manage their efforts, and therefore have fewer cognitive resources to focus on the second and third tests. One reason why participants in the no-context change group may exhibit lower hypermnesia than those in the context change group is because those in the no-context change group know that there will be three tests coming. When participants are aware that there are three tests, it may lead them to implement an effort management strategy, whereby participants' efforts are distributed across the tests so as not to ‘burn out’ on the first test. However, there is a cost to self-presentation: managing one’s self-presentation requires cognitive efforts, which in turn depletes one’s cognitive resources (Baumeister et al., 2005). Exerting such cognitive resources leaves participants with fewer resources to go search through memory for new retrieval routes to previously unrecalled words.

Furthermore, the depletion of such cognitive resources may influence item gains and item losses. Participants who manage their impression across tests may try to deliberately recall fewer items on the first test to leave room for improvement on the second test. The items accessed from memory on the first test may be those with the strongest episodic traces, and then on the second test, participants will be readily able to access the previously recalled items and in addition search memory for previously unrecalled items. The effect of this will be low intertest forgetting between test one and test two. Additionally, participants should also be able to show increased item gains between test one and two because of the artificial low ceiling they have given themselves on the first test. So, we are going to predict that in our study, on the second test there will be increased item gains and minimal item losses. However, on the third test, participants' cognitive resources may be depleted due to participants trying to maintain their impressions. As a result, participants may have minimal item gains and increased item losses across tests two and three. We can expect that hypermnesia will plateau across tests two and three for the no context change group.

General Method

Overview

The aim of this study was to examine whether there is a difference in hypermnesia between participants who were or were not informed about the number of recall attempts. In this study, participants were or were not told that they would have three opportunities to recall as many items as possible. Participants were subsequently presented with a slideshow containing 35 items from Snodgrass and Vanderwart's (1980) set. After a two-minute distractor task, participants were given three attempts to recall as many items as possible. The study measured the number of items recalled, gains or losses in item retention, and errors made across all three recall attempts.

Participants

Participants consisted of volunteers (N=101) from Brandon University undergraduate psychology courses. Participants received a 1% bonus mark towards their course credit. In study one, 60 students participated, and in study two, 41 students participated. Sample size determination was informed by an a-priori power analysis using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) for a two way interaction in a mixed analysis of variance. The parameters for the analysis were alpha=0.05, a medium effect size (f=.25), two levels of a between subject factor (context change vs no context change), three levels of a within subject factor (i.e. test 1, 2, and 3) and a moderate correlation (r=0.50) among the within-subject group. The outcome of the analysis revealed that a minimum sample size of 28 participants per group for each study would be required to obtain a power of .95.

Procedure

Prior to the start of the PowerPoint presentation, participants were given a set of instructions. In the context change group, the instructions did not reveal that three recall tests would be administered, while in the no context change group, participants were informed of the three tests. Participants were presented with a PowerPoint slideshow, containing 35 items, which were either line drawings (Study 1) or words (Study 2) of concrete nouns. Each item was displayed for a duration of five seconds, followed by a two-second blank screen.

After the presentation, both groups engaged in a two-minute word search task to minimize recency effects. On each trial, participants were instructed to write down as many items as they could remember within the five-minute limit. At the conclusion of the third test, participants were informed that the study was complete.

Proposed Analysis

In this study, we aimed to investigate the differences in hypermnesia between the context change and no context change groups using mixed ANOVAs. Specifically, we measured item recall, gains, losses, and errors between the two groups. A mixed, 2 Group (Context Change, No Context Change) x 3 Tests (Test 1, Test 2, Test 3) ANOVA was used to assess total item recall and errors. This allowed us to investigate if hypermnesia occurred across the three tests for each group, as well as the amount of errors made across the three tests. Furthermore, a mixed 2 Group (Context Change, No Context Change) x 2 Tests (Test 1-

2, Test 2-3) ANOVA was used to assess item gains and losses. In order for hypermnesia to be present, item gains must exceed item losses. Through analyzing the variations in the results of the three recall tests of each participant, we examined whether there were significant hypermnesic effects. For each ANOVA we performed, we examined three main effects: the effect of the test itself, the effect of the group, and the interaction between the test and group to determine whether the hypermnesia effect differed across the tests based on whether participants were informed in advance that they would have three attempts to recall as many items as possible.

