LIFETIME OF MEMORY
FOR SELF-GENERATED INFORMATION

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Abstract

In experiments concerning the lifetime of short-term memory such as the classical Brown-Peterson paradigm the to-be-memorized categorical information is presented via sensory stimuli. Therefore the memory could be based on retrieval from the long sensory store. We modified the Brown-Peterson paradigm such that subjects had to memorize internally generated material and prevented them from memorizing sensory information. The results show functions of correct answers over the retention interval that are similar to classical results.

In the memory theory of Shiffrin and Schneider (1977) short-term memory is characterized as a process, being the activated part of long term memory, rather than a structural component. In addition to this Cowan (1984, 1995) proposed a framework in which also the long sensory stores are described as activated parts of long term memory. Because of the different lifetime of the trace, the short sensory stores are considered separate structural components in the model of Cowan.

The long sensory stores of the different modalities and the categorical short-term memory should therefore be based on comparable processes in different codes/areas of the brain and hence yield equal or very much the same results in mnemonic experiments.

Among the different paradigms that Cowan states as evidence for long sensory memory stores, the use of periodic noise (Guttman & Julesz, 1963; for a demonstration see www.periodic-noise.de) is most appropriate as it represents a very unstructured material (e.g.

without any easily perceivable patterns like melodies, vowels, etc. as in other auditory stimuli) and therefore makes categorization of the to-be-memorized material difficult. The more categorization is prevented, the more certain sensory memory stores are utilized.

The similarity of the long auditory memory system with classical parameters of the short-term memory system (e.g. lifetime, capacity, susceptibility to interference) could be shown in a study using periodic noise by Kaernbach (2001). Lifetime of sensory information was measured by determining the longest cycle length of periodic noise that could be detected. With very little training subjects were able to detect periodicity up to 10 and in some cases even 20 seconds. The collected data of Experiment 1 of this study are depicted in Figure 1. They are very similar to classical results obtained with Brown-Peterson paradigms (Brown, 1958, Peterson & Peterson, 1959).
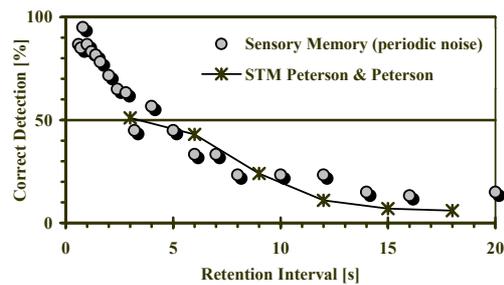

Figure 1: In this graph a comparison between a classical short-term memory (STM) experiment by Peterson and Peterson (1959) and a sensory memory experiment with periodic noise (Kaernbach, 2001) is shown. Both experiment lead to very similar curves.

In previous research, the focus has been directed towards the possibilities to exclude categorical coding when investigating sensory memory. Little attention has been given to the opposite: In studies regarding categorical short-term memory the sensory effects of the stimuli are not isolated or prevented. To be sure that categorical and sensory memory are based on comparable processes (e.g. that both are activated parts of long term memory), it is necessary to examine categorical memory bereft of sensory traces of the stimuli. Therefore we modified a classical Brown-Peterson paradigm in such a way that subjects only memorized internally created material.

Pilot Experiment

In a pilot study we used 3 lines of three-digit numbers, presented for 7 seconds, and 2 lines of four-digit numbers, presented for 4 seconds (all via PC-Monitor). Subjects had to add the numbers and to memorize the result for different retention intervals (3,6,9,12,15s). To prevent sensory traces we chose a total number of presented stimuli (8 or 9 digits) that was higher than the full visual report limit (N=4, see Sperling, 1960) and by instruction and control prevented the subjects from articulating the results overtly.

