

# The Impact of Trace Decay, Interference, and Confusion in a Tonal Memory Span Task

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## ABSTRACT

### Background

There has been growing interest in the short term storage of tonal stimuli and there is an ongoing debate whether they are processed within the same system as verbal stimuli or within a different system (e.g. Jones et al., 1997; Semal et al., 1996; Williamson et al., 2010).

Using a standard memory span task Bittrich (2010) measured the capacity of short term memory for tonal and verbal stimuli. Whereas the number of serially correct recalled items in the verbal condition was six to seven the number of recalled items in tonal condition was about two to three items. This resulted in two main questions for the present study: What are the main causes of forgetting and do they contribute to the same amount in verbal and tonal short term memory?

### Aims

We proposed and tested a mathematical model concerning the impact of the characteristic causes of forgetting – trace decay (i.e. the decay of a memory trace over time), interference by other items (pro- and retroactive), and confusion (i.e. not the item information but the position information is lost) – in a modified memory span task.

### Method

*Participants.* Data were obtained from  $N=11$  participants ( $n=9$  female) aged between 19 and 43 years. Besides the general musical education in school, further special musical training was only reported by three participants, non possessing absolute pitch.

*Experimental Design.* The three within-subjects variables stimulus type (letters vs. tones), list length (1–6), and recall (immediate vs. delayed) were varied and the quality of response registered.

*Stimuli and Apparatus.* Verbal stimuli comprised the German letters {B, F, K, J, L, N, Q, R, S, V, X, Z}, spoken by a male voice at a rate of approx. one second per item. Tonal stimuli were constructed by adding the fundamental frequency and the first five harmonics with decreasing amplitude and applying a piano envelope to the resulting sound. The frequency ranged from  $c=130\text{Hz}$  to  $h=246\text{Hz}$  and  $c'=261\text{Hz}$  to  $h'=493\text{Hz}$  for male and female participants, respectively.

*Procedure.* Participants were tested individually in a quiet room. In each trial they were presented 1–6 tones or letters (stimulus type blocked across sessions, list length randomized within session) which they had to recall in correct serial order. In half of the trials the recall started immediately after the last item. In the remaining trials the recall was delayed.

Realizing 14 replications per condition resulted in a total of  $2 \times 6 \times 2 \times 14 = 336$  trials divided into two sessions of 7 blocks with 24 trials.

*Data Analysis.* Letters were considered as correct if recalled at the correct serial position. For the tonal reproduction a tolerance criterion was applied: Tones were considered as correct response if recalled at the correct position and if the sung frequency was within the range of plus/minus a quarter tone of the given frequency.

### Results

Differences between both conditions concerning the proportion of correct recall as a function of list length and serial position were observed. As expected participants were better in the verbal compared to the tonal memory span task. However, in all conditions performance for item positions declined with increasing list length. The model fit was accomplished with the averaged data, separately for tones and letters. The proposed model fitted the data reasonably well. The parameter estimations revealed a strong impact of forgetting processes in the tonal but not the verbal condition whereas confusion only occurred for the verbal stimuli.

### Conclusions

The findings suggest that different mechanisms of forgetting apply to tonal and verbal stimuli in short term memory. Constraints result from the fact that we only realized list lengths one to six. This might not be sufficient for the letter condition to evoke strong forgetting. Additional research is needed to confirm and broaden the findings.

### Keywords

memory, tonals, verbal, memory span, tones

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