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Effects of mobilizing prior knowledge on information processing: Studies of free recall and allocation of study time

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In this study, three experiments examine the effects of mobilizing prior knowledge on information processing. Subjects generated names of either US presidents or States before studying a relevant list. Study time allocated to different parts of the list and free recall were recorded. In Expt 1, study time was unlimited; no recall differences were found but experimental subjects spent less time studying the material. In Expt 2, total study time was fixed, but subjects were free to allocate the available time to individual items. Experimental subjects spent less time on items in the mobilized category and recalled more items. This facilitative effect of mobilization extended or 'spilled over' from mobilized to non-mobilized information. In Expt 3, where both time for studying individual items and, hence, total study time were fixed, experimental subjects recalled more mobilized category items than controls. These results were interpreted in terms of a cognitive set-point regulating the amount of time spent on processing different parts of the material. Mobilization reduces the time required to reach criteria set for mobilized category items during study since these items have been processed previously. Finally, these experiments prove that the set-point hypothesis applies not only to items actually mobilized but also to non-mobilized same-category items, probably through a process of spreading activation at mobilization.

Which names would come to Dutch students' minds if they were asked to list as many US presidents as possible? They would probably mention Bush, Reagan, Kennedy, Nixon and a few other well-known presidents. If they were subsequently shown a list of US presidents' names in random order (Bush, Hayes, Coolidge, Nixon, Polk, Tyler, Reagan) and asked to recall the items on this list after a 20-minute delay, one might expect that they would recall their initial list better than the subsequent list. The basis for this expectation would be the so-called *generation effect* (Hirshman & Bjork, 1988; Nairne & Widner, 1987). This effect reflects the phenomenon that self-generated items are recalled more easily than items presented by an experimenter. According to Slamecka & Graf (1978), the generation of items would 'serve (...) to increase their subsequent memorability' (p. 603).

Although this recall pattern seems plausible, a quite different pattern has been found by a number of researchers. Peeck (1982) presented two experimental groups

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of subjects and one control group with a list of 16 names of States of the Union and 16 US presidents and asked them to study these 32 items. Prior to studying these items, one experimental group had been asked to bring to mind (mobilize) as many names as possible of US presidents and the other had been asked to mobilize States of the Union. Control subjects were asked to generate names of birds and other animals. Subsequently, all subjects were shown slides with names of both presidents and States in one of three random orders. They were instructed to study each item and try to remember as many as possible. After a delay of 15 minutes, subjects had to write down all items they remembered. Experimental subjects performed better than controls, an effect that could be attributed to higher recall of the mobilized category as opposed to the non-mobilized category. Thus, subjects who mobilized names of presidents recalled more presidents' names than either the States group or the control group, whereas the States group recalled more State names than the presidents group or the control group.

However this recall pattern could not be attributed to the generation effect. Peeck (1982) compared recall frequencies for items that were most frequently mobilized (high-frequency items) and items that were infrequently mobilized (low-frequency items). If the generation effect provides a plausible explanation for the recall pattern, the experimental subjects should show higher recall than controls with respect to names frequently mobilized. No differences would be expected with respect to infrequently mobilized items. However, the experimental groups performed better than the control group for frequently mobilized items as well as for same-category items infrequently mobilized. This analysis shows that the generation effect cannot provide a plausible explanation for the results obtained.

Similar recall patterns were found by Peeck, Van den Bosch & Kreupeling (1982) and Schmidt (1982) using texts rather than lists. Peeck *et al.* (1982) and Schmidt (1982) presented subjects with a text containing information that either matched or did not match previously mobilized knowledge. In both studies, the recall of the experimental group exceeded the recall of the control group, which, surprisingly, could largely be attributed to better recall of non-mobilized information, as if the effect of mobilization 'spilled over' to non-mobilized information. In summary, contrary to the predictions of the generation effect hypothesis, mobilization of prior knowledge seems to facilitate not only the recall of mobilized information but also of non-mobilized information.

Schmidt and his colleagues (Machiels-Bongaerts, Schmidt & Boshuizen, 1990; Schmidt, 1982, 1983) have proposed a cognitive set-point hypothesis to explain this phenomenon. According to this hypothesis, during the processing of information the cognitive system employs a set-point which indicates when sufficient time has been spent on processing that information in order to remember it. When the set-point for a certain information unit is reached, the processing system proceeds to the next unit, and so forth. This theory provides an explanation for the obvious observation that readers do not go on incessantly processing the same information. The set-point determines the processing limit and is determined by a number of factors, such as the complexity of the study material, the reader's goal and level of fatigue.

