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КОГНИТИВНАЯ НАУКА В МОСКВЕ: НОВЫЕ ИССЛЕДОВАНИЯ

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TARGET MOTION DOES NOT INFLUENCE SACCADIC SUPPRESSION OF TARGET DISPLACEMENT

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Abstract: Saccadic Suppression of Target Displacement (SSTD) is a failure of the human visual system to detect a target's spatial displacement performed during a saccade. A temporal blank of the target (Deubel et al., 1996) or a change of the target's surface properties (Tas et al., 2012) breaks the assumption of visual stability and thus restores sensitivity to the displacement. In the present study, we tested whether a target's linear continuous motion would also break the assumption and improve sensitivity. The results of the classic SSTD studies were replicated, but we found no evidence for the influence of a target's motion on this effect.

Keywords: saccadic suppression of target displacement, motion, visual stability, saccade

Though the human visual system works well most of the time, its failures help us to acquire more knowledge of its working principles. One example of visual system failure is an effect called Saccadic Suppression of Target Displacement (SSTD). The SSTD effect is examined in this study with respect to a moving object as the target.

Saccades, rapid ballistic eye movements, cause a disruption in perceptual input. However, this disruption of the visual information stream is not noticed by the observer (Ethel & Matin, 1974). If we compare the retinal coordinates of an object before and after a saccade, they would be different. Part of the coordinates' shift is explained by eye motion. The other part might have two different sources: head motion or the motion of the object itself. The visual system should be able to distinguish these two cases using retinal and extra-retinal cues.

Deubel et al. (1996) showed that though the detection of a target's spatial displacement during a saccade is poor (SSTD), sensitivity to the displacement is restored when a temporary blank of the target is performed after the saccade. In (Tas et al., 2012) it was found that a change of the target's surface properties also increases the number of correct answers about target displacement. The theory of visual stability states that the visual system is biased to assume that the world remains stable during a saccade. The evidence mentioned above violate this assumption, suggesting that the visual system is forced to use extra sources of information to judge the position of the target.

MacInnes and Hunt (2013) showed that a change of the object's shape has a similar effect, and hypothesize that it may be perceived as an illusory motion of the target. In this study, we tested whether task-irrelevant continuous linear target motion increases sensitivity to the target displacement.

Method

Fourteen individuals participated in the experiment (3 males, mean age = 21.4 years). All participants had normal or corrected-to-normal visual acuity and gave informed consent approved by the university ethics committee.

The stimuli were presented on a computer monitor with a refresh rate of 144 Hz and screen resolution of 1920×1080 pixels. Participants' heads were positioned so that the chin and forehead were 80 cm from the screen. Participants looked at the screen binocularly, with the right eye monitored by a SMI iView Hi-speed eye-tracker at a sampling rate of 1250 Hz. Stimulus presentation was performed by a computer script written in Matlab using PsychToolbox.

The experiment consisted of a number of short trials. At each trial, participants were asked to fixate a cross at the center of the screen and confirm it by pressing a button on a joystick. This was used as a trial onset and drift correction. A target (square) appeared at the upper half of the screen. In half of the trials, the target started moving horizontally (six visual degrees per second). When it arrived at the central area of the screen, the cross disappeared. Participants were instructed to move their eyes to the target after that. Meanwhile, a computer program was watching this saccade and moved the target up or down during the saccade (initial target movement continued). In half of the trials, the target blanked temporarily for 250 ms, while in the other half of trials it did not. The participant was asked to decide in which direction the target had been moved and to press a corresponding arrow on the joystick. In the other half of the trials the initial horizontal position of the target was at the center of the screen and it did not perform horizontal motion.

This experiment had a 2×2×2 within-subjects factorial design. Independent variables were the distance of the displacement (either 0.22 or 0.44 visual degrees), blanking/no-blanking and the presence of motion of the target. We merged the results for the different displacement directions. Each participant performed 24 trials for each combination of the conditions. Trials were shown in a random order. After each 50 trials, there was a short break. The ratio of correct answers was measured in each condition.

After the experiment, the data from each trial were checked for correctness. Trials which had more than one saccade to the target or in which the saccade offset was before the shift of the target were discarded (less than 10 %).

Results

Logistic mixed effect model analysis was performed on the data. We transformed proportions of the correct answers to logits to account for the binomial structure of the data. The experiment had a within-subject design, so we also modeled the random subject variability around each fixed effect. The initial model consisted of a fixed intercept. We then added one-by-one fixed effects for Blank, Size of displacement and Motion. The first two additions improved the model, but the last one did not. Table 1 shows the fixed effect estimates, the standard errors of their estimation and the significance (χ^2). Only the effects of Blank and Size are significant.

Table 1

Effect	Estimate	Std Error	p
	0.31	0.15	
Blank	0.85	0.14	<.001
Size	0.44	0.14	.0018
Motion	−0.18	0.14	.183

The results of the classic SSTD studies for blanking and different distance of target displacement are replicated for both the static and moving conditions, but we found no evidence for the influence of target's motion on the target displacement sensitivity. Thought the motion of the target was a candidate for breaking the visual stability assumption, we have found no evidence for it.

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Движение объекта не влияет на саккадическое подавление обнаружения сдвига объекта

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Аннотация. Саккадическое подавление обнаружения сдвига объекта — это снижение чувствительности зрительной системы к смещению объекта, произведенному во время саккады. Сокрытие объекта на время конца саккады (Deubel et al. 1996) или изменение зрительных признаков объекта (Tas et al. 2012) нарушает стабильность зрительного восприятия и тем самым восстанавливает чувствительность к сдвигу. В данном исследовании мы проверяли, окажет ли прямолинейное непрерывное движение объекта такое же влияние на эффект. Результаты предыдущих исследований были воспроизведены, но мы не обнаружили изменения чувствительности зрительной системы в случае движения объекта.

Ключевые слова: саккадическое подавление, движение, стабильность зрительного восприятия, саккада