Experiment 1

Method

In this study, we administered a series of 35 line drawings to N=60 participants in a PowerPoint presentation, and subsequently conducted three recall tests to measure item recall, gains, losses, and errors.

Results and Discussion

The first dependent variable that we examined was the recall of items across tests. A summary of this data is reported in Table 1. Inspection of this data pattern shows that recall increases across the tests. We conducted a 2 (context change vs. no context change) x 3 (tests) mixed factor analysis of variance based on the data summarized in Table 1. The main effect of test was significant $F(2,116)= 26.213$, $MSerror= 1.829$, $p<.05$. A follow up Tukey HSD test shows that recall on test 1 was lower than both test 2 and test 3, and there was no significant difference between test 2 and test 3. This shows that across the three tests, people are recalling more items but they reach the maximum number of items on the second test. Furthermore, there was no significant main effect of group $F<1$ and the interaction between the test and group was also not significant $F< 1$. From these results we have evidence that hypermnesia occurs in both the context change and no context change group, and we have no evidence that hypermnesia significantly differs between groups.

Table 1

Mean and Standard Deviation of Items Recalled Across Tests for Each Group

		Tests					
		Test 1		Test 2		Test 3	
		M	*SD*	*M*	*SD*	*M*	*SD*
Groups	Context Change	17.55	5.578	18.55	5.366	19.17	5.285
	No Context Change	17.10	5.069	18.52	5.328	18.97	5.030

We next examined the number of gains on test 2 and test 3. Item gains (also known as reminiscence) occur when participants are able to recall new items that they were not able to recall on earlier tests. Table 2 reports item gains across tests between groups. We conducted a 2 (context change vs. no context change) x 2 (tests) mixed ANOVA. Although we found gains, they did not significantly differ between test 2 and test 3 $F(1,58)= 3.063$, $MSerror= 1.757$, $p=.085$. Moreover, there was no significant main effect between the groups $F(1,58)=1.394$, $MSerror= 1.547$, $p=0.23$. Across the three tests, participants were remembering more information, however, this effect does not vary by group. There was also no evidence of an interaction $F<1$. This demonstrates that those in the context change group reported a similar number of gains across tests as those in the no context change group.

Table 2

Average Number of Gains on Test 2 and Test 3 for Each Group

				Item Gains			
				Test 2		Test 3	
Groups	Context Change	*M*	*SD*	1.83	1.277	1.69	1.340
	No Context Change	*M*	*SD*	1.94	1.340	1.23	1.203

In addition, we examined the number of losses across tests. Item losses (also known as interest forgetting) occur when participants are able to recall items on earlier tests, but then fail to recall them on subsequent tests. The data pattern is reported in Table 3. A 2 (context change vs. no context change) x 2 (tests) mixed ANOVA shows that there were no differences in losses across tests. Furthermore, the number of losses across tests was not significant F<1. Additionally, there were no differences in losses between groups F(1,58)=1.144, MSerror=1.296, p=.289. Furthermore, there was no interaction of losses between tests and groups F<1.

Table 3

Average Number of Losses on Test 2 and Test 3 for Each Group

	Item Losses	
	Test 2	Test 3

Groups	Context Change	*M*	*SD*	.93	.923	.97	.906
	No Context Change	*M*	*SD*	.58	1.366	.87	.934

Finally, the number of errors were examined. When participants recalled items that were not presented at study, they made errors, also referred to as incorrect items. Table 4 represents the average number of incorrect items recalled on test 1, 2, and 3. Furthermore, a 2 (context change vs. no context change) x 3 (tests) mixed ANOVA showed that there was a significant increase in the number of incorrect items recalled across tests F(2,116)= 13.418, MSerror= 1.827, p=0.0001. A follow up Tukey HSD test shows that test 1 is not different from test 2, but there was a significant difference from test 2 to test 3. So as each test went on, people recalled more incorrect items and recalled the maximum number of incorrect items on test 3. It did not matter which group participants were placed in, as participants made the highest number of errors on test 3. When the number of incorrect items recalled were examined, there was no significant main effect for group F(1,58)=1.469, MSerror= 10.371, p=.230. and there was no interaction in the number of errors made F(2,116)= 1.674, MSerror= 1.360 p=.192.