However, during mobilization certain items have already been activated and processed. When studying a list, such items will require less processing time and

therefore more time will be available for studying items not previously mobilized. Thus, this theory predicts an overall facilitation effect of mobilization extending to non-mobilized items when total study time is fixed, but can be freely allocated to any part of the information as was the case in the Peeck *et al.* (1982) and Schmidt (1982) experiments. However, the cognitive set-point hypothesis also predicts that, when total study time is unlimited both experimental and control subjects will reach the set-point for all items, and therefore show similar recall performance. Since a control group does not mobilize relevant prior knowledge in advance and, hence, cannot establish a processing advantage similar to the experimental subjects, it follows that control subjects can be expected to need more time for studying the material. In addition, one would expect experimental subjects to spend less time on mobilized items as compared to non-mobilized items, simply because some time had already been spent on processing that material prior to studying the target material.

However, preliminary studies (Machiels-Bongaerts & Boshuizen, 1989) suggest that the set-point hypothesis may not only explain study time and recall patterns of items previously mobilized but also seems to apply to non-mobilized items in the same category. Their data suggest that during mobilization of information spreading activation seems to occur to items that are not retrieved but are nevertheless processed to some extent. For instance, the non-mobilized item 'Johnson' could receive spreading activation from the mobilized item 'Kennedy'. If spreading activation occurs during the mobilization of items of a certain category, one would expect non-mobilized items of the same category to have the same results as mobilized items in terms of study time and recall. In the present experiments, this assumption was tested by comparing allocation of study time and recall patterns of mobilized, same-category non-mobilized and non-category items. If same-category non-mobilized items receive spreading activation during mobilization (and if the set-point hypothesis applies to them as well), it can be predicted that the cognitive set-point for these items will be reached quicker than for non-category items requiring shorter study times and achieving better recall.

In summary, according to the set-point hypothesis, mobilization of relevant knowledge prior to a processing event has two effects, both resulting in a processing advantage. First, it influences the way in which subjects allocate available study time which, in turn, affects recall. Second, non-mobilized items receive spreading activation during mobilization. Consequently, when the list is presented these items will be processed like mobilized items as opposed to non-category non-mobilized items.

In order to test these predictions of the cognitive set-point hypothesis, three experiments were conducted. The material to be studied was a list of 32 items, 16 names of US presidents and 16 names of States of the Union adapted from Peeck (1982). Prior knowledge was mobilized by encouraging subjects to bring to mind as many names as possible of either US presidents (this group will be called the presidents group) or States of the Union (the States group). A control group generated as many names of composers as possible. In these experiments, total time available to process the 32-item list (the so-called *total study time*) was manipulated as well as the time available to study each list item individually (the so-called *local study time*). Total and local study time were either free (at subjects' discretion) or fixed

(study time was limited by the experimenter). These manipulations result in three possible combinations of study time: (a) total and (hence) local study time free; (b) total study time fixed but local study time free; and (c) both fixed.

In Expt 1 both local and total study time were free; subjects of both experimental groups and the control group were free to decide how much time they would spend on processing each item. The cognitive set-point hypothesis predicts that processing information relevant to prior knowledge mobilized requires less time than processing non-mobilized information. Thus, it was expected that the presidents group would allocate less time to president names than to State names, whereas the States group was expected to show the reverse. The control group was expected to allocate an equal amount of time to president names and State names since neither of these categories had been generated during mobilization. In addition, the control group would spend more time studying the list than either the presidents or the States group, since it would need more time to reach set-point for the items studied. When available study time is free, the cognitive set-point hypothesis predicts that no differences in recall will occur between the experimental groups and the control group, since each group will compensate by spending more time studying items for which no prior activation took place. In addition, it was expected that experimental subjects would allocate less time to non-mobilized same-category items as a result of spreading activation during mobilization.

In Expt 2 total study time was limited, but the subjects were free to allocate this amount of time to items in either of the two categories since local study time was free. It was expected that the experimental groups would spend relatively less time on studying mobilized information, since these items had already been processed to a certain degree during mobilization, and relatively more time on processing non-mobilized information. According to the cognitive set-point hypothesis, this processing pattern would result in two recall phenomena. First, overall recall of the experimental groups would exceed recall of the control group owing to their processing advantage. Second, since each of the experimental groups had relatively more time available to process non-category items, superior recall of the experimental groups would be expected for both mobilized and non-mobilized categories, accounting for the 'spilling-over' effect observed in other studies (Peeck *et al.* 1982; Schmidt, 1982). Finally, effects of spreading activation during mobilization would be similar to those in Expt 1 and would result in shorter processing times for non-mobilized same-category items than for non-mobilized non-category items.

In Expt 3 both total study time and local study time were fixed. So, subjects were presented with each item for a fixed amount of time. According to the cognitive set-point hypothesis, under this fixed study-time condition, the processing advantage acquired through mobilization would lead to superior recall of the mobilized category by the experimental groups and, hence, better overall recall. This effect would be strengthened by the spreading activation received by non-mobilized same-category items.

EXPERIMENT 1

Method

Subjects

Subjects were 18 students at the University of Limburg, randomly assigned to three conditions that differed in the experimental task to be carried out during the mobilization stage.

