Habituation of the Distractor Effect: Evidence in Eye Movements and ERPs

Sven-Thomas Graupner, Johannes Marx, Sebastian Pannasch & Boris M. Velichkovsky

graupner@applied-cognition.org

Applied Cognitive Research Unit, Psychology III, Technische Universität Dresden, Germany

Introduction

The *remote distractor effect* is a phenomenon characterised by an increase in saccadic reaction time of about 100 ms when a target appears together with a distractor (Walker, 1995). Due to the fast onset of the effect (60 - 70 ms) Reingold and Stampe (2000) suggested a interpretation as a low-level, reflex-like, oculomotor effect related to inhibitory processes in the superius colliculus (SC). However, we recently demonstrated that similar effects can be obtained with distractors of different modalities (Pannasch, 2001). Our results did not support the notion of a plain oculomtor reflex. A possible alternative explanation may provide the concept of the orienting response (OR) as proposed by Sokolov (1963). It describes a reflex-like immediate response (behavioral and physiological) to novel stimuli or changes in the environment. An essential feature of the OR is the habituation: the effect decreases for repeated stimulus presentations. Evidence for the OR and its habituation is commonly measured via psychophysiological methods like event related brain potentials (ERP). In a study with free visual exploration of images, eye movements and ERPs were recorded in parallel. Visual and auditory distractors were presented to investigate possible effects of habituation in both fixation duration and ERPs.

Method

- 46 subjects (11 male 35 female; age: *M* 23.4 ± *SD* 6.1)
- recording of eye movemets with the SR Research EyeLink I System
- EEG recordings with Synamps Amplifier (Model 5083, Neuroscan) at Fp1, Fp2, F7, F3, F4, F8, T7, Cz, T8, P7, P3, Pz, P4, P8, O1, O2 , VEOG, HEOG electrode site, referenced to linked earlobes
- free picture viewing task with instruction to memorize the content of the picture and to ignore appearing distractors
- 2 blocks, one for presentation of visual and the other for auditory distractors
- 80 digitized images of paintings (see example) in randomized order
- a distractor was presented at each 5th fixation within a picture
- distractors appeared at the position of the selected fixation 100 ms after its onset

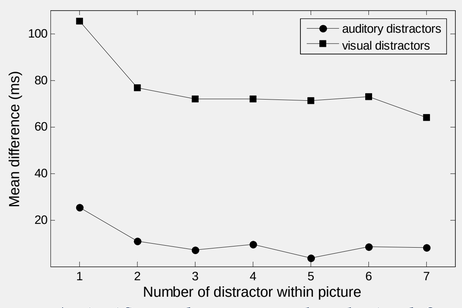
Visual distractors were light blue circles of 2.7° diameter and 0.3° margin width, presented for 75 ms (see example).

Auditory distractors were pure sinusoidal 1500 Hz tons with a duration of 75 ms and 70 dB sound pressure level presented binaurally via earphones (EartoneTM 3A).

Results

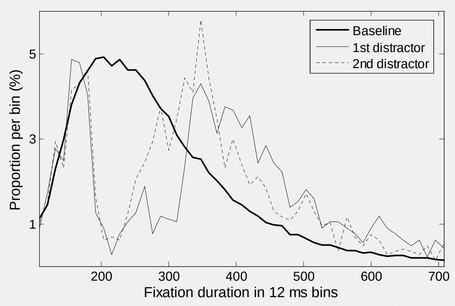
within picture

difference values of fixation duration



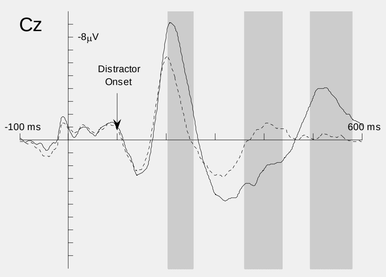
A significant decrease can be obtained for both modalities (visual: $p < .001$; auditory: $p < .05$) and can be explained mainly by a rapid decrement from 1st to 2nd distractor.

distribution of fixation duration (visual only)

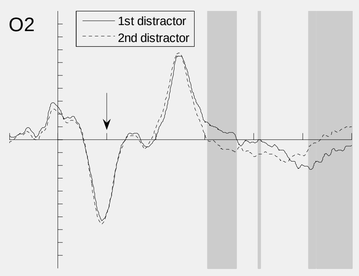


A clear dip in the distribution is visible at approx. 210 ms for both the 1th and 2nd distractor and a second dip at approx. 300 ms differentiates between 1st and 2nd distractor.

ERP for auditory distractors

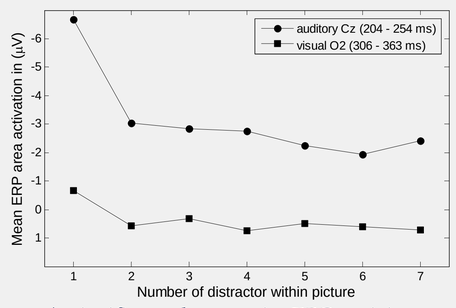


ERP for visual distractors



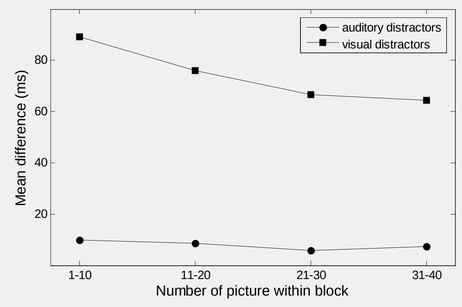
To compare the ERPs of 1st and 2nd distractor we used a statistical method introduced by Blair and Karniski (1993). Significant deviations ($p < .05$, indicated by grey background) for auditory distractors were found as early as the N100 component with a distribution across scalp. The earliest deviation for visual distractors was observed within an interval of 300 - 360 ms after the fixation onset with a more occipital-parietal distribution.

mean ERP-activity in interval

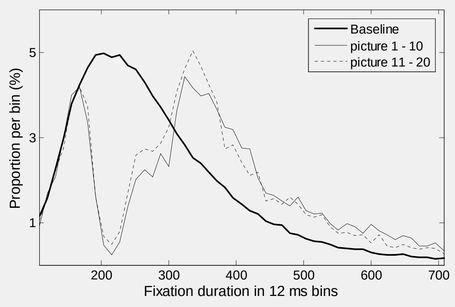


A significant decrease in ERP activity can be found for both modalities ($p < .001$) using the significant intervals indicated by the method of Blair and Karniski (1993).