Table 4

Average Number of Incorrect Items Recalled on Test 1, 2 and 3 for Each Group

	Tests					
	Test 1		Test 2		Test 3	
	M	*SD*	*M*	*SD*	*M*	*SD*

Groups	Context Change	1.03	1.451	1.55	2.063	2.48	3.147
	No Context Change	.87	1.432	.90	1.491	1.55	2.420

The results of our first study indicate that hypermnesic effects were present. This means that there was an increase in the number of items recalled across each test. The number of items that participants were able to recall (reminiscence) exceeded the number of items that they forgot (intertest forgetting) across each test. However, this effect did not differ when participants were placed in the context change group vs. the no context change group. In this study, participants were exposed to a series of line drawings which they were asked to recall across the three tests. It's conceivable that requesting participants to recall line drawings might have been too effortless of a task, given that visual information tends to be more easily retained in memory compared to verbal information. Introducing a greater degree of task difficulty by presenting words instead of line drawings could potentially facilitate discrimination between the context change and no context change groups. This is because verbal stimuli may pose a greater challenge to working memory and require additional cognitive processing compared to visual stimuli, thereby increasing the sensitivity of the task. So for our second study, we exposed participants to words instead of line drawings.

Experiment 2

Method

In the second study, we used “the same content” from experiment one, with the only difference being that we translated the previously shown line drawings into words. N=41 participants were told to remember the 35 words. We then subsequently measured item recall, gains, losses, and errors.

Results and Discussion

For our second study, we first examined the recall of items across tests. Inspection of this data pattern shows that recall increases across the tests. A summary of this data is reported in Table 5. We conducted from experiment 1 the mixed factor analysis of variance based on the data pattern found in Table 5. The main effect of test was significant F(2,78)= 5.612, MSerror= 1.518, p<0.05. A follow up Tukey HSD shows that there are no significant differences in recall between each test, but the overall changes from test one to three were significant and demonstrate hypermnesia. Furthermore, there was no significant main effect of group F(1,39)= 2.259, MSerror= 102.721, p=0.41. Additionally, the main interaction was not significant, F<1. From these results we have evidence that hypermnesia occurs in both the context change and no context change group, and we have no evidence that hypermnesia significantly differs between groups.

Table 5

Mean and Standard Deviation of Items Recalled Across Tests for Each Group

		Tests					
		Test 1		Test 2		Test 3	
		M	*SD*	*M*	*SD*	*M*	*SD*
Groups	Context Change	13.57	4.986	14.48	5.698	14.81	6.030
	No Context Change	16.75	6.172	17.05	6.362	17.30	6.317

We next examined the number of gains on test 2 and test 3. Table 6 reports that there were no increases in item gains across tests. We conducted a 2 (context change vs. no context change) x 2 (tests) mixed ANOVA. There was a significant effect between groups F(1,39)= 3.738, MSerror= 1.805, p=0.060. Participants who were in the context change group were able to recall a greater number of new items than those who were placed in the no context change group. Item gains did not significantly differ between test 2 and 3, F<1. There was also no evidence of an interaction F<1.

Table 6

Average Number of Gains on Test 2 and Test 3 for Each Group

				Item Gains			
				Test 2		Test 3	
Groups	Context Change	*M*	*SD*	1.67	1.653	1.38	1.396
	No Context Change	*M*	*SD*	.95	.999	.95	.826

In addition, we examined the number of losses across tests. We conducted a 2 (context change vs. no context change) x 2 (tests) mixed ANOVA. The data pattern is reported in Table 7, which shows that there were no differences in losses across tests. Furthermore, the number of losses across tests was not significant F(1,38)=1.126, MSerror=.711, p=.295. Additionally, there were no significant differences in losses between groups F<1 and there was also no interaction of losses between tests and groups F<1.

Table 7

Average Number of Losses on Test 2 and Test 3 for Each Group

				Item Losses			
				Test 2		Test 3	
Groups	Context Change	*M*	*SD*	.75	.639	1.05	.945
	No Context Change	*M*	*SD*	.70	.923	.80	1.056

Finally, the number of errors were examined. Table 4 represents the average number of incorrect items recalled on test 1, 2, and 3. Furthermore, the earlier described ANOVA showed that there was a significant increase in the number of incorrect items recalled across tests $F(2,78)= 12.588$, $MSerror= 1.669$, $p<0.01$. A follow up Tukey HSD test shows that errors on test 1 were lower than both test 2 and test 3, and there was no significant difference between test 2 and test 3. This shows that across the three tests, people increasingly make more errors but they reach the maximum number of items on the second test. When the number of incorrect items recalled were examined, there was no significant main effect for group $F<1$ and there was also no significant interaction in the number of errors made $F<1$.