Procedure

Subjects were tested individually. The experimental procedure consisted of four stages: (a) mobilization; (b) studying the item list; (c) a distraction interval; and (d) a free recall test. During mobilization subjects were either asked to generate as many names of US presidents, names of States of the Union or, as a control condition, names of composers as possible. Names mobilized by the subjects were recorded on audiotape. In the study stage subjects were individually presented with the names of 16 US presidents and 16 States of the Union. Each item on the list appeared separately on a computer screen (IBM model PS/2; diagonal screen size 13 in). The subject's distance from the screen was approximately 25 in.

Half of the list was assumed to be well known to all subjects; the other half of the list consisted of names that were considered to be less familiar or even entirely unfamiliar. This classification was based upon the results of a pilot study (Machiels-Bongaerts & Boshuizen, 1989). In the pilot study, two groups of subjects either mobilized names of US presidents or States of the Union. Items that were often mobilized and items with a low mobilization frequency were selected for the present experiments.

All subjects were presented with a list of US presidents and States of the Union in one of three random presentation orders and informed of this procedure. They were instructed to study each item and try to remember as many items as possible. They were also requested to try to remember the item's category. President names were underlined. Subjects could decide for themselves how much time they would spend on each item. By pushing a button the first item of the list appeared. This item disappeared from the screen when the button was pushed again and the next item on the list was presented automatically. Study time for each item was measured. Subjects could only see each item once. After the study stage, each subject had to write the answer to a number of unrelated questions. This distraction task took 20 minutes. Finally, subjects were asked to recall every item they could remember as well as the item's category. Subjects' free recall was recorded on audiotape.

Analysis

For each subject of the experimental groups the number of correctly mobilized names of either US presidents or States of the Union was counted. The number of matches between mobilized items and list items was also established for each subject in these groups. In addition, the number of correctly recalled items for each category was calculated as well as the mean study time in seconds for the two categories.

Results and discussion

Mobilization protocols of the two experimental groups showed a difference in the number of correctly mobilized items ($F(1, 10) = 8.767$, $p < .05$). The mean number of correctly mobilized names was 7.833 for the presidents group and 10.5 for the States group. The number of mobilized items matching the 32 items on the list, however, was similar for the two groups ($F(1, 10) < 1$). The presidents group had previously mobilized 29 per cent of the list items. The match between mobilized items and list items was 32 per cent for the States group. The mobilization data in Expts 2 and 3 were similar to the data reported in Expt 1.

Table 1 shows the mean study time of the three groups for the two categories.

The three groups of subjects differed in the amount of total study time required to study the 32 items at the 10 per cent level $F(2,15) = 3.181$, $p < .07$). Equal amounts of study time were spent on the two categories ($F(1,15) < 1$). A significant interaction of treatment and item category was found ($F(2,15) = 45.181$, $p < .0001$). The expected pattern of study time allocation was found for processing both president and State names, as was shown by means of subsequent Newman-Keuls comparisons (at the .05 level). The presidents group required less study time for president names than the control group or the States group. The States group needed less time for studying State names than the control group or the presidents group. Furthermore, as t tests revealed, the presidents group spent less time on processing president names than on State names ($t(5) = 5.42$, $p < .01$). The reverse pattern was obtained for the States group ($t(5) = 6.162$, $p < .01$), whereas the control group did not differ in this respect ($t(5) = 1.149$, $p = .30$).

To test the assumption that spreading activation occurred during mobilization, facilitating recall of non-mobilized same-category items, an additional analysis was conducted. For this analysis the 32 items were subdivided into three classes: (a) mobilized items; (b) non-mobilized same-category items; and (c) items of the other non-mobilized category. If spreading activation had occurred during mobilization, the processing of non-mobilized items within the category activated would require less study time than items of the non-activated category, since their set-points would be reached quicker. Of course, mobilized items would require the smallest amount of study time to reach the cognitive set-point. Table 2 shows the results of this analysis.

The presidents group and the States group did not differ in total amount of study time spent ($F(1,10) < 1$). Unequal amounts of study time were spent on the three item types ($F(2,20) = 61.885$, $p < .0001$). The two experimental groups showed the same pattern of study time allocation to the three item types ($F(2,20) < 1$). As predicted, a linear effect was found ($F(1,10) = 122.447$, $p < .001$). Mobilized items required less study time than non-mobilized same-category items. On the other hand, items in the non-mobilized category were processed longer than non-mobilized same-category items. Thus, these results support the assumption that spreading activation occurs during mobilization, reducing the amount of study time required to reach set-point for non-mobilized items within the category activated.

Mean numbers of names of presidents and States correctly recalled by the three groups of subjects are presented in Table 3.

The three groups did not differ in mean number of items correctly recalled ($F2,15) = 1.159$, $p = .34$). The two item categories did not differ in level of difficulty ($F(1,15) < 1$). The interaction between treatment and category was not significant ($F(2,15) < 1$). As was demonstrated by means of Newman–Keuls comparisons, no recall differences between the three subject groups were found for either president names or State names.

