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Attention and feature integration in the feature inheritance effect

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Abstract

Features of neighboring elements are not processed independently. Often, it is assumed that nearby features are integrated by a (pre-attentive) pooling mechanism. Here, we show that in the feature inheritance effect some features are integrated across space whereas others are not. This result may be partly explained by a very focused spatial attention. Our findings challenge models based on a simple pooling mechanism.

Keywords: Feature integration; Temporal processing; Masking; Verniers; Attention; Feature binding

1. Introduction

How features are integrated in the mammalian brain is one of the open issues in the neuro- and cognitive sciences. Using the recently discovered feature inheritance effect, we could show that features of one element can be attributed to another element of the visual display, i.e., features can be mis-localized (figure 1; Herzog & Koch, 2001).

In feature inheritance, a stimulus is followed by a grating which masks the preceding stimulus but simultaneously expresse some features of the stimulus (Herzog & Koch, 2001). For example, if a vernier precedes a grating comprising five elements, the vernier remains largely invisible whereas the grating appears to be offset in the direction of the vernier—though the grating is not offset at all (Fig. 1). We called this effect feature inheritance since a feature of one element presented at one point in time is bequeathed to a variety of elements displayed at a subsequent point in time. Inheritance is not restricted to vernier offsets. Feature inheritance occurs also with oriented lines or for the direction of movement induced by a vernier displayed in apparent motion (Herzog & Koch, 2001; for an animation of stimuli stimuli[1]).

In spite of observers' claims to perceive the whole grating as offset, it turns out that subjects focus attention either on the left-most or on the right-most element of the grating where they perceive the vernier offset in the vernier inheritance paradigm (Fig. 1). Mis-localization has occurred since the vernier was presented at the center of the screen. It seems that feature inheritance depends strongly on attention.

Here, we characterize these attentional factors. We show that offsets of grating elements can be combined with the vernier offset in the focus of attention, i.e., at the attended edge element. We inserted offsets at this attended edge in a direction opposite to the vernier to show that the integration of offsets is scaled and the vernier offset can be nulled. Attention can be directed to the edge covertly, i.e., attention can be allocated without eye

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[1] http://www.neuro.uni-bremen.de/~web/index.php?id=33&link=/~vernier

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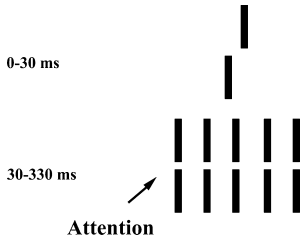

Fig. 1. A vernier stimulus is followed by a grating comprising five verniers without offset. Subjects attend to one edge element of the grating where they perceive the offset of the preceding vernier. Mislocalization of the vernier offset occurs since the vernier is presented in the center of the display whereas attention is on one of the edge elements.

movements. The distance between the location of vernier presentation and the focus of attention seems to change feature integration since performance deteriorates with increasing spacing of the grating, i.e., with an increased distance between vernier and attended edge. The feature inheritance effect allows to dissociate the focus of attention from the location of target presentation.

2. General materials and methods

2.1. Stimuli

Stimuli appeared on a point-plot display (HP 1332 A or HP 1333 A) controlled by a Macintosh computer via fast 16 bit D/A converters (1 MHz pixel rate). A vernier consisted of two vertical segments each 10′ long separated by a vertical gap of 1′. Thus, a vernier was 21′ long. The two vernier segments could be offset in the horizontal direction either to the left or right. In most conditions, the vernier was immediately followed by a grating comprising five aligned verniers (Fig. 1). Except for offset, spatial parameters of the vernier and the following grating elements were identical. The horizontal spacing between grating elements was 200″ (except for experiments 3.3.1 and 3.3.2). Hence, the spatial extent of the grating was 800″ (except for experiment 3.3.2). In many conditions, elements of the masking grating are offset in addition to the vernier. If these elements are offset in the direction opposite to the vernier, these elements are said to be *anti-offset*. The anti-offset sizes are usually much smaller than those used for the vernier.

We refreshed stimuli every 10 ms. Before the stimuli were presented, a fixation spot was turned on in the center of the screen simultaneously with four markers at the corners of the screen for 1 s followed by a blank screen for 200 ms.

Subjects observed the stimuli from a distance of 2 m in a room illuminated dimly by a background light (0.5 lux). Background luminance was below 1 $\frac{cd}{m^2}$. Luminance of stimuli was around 80 $\frac{cd}{m^2}$.

2.2. Procedure and task

In feature inheritance, observers spontaneously attend to one of the edges of the grating where they perceive the illusory vernier offset (Fig. 1). This element is said to be the preferred edge. In the experiments, we asked subjects to attend to this preferred edge or to the opposite edge constantly in one block. In a binary forced choice task, observers had to report the illusory offset direction (“left” vs. “right”) of the attended grating element by pressing one of two push buttons. We will show that subjects base their decisions on the illusory offset of the attended edge element and not “directly” on the preceding vernier (Fig. 2; the vernier is largely invisible because of short presentation time).

If provided, feedback about observers’ incorrect responses was conveyed by a tone (no tone signaled a correct response). A block of stimulus presentations consisted of 80 trials.

For each subject, every condition was measured twice. The order of conditions was randomized for each

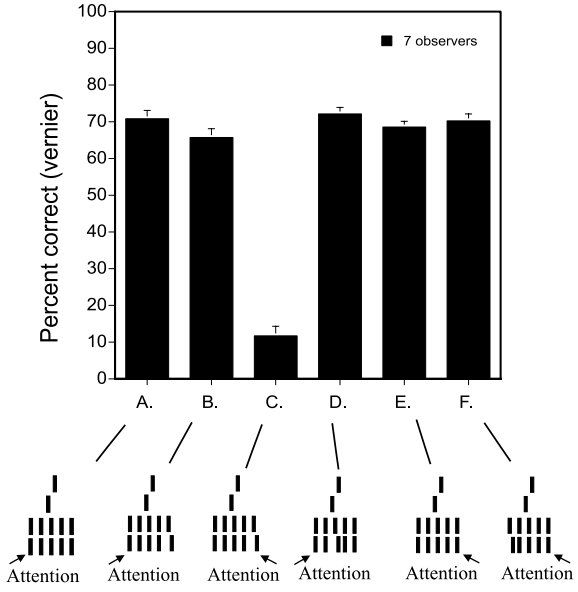

Fig. 2. We displayed a vernier followed by a five element grating in six conditions. (A) The preceding vernier was followed by a grating comprising only aligned elements. Subjects attended to their preferred edge (here indicated as the left edge). (B) The grating comprised four elements without offset plus an additional anti-offset element at the non-preferred edge. (C) The same stimuli were used as in the second condition. However, subjects were instructed to attend to their non-preferred edge. (D) The center element of the grating was anti-offset. Subjects attended to their preferred edge. (E and F) Subjects attended to their non-preferred edge. The grating contained an anti-offset element at the preferred edge (F) or none at all (E). Offset sizes are exaggerated for clarity’s sake. *Results.* Accuracy in conditions A–F (determined relating to the preceding vernier). Only in condition (C), there was a marked decline in performance. It seems that anti-offsets have a strong impact on performance only if they are in the focus of attention (C). See also figure 2 of Herzog and Koch (2001) which covers conditions A–C.