Table 8

Average Number of Incorrect Items Recalled on Test 1, 2 and Test 3

	Tests					
	Test 1		Test 2		Test 3	
	M	*SD*	*M*	*SD*	*M*	*SD*

Groups	Context Change	1.29	1.488	2.38	2.747	2.48	2.112
	No Context Change	1.10	1.210	2.20	2.505	2.60	2.542

The results of our second study are similar to the results of our first study. In our second study, hypermnesic effects were once again present. Our results indicate that participants were able to remember more items on each test than they forgot, leading to an overall increase in the number of items recalled. In addition, we see that there was a significant difference in item gains between the context change and no context change groups. Overall, the results of the second study may suggest that the use of words instead of line drawings is capable of differentiating item gains between the context change and no context change group.

General Discussion

The results indicate for both experiment 1 and 2, hypermnesia was present in both the context change and no context change groups. This means that the overall number of items increased across the three tests, and therefore, item gains exceeded item losses. When comparing experiment 1 and 2, although hypermnesia was present in both experiments, we see that the overall number of items recalled was higher when participants were exposed to images instead of words. These results correspond with Roediger et al. (1982) *cumulative recall hypothesis* which contends that hypermnesia happens when recall has reached its asymptotic level, which is influenced by certain testing conditions, including using test items that are images instead of words. Furthermore, Wallner and Bauml's (2018) study also found that hypermnesia was greater when participants were asked to recall images instead of words. This finding holds true for our current study, as images are dually encoded whereas words are only encoded once.

Our results indicate that item gains drove our hypermnesia effects. Furthermore, in the traditional hypermnesia experiment, participants are unaware of how many tests there are going to be. Our results demonstrate that when presenting participants with words instead of line drawings, the use of the traditional method to measure hypermnesia results in more gains across both tests, compared to when participants are told that they will be receiving three tests. It appears that we have some evidence that not warning participants about the number of tests they will be receiving leads to greater reminiscence. We believe that when participants were told there would be three tests, they implemented an effort management strategy whereby participants distributed their efforts across the three tests. Implementing an effort management strategy uses cognitive resources, which may have led to minimal reminiscence in the no context change group compared to the context change group. These results correlate with Baumeister et al. (2005), in that managing one's self presentation depletes cognitive resources. Furthermore, presenting participants with more challenging conditions (i.e. words instead of line drawings) may facilitate subjects searching for alternative retrieval routes when multiple tests are not expected. This finding is consistent with Wallner and Bauml's (2018) *changes in cue set hypothesis* which states that alternative retrieval routes may be used to recall items on later tests which were not recalled on earlier tests, leading to an increase in the number of new items recalled (Wallner & Bauml, 2018). A reason that we may have received these results is that when participants are exposed to words instead of images, the task is more challenging and therefore requires participants to use greater cognitive resources to search memory when multiple tests are not expected. Therefore, accessing these alternative routes increases reminiscence. We did not observe any effect of test, group, or interaction when examining item losses for both of our experiments. These results demonstrate that while people tend to remember more items across tests, the number of items that they forget does not increase nor decrease. Therefore, an increase in item gains is what is driving our effect of hypermnesia.

The examination of participants item errors (where participants recalled items that were not presented to them) in both experiments show that item errors increase across tests. However, the item errors occur at both the same rate for those in the context change group and those in the no context change group. There were no differences between groups, and no interaction was present.

This study had multiple limitations worth noting. Firstly, our sample size was smaller than desired for the second experiment, with only 20 participants in the context change condition and 21 in the no context change condition. This limited our statistical power and may have affected the generalizability of our findings. Additionally, the length of delay between item presentation and test was relatively short, which may have limited the magnitude of hypermnesia observed. Future studies could assess hypermnesia by replicating the present study and increasing the length of delay between presentation and test. Furthermore, our study focused solely on the effect of informing participants about the number of tests they would receive on hypermnesia, while other factors that could influence hypermnesia were not examined. For instance, future studies could investigate the impact of factors such as the time of day of testing or the emotional valence of the stimuli.

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