These results confirm the predictions of the set-point hypothesis. As a result of mobilizing relevant prior knowledge the two experimental groups gained a processing advantage over the control group. Processing information previously mobilized required less time than studying non-mobilized information, since the set-point for these items was reached quicker. Thus, the presidents group needed less

Table 1. Mean study time per item (in seconds) as a function of mobilization treatment: Local and total study time free (SDs in parentheses)

Mobilization treatment	Category		
	President	State	Means
Presidents	4.928	8.935	6.932
	(1.452)	(2.855)	
States	8.580	4.811	6.695
	(2.648)	(1.179)	
Control	9.573	9.413	9.493
	(2.634)	(2.555)	
Means	7.694	7.720	7.707

Table 2. Mean study time per item (in seconds) as a function of mobilization treatment: Local and total study time free (SDs in parentheses)

Mobilization treatment	Item type		
	Mobilized	Non-mobilized	Non-category
Presidents	3.267	6.590	8.935
	(0.903)	(2.087)	(2.855)
States	3.218	6.403	8.580
	(0.930)	(1.800)	(2.648)
Means	3.243	6.497	8.758

Table 3. Mean number of correctly recalled items as a function of mobilization treatment: Local and total study time free (SDs in parentheses)

Mobilization treatment	Category		
	President	State	Means
Presidents	10.167	9.833	10.000
	(0.983)	(0.753)	
States	10.167	10.167	10.167
	(0.983)	(1.472)	
Control	9.333	9.500	9.417
	(1.033)	(1.049)	
Means	9.889	9.833	9.861

time than the control group to reach the cognitive set-point for the president names, whereas the States group needed less time than the control group to reach the set-point for the State names. As predicted, the control group required more time to study the list. It was assumed that this would happen because the control group would need more time to reach the set-point for the various items. As a result, the control group showed similar recall to the two experimental groups. Since the subjects were entirely free to spend as much time as they thought they needed to study the items, it is difficult to see how any cognitive mechanism besides a set-point for information processing could account for these results.

Furthermore, the study time data indicate that spreading activation from mobilized to non-mobilized items must have occurred during mobilization. These data confirm the prediction of the cognitive set-point hypothesis that mobilizing prior knowledge facilitates the processing of both mobilized and non-mobilized items of the category activated.

EXPERIMENT 2

In Expt 2 total study time was fixed, but since local study time was free, the subjects could freely allocate the available time to items in either of the two categories. The cognitive set-point hypothesis predicts that the presidents group and the States group would allot less processing time to mobilized items since these items had already been processed to a certain degree during mobilization. Furthermore, it was expected that the processing of non-mobilized items within the category activated was facilitated by spreading activation during mobilization, although to a lesser extent than mobilized items. Therefore, the experimental groups could allocate relatively more time to items of the non-mobilized category. In addition to this time-allocation pattern, it was predicted that under this condition recall of the experimental groups would exceed that of the control group. Thus, the facilitation effect of mobilizing prior knowledge was expected to extend from mobilized information to non-mobilized information.

Method

Subjects

Subjects were 18 students of the University of Limburg, with six randomly assigned to each of the three conditions.

Procedure

Basically the same procedure was used as in Expt 1. Experiment 2 only differed from the previous experiment with respect to the study stage. In Expt 2, total study time was fixed, but could be freely allocated to the 32 items. The maximum amount of available study time in this condition was two minutes and 15 seconds. Within this fixed amount of time, subjects had to finish studying the item list, but were not obliged to use the whole of this total study time. While studying the items presented, subjects could observe how much time was left from the permitted study time. When the first item was presented in the centre of the screen, a row of 27 red boxes appeared at the bottom of the screen. This row represented the amount of total study time. After five seconds, the first red box turned yellow; five seconds later, the next box turned yellow and so on. Subjects had to finish studying the list before all boxes in the row had changed colour. A new item was presented every time the subject pushed the button. This way, all items on the list appeared once.

Table 4. Mean study time per item (in seconds) as a function of mobilization treatment: Local study time free/total study time fixed (SDs in parentheses)

Mobilization treatment	Category		
	President	State	Means
Presidents	2.894	4.509	3.701
	(0.076)	(0.365)	
States	4.524	2.987	3.755
	(0.169)	(0.275)	
Control	4.005	3.920	3.962
	(0.259)	(0.214)	
Means	3.838	3.805	3.806

Results and discussion

Table 4 shows the mean study times for the two categories for the three subject groups.

