How similar is similar? A novel sensory memory task based on visual pink noise

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Memory tasks aiming at testing pattern separation contain pictures of everyday objects: old (targets), new (foils), and similar stimuli (lures). Lure similarity depends on context and knowledge (Fig. 1).

We have developed a task that is based on so-called visual pink noise (1/f filtering of spatial frequencies, Fig. 2). The stimuli can be blended to construct lures with any degree of physical congruence with targets. It is the first memory task testing pattern separation with quantifiable congruence of old and similar stimuli. This allows to study the psychophysical laws relating physical congruence and psychological similarity.

We performed 3 experiments with this novel task. In Experiment 1 we collected data for 48 participants. Lures were created at 4 congruence levels via pixel blending. The data (Fig. 3) show that participants can well remember targets and distinguish them from lures. A model based on Gaussian signal detection theory (SDT, Fig. 4) was fitted to the data.

The sensitivity parameters of the SDT fit (d' of lures and target) seem to follow a power function of the squared correlation between lures and targets (Fig. 5a). The exponent is close to two: Psychological similarity seems to be related to the quartic correlation between the stimuli.

This was tested in Experiment 2 with two groups (N=2×24). In one group, lures were generated via blending, in the other via pixel substitution. The parameters of blending and pixel substitution were chosen so as to obtain an evenly distributed quartic correlation: r^4 = 0.2/0.4/0.6/0.8. Fig. 5b shows the resulting d' values: They are approximately a linear function of r^4, independent of the method of lure generation.

In Experiment 3 we tested long term memory and naming performance. Participants (N=28) had to learn one-letter names (F,G,H,J) for 4 targets. They were tested with targets and foils. First, they had to indicate whether the stimulus was old or new. Then they were asked its name. They had to answer this question independent of target type and answer. This test was performed immediately after learning and after one week.

Fig. 6 shows the results. Sensitivity and naming performance were only slightly worse after one week (n.s.). Naming performance is well above chance even for misses, i.e. for stimuli erroneously classified as new. With a four-axes Gaussian SDT model for the four targets we could predict naming performance for hits and misses on the basis of the individual SDT parameters.

In summary we could demonstrate long-term memory for pink noise stimuli and derive a psychophysical law relating physical congruence (correlation) to similarity.
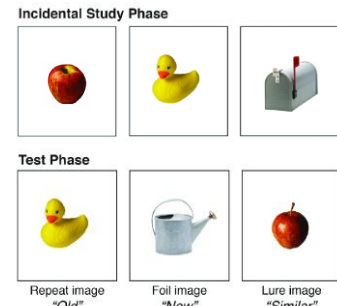
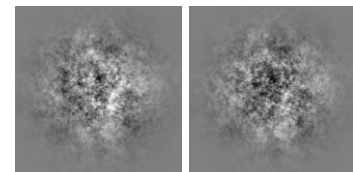Fig. 1. Stimuli of the Mnemonic Similarity Task (Stark et al., 2015)

Fig. 2. Visual pink noise stimuli. a) Target, b) Lure with r^2=0.69
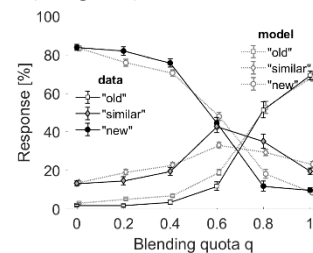

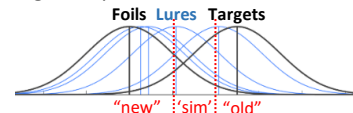Fig. 3. Exp. 1: Data and model fit
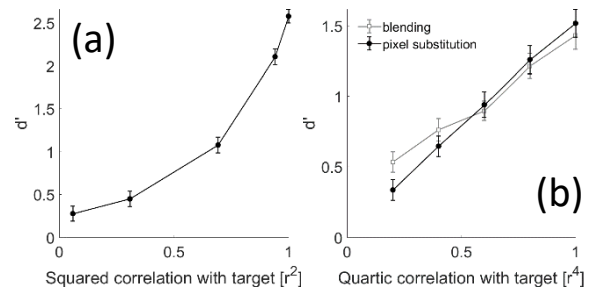

Fig. 4. Exp. 1: Gaussian SDT model

Fig. 5. a) Sensitivity data (d' values) of Exp. 1 as a function of the squared correlation of lures and targets. b) Sensitivity data of Exp. 2 as a function of quartic correlation.
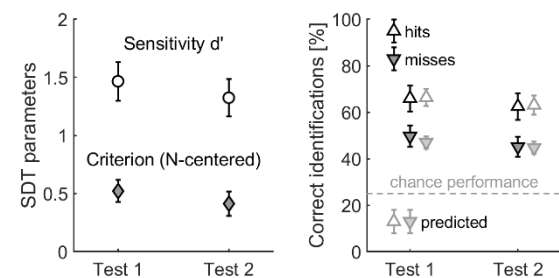

Fig. 6. Sensitivity data and naming performance of Exp. 3