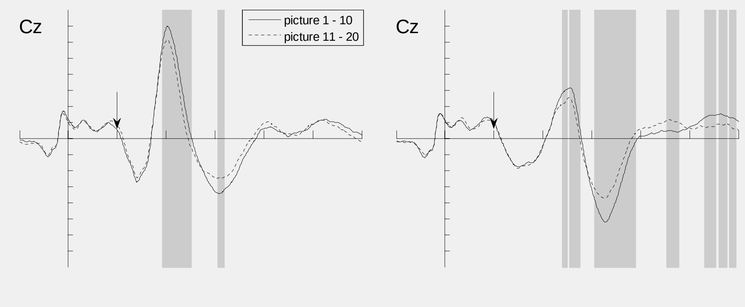
across pictures



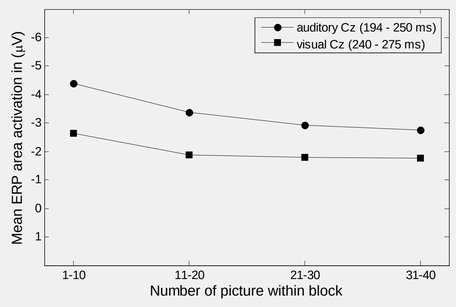
A significant decrease can be obtained for the visual modality only ($p < .001$).



A clear dip in the distribution is also visible at approx. 210 ms for both conditions. The second dip, as observed above, has a similar latency (approx. 280 ms) but is less pronounced.



Significant deviations were found for auditory distractors reflecting condition specific differences of the N100 component at Cz. For visual distractors the earliest deviation can also be found at Cz within an interval ranging from 240 - 275 ms representing differences in N100 with a mainly frontal distribution.



In contrast to fixation durations a significant decrease in ERP activity can be found for both modalities ($p < .001$).

Discussion and Conclusions

Our results demonstrate clear effects of habituation in fixation duration for both modalities. This habituation was obtained *within* pictures, whereas for the *across* pictures analysis the decrease was found only for visual distractors. The absence of such a decrease for auditory distractors might be related to the small average effect.

A similar habituation of the effect indicates our ERP data. We found significant deviations for both modalities; *within* pictures and *across* pictures. ERPs of auditory distractors show early deviations at the N100 component level. ERPs of visual distractors in the *within* picture analysis show a significant deviation approx. 50 ms after the N100 peak with an occipital-parietal distribution. The *across* pictures analysis shows an early N100 deviation as well as an P200 deviation with a stronger fronto-central distribution. Subsequent analyses of deviant ERP areas demonstrate a clear decrease in activity for both modalities, *within* and *across* pictures. The fast decrease of ERP activity *within* pictures (from the 1st to the 2nd distractor) is very similar to the pattern observed for fixation durations. Additionally to the results for the fixation durations, ERP activity for auditory distractors showed a significant decrease *across* pictures.

Another interesting observation shows the plot of the fixation duration distribution for visual distractors in the *within* picture condition. In accordance with the results of Reingold and Stampe (2000) saccadic inhibition starts about 70 ms after the presentation of a distractor with a maximum at about 110 ms. The first dip is very similar for the first 2 distractors, whereas the second dip shows a clear difference at about 200 ms after the distractor onset. This suggest that the distractor effect constitutes of two sources. A first reflex like inhibition of saccadic activity by SC as proposed by Reingold and Stampe (2000) and a second inhibition by SC that is modulated by cortical activity. The later idea is supported by the temporal cooccurrence of the significant deviations in ERP and the second dip in the distribution of fixation duration as well as similar habituation patterns in fixation duration and ERPs.

In conclusion, the present study indicates effects of habituation and thus supports our general idea to interpret the distractor effect in a broader concept of the OR. Moreover, it allows to integrate early explanatory concepts. Further research is needed to provide more evidence and to rule out if the decrease can be explained by refractory processes.

References

Blair, R. C., & Karniski, W. (1993). An alternative method for significance testing of waveform difference potentials. *Psychophysiology, 30*(5), 518-524.

Pannasch, S., Dornhoefer, S. M., Unema, P. J. A., & Velichkovsky, B. M. (2001). The omnipresent prolongation of visual fixations: saccades are inhibited by changes in situation and in subject's activity. *Vision Research, 41*(25-26), 3345-3351.

Reingold, E. M., & Stampe, D. (2000). Saccadic inhibition and gaze contigent research paradigms. In A. Kennedy, R. Radach, D. Heller & J. Pynte (Eds.), *Reading as a Perceptual Process* (pp. 1-26): Elsevier Science Ltd.

Sokolov, E. N. (1963). *Perception and conditionned reflex*. London: Pergamon Press.

Walker, R., Kentridge, R. W., & Findlay, J. M. (1995). Independent contributions of the orienting of attention, fixation offset and bilateral stimulation on human saccadic latencies. *Experimental Brain Research, 103*, 294-310.