Not surprisingly, the three groups did not differ with respect to the amount of total study time spent ($F(2, 15) = 2.591$, $p = .11$) since total study time was fixed in this experiment. Equal amounts of study time were spent ($F(1, 15) < 1$) on the two categories. The interaction of treatment and category was significant ($F(2, 15) = 241.064$, $p < .0001$). Subsequent Newman–Keuls comparisons (at the .01 level) showed that the presidents group spent less time on president names than either the states group or the control group; the States group spent less time on State names than the presidents group or the control group. Furthermore, the presidents group paid more attention to State names than to president names ($t(5) = 10.832$, $p < .0001$), whereas the States group spent more time on president names than State names ($t(5) = 19.254$, $p < .0001$). For the control group, study times were similar for both categories ($t(5) = 1.765$, $p = .14$).

In this experiment, the assumption that spreading activation occurred during mobilization was also tested. From this assumption, it can be deduced that mobilized items require less processing time to reach their set-points than non-mobilized items within the same category. In turn, these items would take less time than items of the other, non-activated category since they could have received spreading activation during mobilization. To test this assumption, the 32 items were subdivided once more into three classes: (a) mobilized items; (b) non-mobilized same-category items; and (c) items from the non-mobilized category. Table 5 shows the results of this analysis.

The two groups did not differ in the amount of study time spent ($F(1, 10) < 1$). Different amounts of study time were spent on the three item types ($F(2, 20) = 269.438$, $p < .0001$). Identical patterns of study time allocation to these item types were found for the two subject groups ($F(2, 20) < 1$).

The predictions of the cognitive set-point hypothesis were confirmed. Again, a

Table 5. Mean study time per item (in seconds) as a function of mobilization treatment: Local study time free/total study time fixed (SDs in parentheses)

Mobilization treatment	Item type		
	Mobilized	Non-mobilized	Non-category
Presidents	2.290	3.498	4.509
	(0.172)	(0.171)	(0.365)
States	2.327	3.647	4.524
	(0.397)	(0.226)	(0.169)
Means	2.309	3.573	4.517

linear effect was obtained ($F(1, 10) = 535.141$, $p = .0001$). Non-mobilized same-category items were studied longer than mobilized items of this category. Yet, items of the non-mobilized category were processed longer than non-mobilized items of the category mobilized. These results replicate and extend the findings of Expt 1. They imply that, during mobilization, unvocalized items of the same category are preprocessed as a result of spreading activation, resulting in facilitation effects for non-mobilized items within the category activated.

Mean numbers of names of presidents and States correctly recalled by the three groups of subjects are presented in Table 6.

Table 6. Mean number of correctly recalled items as a function of mobilization treatment: Local study time free/total study time fixed (SDs in parentheses)

Mobilization treatment	Category		
	President	State	Means
Presidents	7.167	9.833	8.500
	(0.983)	(0.983)	
States	9.833	7.333	8.583
	(1.329)	(1.506)	
Control	6.500	7.000	6.750
	(0.837)	(1.095)	
Means	7.833	8.056	7.944

The three groups differed in mean number of items recalled ($F(2, 15) = 5.646$, $p < .05$). Identical recall scores were obtained for the two item categories ($F(1, 15) = 1.29$, $p = .27$). The interaction of treatment and item category appeared to be significant ($F(2, 20) = 58.629$, $p < .0001$). Overall, as was shown by means of Newman–Keuls comparisons (at the .05 level), the recall of the control group was poorer than that of the presidents group as well as the recall of the States group.

Newman–Keuls comparisons (at the .01 level) also showed that the States group recalled more president names than both the presidents group and the control group, whereas the presidents group out-performed both the control group and the States group in recall of State names. Furthermore, the presidents group recalled more State names than president names ($t(5) = 8.000, p < .001$), whereas the opposite was found for the States group ($t(5) = 11.18, p < .0001$). Recall of the two item categories did not differ for the control group ($t(5) = 1.168, p = .30$).

Both the study time patterns and the recall results found in Expt 2 provide support for the cognitive set-point hypothesis. The two experimental groups recalled significantly more items from the list than the control group due to the processing advantage acquired during mobilization. The 'spilling-over' effect can be clearly observed in both the recall data and the allocation of study time. The higher recall of the presidents group compared to the control group could be attributed to better recall of State names, whereas the States group out-performed the control group with respect to better recall of president names. Similarly, both experimental groups spent more time on non-mobilized items than on mobilized ones.

However, it is important to note that, in contrast to the predictions of the cognitive set-point hypothesis, the two experimental groups did not out-perform the control group with respect to recall of items from the mobilized category. Newman–Keuls comparisons (at the .05 level) revealed that the presidents group did not recall more president names than the control group; the States group did not out-perform the control group in recalling State names. The set-point hypothesis states that items from the mobilized category will be allocated less time but be recalled better compared to a control condition, owing to previous processing of that information. The recall data, however, do not support this prediction. It is unclear why the cognitive set-point hypothesis fails here. We will not elaborate on possible explanations at this point but return to the issue in the General Discussion section.

