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Effects of trial repetition in texture discrimination

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Abstract

Performance on the texture discrimination task improves with practice but was also shown to decrease between closely spaced sessions. Here we explored immediate changes in performance *within* a single session. We found that, after an initial increase, performance declined with further training within a single session. This deterioration in performance was smaller when the inter-trial interval was longer than 3 s. Performance recovered when targets were presented in new locations within the texture stimulus—thereby excluding a general fatigue process or adaptation to the stimulus light-intensity as an explanation for our findings. Further, the complete transfer of deterioration between eyes pointed to cortical origin. Deterioration was also found for task-irrelevant targets, indicating the involvement of a sensory mechanism. Collectively, these findings trace the deterioration of performance in the texture discrimination task, previously observed across several hours, to cortical events occurring during or immediately after stimulus presentation.

Keywords: Adaptation; Perceptual learning; Spatial vision; Texture discrimination

1. Introduction

In general, repeated performance of a task leads to improved performance. This effect of practice has been shown in the texture discrimination task (Karni & Sagi, 1991; Karni & Sagi, 1993). Recently, however, it was found that practice can reduce performance in the texture discrimination task. Using the texture discrimination task, Mednick and colleagues (Mednick et al., 2002) showed that multiple training sessions within a single day led to decreased performance (Mednick et al., 2002). Their findings could not be explained by the effect of general fatigue, since sessions were spaced by several hours and performance recovered when the stimuli were switched to a new, untrained location in the visual field. Performance also changes within a single practice session. Within-session performance was reported to improve during the initial phase of learning, mainly in the first session (Karni & Sagi, 1993), to be relatively stable during the following daily sessions (Karni & Sagi, 1993), or to decline during a second daily session (Mednick, Arman, & Boynton, 2005).

The aim of the present research was to examine within-session effects on performance. Of particular interest was the effect of different amounts of training within a single session on the performance within that session. Such effects might occur due to learning and sensory adaptation to the stimulus energy. In the absence of known mechanisms, a distinction between adaptation and learning can only be based on phenomenology; here we assume a demarcation based on task-relevancy. Sensory adaptation, such as contrast adaptation, is thought to be independent of the task performed and the adapting stimulus (Festman & Ahissar, 2004). Perceptual learning, however, depends on the task performed (Ahissar & Hochstein, 1993; Karni & Sagi, 1995) and affects not only the trained stimulus aspects but also the associated stimulus parts (Seitz & Watanabe, 2003).

Effects resulting from the amount of training within a session are not restricted to perceptual learning (Ofen-Noy, Dudai, & Karni, 2003). These effects may

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have critical implications for constructing efficient training and for understanding the nature of neural experience-dependent modifications that accompany performance changes. The interaction of within-session effects and between-session effects is presently not known. A recent study with the texture discrimination task found a non-monotonic dependency of between-session improvement on the number of trials within a session (Censor, Karni, & Sagi, 2006). In particular, between-session improvement was not observed with sessions containing too many trials, pointing to a strong interaction between processes operating within and between sessions.

The present study was designed to evaluate the effects of increasing the number of trials on performance within a single session. To this end, we used a variation of a texture discrimination task (Karni & Sagi, 1991) in which participants had to determine whether two targets were aligned the same or differently (Fig. 1). We conducted four experiments, detailed below, that demonstrate instability in performance within a session. The observed instability suggests the existence of within-session adaptation processes in texture discrimination task.

2. Methods

2.1. Participants

All together, 26 individuals (age range 17–32, 7 males) participated in the experiments. Participants gave informed consent and were monetarily compensated for their time. The number of sessions in which data were collected for each of the experiments is detailed below. Depending on random assignment, each individual might have been tested multiple times in one or more of the experiments with the strict constraint that only one session was given in a single day.