Similar to Brown-Peterson paradigms, subjects had to perform an interfering task during the retention interval: In a 1.5-s rhythm two initial random letters were presented with a random alphabetical difference between 6 and 10. Then subjects had to alternately recite the alphabet from the given letters. For example: D & J were shown succeedingly at two different screen positions. Afterwards a visual signal ("#") appeared on the screen, alternately at the two screen positions in the same 1.5-s rhythm, as a help and guideline for the subject. The subject would have to recite: E K F L G M ... With about half an hour of training most of the subjects were performing this task very well. The results depicted in Figure 2 show that the original Peterson&Peterson data are very similar to the second condition of our experiment. The latter was chosen for our main experiment.
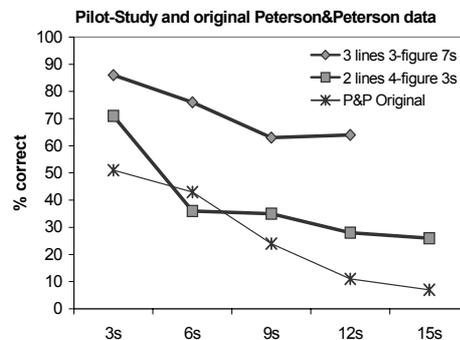

Figure 2: The graph shows the comparison of the classical data obtained by Peterson&Peterson (1959) with our pilot study with a task in which subjects had to memorize internally generated material (i.e. the result of a numerical summation) in order to prevent sensory memory effects.

Main Experiment

In the experiments of Peterson and Peterson auditory stimuli were used. We presented our stimulus material visually. In order to better compare their paradigm to ours we added a Peterson&Peterson-like condition ("visual P&P") to our study that differed with their original experiment with respect to the stimulation modality (i.e. visual stimuli). In this condition subjects were presented visually with consonant trigrams, for example FWH, and in the retention interval had to count down from a given random number in steps of three (e.g.: 357, 354, 351, 348, ...) in a 1.5-s rhythm.

To obtain a better comparability of the visual P&P condition with the non-sensory condition, we matched the difficulty of both in an additional pilot study with three subjects, resulting in short and long presentation times of 2 and 4s for visual P&P and 3 and 7s for the non-sensory condition.

The 10 subjects of the main experiment were psychology students, aged between 20 and 24. The approximately one-hour long experimental sessions consisted of four blocks corresponding to four conditions (two task types, visual P&P and self-generated information; two presentation times, long/short) in random order. In one block 30 trials of the same condition with randomized retention intervals (3,6,9,12,15s) were presented. This results in 120 trials for one session. The first of six sessions was used for training and the other five were regular experimental sessions.
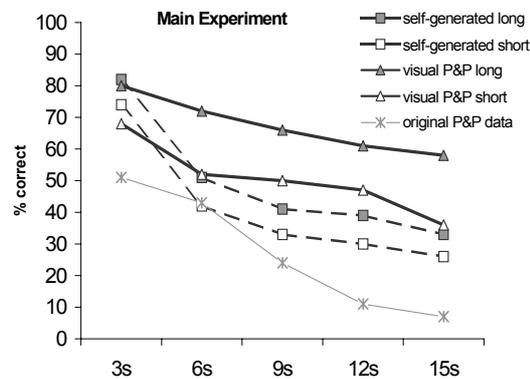

Figure 3: The graph shows the four experimental conditions (P&P vs. non-sensory × long vs. short) averaged across all experimental sessions (for details, see text). For comparison, the original Peterson&Peterson data are shown.

Results and Discussion

The shape of the curves, depicted in Figure 3, is similar for three of the four conditions. Only the P&P-long condition has a slightly different form. This is probably caused by an inadequate match of difficulty between the long and the short condition.

The original data of Peterson and Peterson are slightly different from our visual P&P data. The reason for this is probably the different form of presentation.

In summary we can conclude that the Peterson and Peterson experiment was replicated with a slightly different curve shape, because of differences in stimuli presentation. The curves nevertheless show a similar course over the retention interval, which supports the hypothesis of Cowan that the long sensory stores are an activated part of the long term memory.

With the adoption of Cowan's framework, a lot of research effort was put into the examination of long sensory stores eliminating effects of categorical memory. Our approach was to vice versa examine categorical short-term memory with the exclusion of sensory effects. We are the first to show the similarity of both systems with such a paradigm.

In addition to this study we plan to conduct other experiments utilizing this paradigm with better matched task difficulties and with further tasks that also require internal recoding of the to-be-memorized material (e.g. adapted problem solving tasks). First comparisons with modeled data based on a tuned trace theory by Staddon, et al. (2001) show promising similarities that strengthens our confidence in this approach.

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