EXPERIMENT 3

In Expt 3 both total study time and local study time were fixed. Each item on the list was presented for a fixed amount of time. It was assumed that the two experimental groups would have a lead over the control group as a result of both pre-processing of mobilized items and the spreading activation effect on other items within the same category. Thus, under fixed local study-time conditions the experimental groups could be expected to reach the set-point for more items from the mobilized category in comparison to the control group. For the non-mobilized category no differences were to be expected, since no 'spilling over' of study time could take place. Therefore, the cognitive set-point hypothesis predicts that the experimental groups would out-perform the control group for category items when both local and total study time were fixed.

Method

Subjects

Subjects were 18 students of the University of Limburg, randomly assigned to one of the three conditions.

Procedure

Experiment 3 only differed from the previous experiments in that both local and, hence, total study time were fixed: subjects had no choice over allocation of study time to the 32 items. Each item on the list appeared once on the screen for three seconds with an interval of one second between presentations.

Results and discussion

Mean numbers of names of presidents and States correctly recalled by the three groups of subjects are presented in Table 7.

Table 7. Mean number of correctly recalled items as a function of mobilization treatment: Local and total study time fixed (SDs in parentheses)

Mobilization treatment	Category		
	President	State	Means
Presidents	9.833 (0.753)	7.333 (1.366)	8.583
States	7.833 (1.835)	10.333 (1.966)	9.083
Control	6.833 (0.408)	7.167 (1.169)	7.000
Means	8.167	8.278	8.222

The three groups of subjects differed in the mean number of items correctly recalled ($F(2, 15) = 4.646, p < .05$). Again, similar recall scores were obtained for the president and States categories ($F(1, 15) < 1$). A significant interaction of mobilization treatment and category was found ($F(2, 15) = 27.825$, $p < .0001$). Subsequent Newman–Keuls comparisons showed that both the presidents group and the States group out-performed controls in overall recall. Furthermore, as was shown by Newman–Keuls comparisons (at the .01 level), the presidents group recalled more president names than either the control group or the States group, whereas the latter group out-performed the presidents group and the control group in the recall of State names. In addition, the presidents group recalled more president names than State names ($t(5) = 5.839$, $p < .01$). On the other hand, the States group recalled more State names than president names ($t(5) = 5.839$, $p < .01$), whereas the control group recalled the items of the two categories equally well ($t(5) < 1$).

As predicted, the experimental groups out-performed the control group in the totally fixed time condition – an effect that could be attributed to better recall of items of the mobilized category. These data suggest that, indeed, recall is the result of an additive effect of time used for mobilization and time available at study as suggested by the cognitive set-point hypothesis. An additional analysis was carried out to test the proposition that the generation effect would also account for the better recall of the experimental groups. According to this hypothesis, self-generated items would be recalled better than items provided by the experimenter (McDaniel, Riegler &

Waddill, 1990; Slamecka & Graf, 1978). It could therefore provide an alternative explanation for the recall pattern found in Expt 3. However, if the generation effect hypothesis were applied to the present experiment, one would expect not only the mobilized category to be better remembered than the non-mobilized category, but, more importantly, mobilized items *within* a category to be better remembered than non-mobilized items within that same category.

To test the generation effect explanation, the president and States categories were split into two subclasses, each consisting of eight items: items that were often mobilized (that had a high mobilization frequency) and items that were hardly ever mobilized (low mobilization frequency). Recall was compared with respect to these four categories. So, if the generation effect hypothesis were to provide a valid explanation for the results obtained in Expt 3, the experimental groups must out-perform the control group solely with respect to frequently mobilized items. Table 8 shows the results of this frequency analysis.

Table 8. Mean number of correctly recalled items with high and low mobilization frequencies by the experimental groups and the control group: Local and total study time fixed

	Recall frequency	
Mobilization treatment	Experimental group	Control group
Presidents		
High	3.63	3.75
Low	3.75	1.38
States		
High	4.75	4.25
Low	3.00	1.13

The results of this analysis show that the better recall of the experimental groups was not due to superior recall of items generated during the mobilization stage. In fact, the experimental groups and control group performed equally well with respect to items with high mobilization frequencies. With respect to items that were infrequently mobilized, however, the experimental groups out-performed the control group. The presidents group recalled more president names that were only occasionally mobilized; the States group showed higher recall for State names with low mobilization frequencies. These differences were all statistically significant, indicating that the generation effect hypothesis does not provide sufficient evidence for the results of the present experiment.

GENERAL DISCUSSION

The cognitive set-point hypothesis assumes that people use an internal standard against which they measure when they have spent sufficient time on a certain unit of

information and when the cognitive system can proceed to process subsequent units (Machiels-Bongaerts *et al.*, 1990; Schmidt, 1982, 1983). This point of view has a number of implications for the allocation of study time to different items on a list and their subsequent recall. These implications were tested using the mobilization paradigm developed by Peeck (1982). The general idea is that mobilizing prior knowledge facilitates the processing of new relevant information by influencing time spent on different parts of that information. Since at mobilization some processing time has already been spent on some particular aspect of that information, when experimental subjects encounter that specific item again they reach the cognitive set-point sooner than control subjects. Thus, mobilizing prior knowledge may influence the processing of subsequently presented information, inducing shorter processing times, better recall, or both, depending on the processing conditions.