2.2. Task and stimuli

We used a variation of a texture discrimination task (Karni & Sagi, 1991). Participants watched a computer screen from a distance of approximately 1.2 m in a dark room. Each trial was initiated by the participant pressing the middle button on a three-button mouse after a white fixation circle appeared in the middle of the screen. The stimulus was composed of a 19 × 23 array of horizontal white line segments on a black background with two targets defined by orientation difference. The targets were horizontally or vertically arranged sets of three diagonal line segments (Fig. 1). The two targets were presented at equal distances from the fixation point either on the horizontal mid-line or, in different experiments, in diagonally opposing quadrants of the screen (i.e. upper-left and lower-right or lower-left and upper-right). Stimuli were presented for 18 ms followed by a variable blank interval (stimulus-to-mask onset asynchrony, SOA) that was followed by the presentation of a patterned mask (150-ms duration). The mask was composed of 19 × 23 V-shaped elements with the elements' orientation randomized during each trial. Participants made a two-alternative, forced-choice decision between 'same' or 'different' (clicking on either the right or left buttons of a three-button mouse). Participants responded 'same' when the three segments comprising the two targets were aligned similarly (i.e. both horizontal or both vertical) or 'different' when they were aligned differently (i.e. one horizontal and the other vertical). Feedback (a beep sound) was given for incorrect answers. Trials were grouped into blocks of constant SOA. There were four possible target arrangements presented within a block (two targets, each having two possible orientations), one of which was selected at random during each trial. Blocks were terminated when the number of presentations of each of the four arrangements exceeded a pre-defined number (N/4). The number of trials per block (N) for each experiment is provided in the Section 3, with the actual number of trials being slightly larger. The percentage of correct responses was calculated per block for the given number of trials (N) with equal numbers of the four possible target arrangements. No additional fixation task was employed [in contrast to Karni and Sagi (1991)].

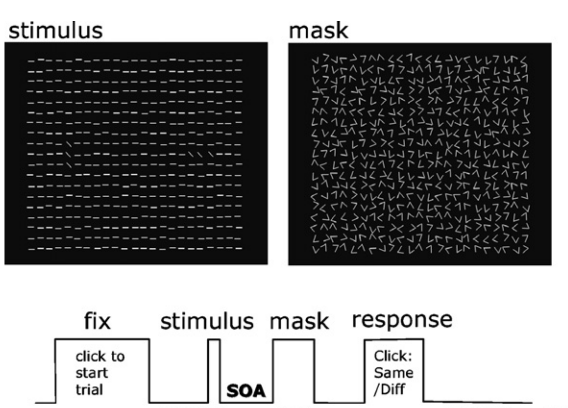

Fig. 1. Experimental trial. Trials were self-initiated and a fixation screen (a small 'O' at the screen center, not shown) was followed by a stimulus screen (upper left) that included two targets composed of 3 45° line segments, embedded in an array of 19 × 23 horizontal segments. The stimulus was presented for 18 ms and was followed by a mask (array of 19 × 23 V-shaped segments, upper right) presented after a variable SOA (Stimuli-to-mask Onset Asynchrony).

2.3. Measurements

Performance was measured by the rate of correct responses in a block. Threshold SOAs in ms were calculated by interpolating the SOA for which 80% probability of a correct response would be obtained. Comparisons between conditions were done using Repeated-Measure ANOVA (models specified in text). Further statistical tests were done using 2-tail t-tests corrected for multiple comparisons (Bonferroni) when performed for more than a single pair.

2.4. Experimental procedures

Experiment 1: Fifteen participants (age range 18–27, 4 males) were tested multiple times on different days, providing a total of 69 sessions. Before the experiment proper, an individual threshold was determined for each participant. This threshold was determined via descending SOAs (blocks of successive 20 trials with descending SOAs; 400, 300, 200, 160, 140, 120, 110, 100, 90, 80, 70, 60, and 50 ms). In this initial threshold estimation testing was terminated when the participant was performing near the chance level.

In the experiment proper, participants were given 1000 trials using a single, above-threshold SOA. For an above-threshold SOA, we chose one in which the performance in the initial test was better than 90% correct responses. Performance was analyzed in blocks of 40 trials. Participants were instructed not to take voluntary breaks longer than 30 s in between trials. All together, we determined performance in 69 sessions. Across these sessions we were using variable test parameters, as described below.

Three test parameters were manipulated. First, we used binocular or monocular viewing (49 and 20 sessions, respectively). Second, we had participants with different amounts of previous exposure to the task. Prior exposure was the result of the same participants being tested on previous days, ranging from 0 (for the first day of testing) to 13 prior daily sessions. The third parameter was the single above-threshold SOA. This ranged between slightly above and greatly above the participants' thresholds (difference between threshold and selected test SOA: 5–292; SOAs: 70–400; thresholds: 55–275; range in ms). Using these multiple alterations in