In Expt 1, two experimental groups mobilized names of either presidents or States, whereas a control group mobilized names of composers. Subsequently, all subjects studied a list of names of presidents and States. Subjects were free to spend as much time on each of the items as they deemed necessary. As predicted by the cognitive set-point hypothesis, the control group displayed overall recall performance similar to that of both experimental groups but needed more time to reach that level. Both experimental groups recalled equal numbers of items in each category. However, they allocated about half as much time to studying the items in the mobilized category, indicating that processing at mobilization curtailed processing time at subsequent presentation. The shorter study time in combination with the lack of differences in recall provided strong support for the existence of a cognitive set-point against which subjects measure whether sufficient time has been spent on an item in order to remember it. This set-point may vary depending on the importance of the task as perceived by the subjects or through external pressures. But by no means does the idea of a set-point imply that subjects study material to a 100 per cent criterion. In Expt 1, for instance, subjects studied the material for about four minutes and recalled about 20 out of 32 items, although they were free to spend as much time as they liked.

When total study time was limited but local study time was free, as was the case in Expt 2, the experimental subjects allocated more study time to items in the non-mobilized category, whereas the control subjects allocated an equal amount of time to items in both categories. In accordance with predictions, recall of the experimental groups exceeded recall of the control group; an effect that was entirely due to better recall performance of items from the non-mobilized category. Again, these results could be explained by assuming that subjects employ a cognitive set-point: generation of prior knowledge causes certain items to be pre-processed, hence less time is needed for processing these same items to set-point when encountered in the list. The excess time is used to study items from the non-mobilized category more extensively.

Experiment 3, incorporating restriction of both local and, therefore, total study time extended the results of the previous experiments. The experimental subjects demonstrated better recall compared to the control group, an effect that was entirely due to better performance on the mobilized category items. These results indicated that mobilization of prior knowledge, even under conditions of fixed processing

time, facilitates the recall of information relevant to that knowledge. This finding provides an additional indication that prior mobilization time is added to processing time at study resulting in superior recall of items from the mobilized category, as predicted by the theory of a cognitive set-point.

In addition, the present experiments provide evidence that facilitative effects of mobilizing prior knowledge are by no means restricted to just the processing of mobilized items. In Expts 1 and 2, analyses of study time allocated to non-mobilized items from the mobilized category suggested that mobilization effects extend to these items as well. Although experimental subjects took more time to study non-mobilized same-category items than mobilized items, they spent significantly less time on these items compared to time spent on items from the non-mobilized category. In Expt 3, it was demonstrated that experimental subjects, in comparison to the control subjects, performed particularly well in the recall of non-mobilized items of the mobilized category, a finding also reported by Peeck (1982). These results seem to imply that at mobilization spreading activation affects items of the same category which, although not vocalized, are processed nevertheless. This pre-processing causes these non-mobilized items from the mobilized category to reach set-point quicker than items from the non-mobilized category, hence the shorter processing times and better recall under time constraints (Machiels-Bongaerts & Boshuizen, 1989). Observations of subjects during the experiment provide some anecdotal evidence for the idea of spreading activation at mobilization and its role in the processing of the list. For instance, a subject in the presidents group could not come up with the name 'Roosevelt'. He mentioned some features of this president (e.g. wheel-chair, talks with Stalin) but was unable to produce his name. When he was studying the list, the name 'Roosevelt' appeared on the screen. Immediately, he buried his head in his hands, realizing that this was the item he failed to mobilize earlier. So, non-mobilized items of the category mobilized also seem to benefit from mobilizing prior knowledge since these items become more accessible as a result of spreading activation. In conclusion, the cognitive set-point hypothesis appears to account for the subject's processing treatment of both mobilized and non-mobilized items of the mobilized category.

The alternative explanation for recall effects of mobilization is less convincing. The generation effect hypothesis (Slamecka & Graf, 1978) predicts that items produced by the learner himself will be better recalled than items provided by the experimenter. In Expt 1, no differences in recall were found between mobilized and non-mobilized items. In Expt 2, items of the non-mobilized category were recalled more easily than subject-generated items. Even in Expt 3, in which items from the mobilized category were recalled more easily, it was shown that the effect was entirely due to a better recall of non-generated items within the mobilized category. Of course, these different outcomes could be the result of using a somewhat different experimental manipulation. In that case, however, the present findings limit the generality of the generation effect to the generate–read paradigm (McDaniel, Riegler & Waddill, 1990).

One could argue that the cognitive set-point phenomenon is the result of meta-memory processes. One of the major skills involved in meta-memory, in other words knowledge people have about their own memory, is monitoring. Glover, Ronning

& Bruning (1990) define monitoring as 'keeping track of one's progress as materials are committed to memory' (p. 105). This implies that subjects consciously and actively control the way they process information. The present experiments do not provide evidence in favour of such a proposition, yet they do not contradict it either.

However, although the cognitive set-point hypothesis accurately predicted allocation of study time, prediction of recall patterns was less convincing. In Expts 2 and 3 two anomalies were detected that need further scrutiny.

To start with the easy anomaly: in Expt 3 both local and total study time were fixed. It was predicted that the experimental subjects would perform well in recalling items for which there had been prior mobilization because of the processing advantage gained at mobilization. This prediction was confirmed. Further analysis revealed that the better recall was entirely due to superior recall of non-mobilized items within the mobilized category. (This effect was attributed to spreading activation received by these items at mobilization.) It is not clear, however, why the experimental subjects did not perform better in recalling specific items that had been mobilized. Their processing advantage for these items should have given them the edge over the control group as well. A closer examination of these items reveals that most of them are highly salient. Items like 'Reagan', 'Kennedy', 'New York' and 'California' must have been encountered and processed many times in the past, even by the Dutch students who volunteered as subjects in the present experiments. These items have become so easily accessible that studying them is not really necessary for recall. Therefore, for these highly salient items no differences would be expected between experimental and control subjects. This analysis would suggest further research with material that is less salient and whose mobilization would require more cognitive effort. Under those conditions, one may expect recall differences for mobilized items as well.

More difficult to understand are the recall patterns produced in Expt 2. In that experiment, total study time was fixed but could be freely allocated to any item on the list. It was anticipated that experimental subjects would recall more items on the list than the control group (which they did) and that experimental subjects would spend relatively more time on studying items from the non-mobilized category (which they also did). However, the recall pattern of items from mobilized and non-mobilized categories as shown in Table 6 is difficult to interpret in the light of the set-point hypothesis. What is the explanation for the fact that items from the non-mobilized category are more easily recalled than items from the mobilized category? (Setting apart the performance of the experimental from the control subjects who recalled both categories equally well.) The set-point hypothesis in itself would predict either (a) no differences if the set-point for all items had been reached or (b) better recall of the mobilized category if there was insufficient time to reach set-points for the non-mobilized category. These predictions are clearly at variance with our findings, although they match the findings of Peeck *et al.* (1982) and Schmidt (1982) who used texts. These authors also find no differences between experimental subjects and controls for the mobilized information but facilitative effects for non-mobilized information. Three possible explanations come to mind.

First, mobilizing prior knowledge could have interfered with memorizatic during the study phase. For instance, one subject mobilized 'Bush'. During

recall, this name came to his mind but he was not sure whether he had seen this item when studying the list or had mobilized it previously or perhaps both. To avoid confusion, subjects may have focused on items of the other non-activated category during the study stage. If a subject of the presidents group remembered the item 'California' during free recall, s/he could be pretty sure that it was part of the list. This attitude would reduce the number of recalled items in the mobilized category. This explanation, however, does not seem very plausible since the mobilized items matching the list were widely recalled in the three experiments: the mean correspondence between mobilized category items and recall of these items was 83 per cent for the presidents group and 80 per cent for the States group.

A second possible explanation could lie in the novelty factor. The idea that during learning subjects focus specifically on new information is a recurrent theme in the learning and memory literature. As Kintsch (1980) puts it: 'It's change, incongruity, surprise that leads to new learning' (p. 92). In fact, Peeck *et al.* (1982) also suggest that the shift in recall under mobilization conditions may be the result of the attraction of the new. Schmidt (1982) speaks of a 'boredom hypothesis' that may account for this shift. Subjects become bored at being confronted with the same material again and therefore focus more attention on the new non-mobilized material. This explanation, however, is unsatisfactory, because some of the items in the mobilized category were new or very nearly new to the experimental subjects, whereas some of the material in the non-mobilized category must have been quite familiar, even though it was not previously mobilized. Imagine a subject who mobilized names of presidents. To her or him 'California' was certainly not more unusual and, hence, more interesting than 'Polk'. Why then, would s/he spend more time on processing the name of the State?

A final explanation might be that mobilization of prior knowledge leads subjects to overestimate the extent of their knowledge and, thus, lower their set-points for that information. Lower set-points would necessarily result in allocating less time to items in the mobilized category, leaving more time for studying the non-mobilized category. This decrease in study time would go beyond predictions from the set-point hypothesis, which fail to allow for lowered set-points, and would account for the recall pattern we found. The allocation of study time in Expt 2 does not contradict this supposition. But what does militate against this hypothesis – and, for that matter against the novelty hypothesis – is the result of Expt 1. In Expt 1, subjects were free to spend as much time as they wished on the items and no differences in recall due to lowered set-points or novelty value were observed.

Based on these observations, further studies of the mobilization of prior knowledge paradigm would seem to be appropriate.

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