P-31: Selective Attention Effects on Binocular Rivalry to Simple and Complex Dynamic Imagery

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Abstract
Selective attention increased the proportion of time that the attended members of a pair of either simple (gratings) or more complex (movie clips) dichoptic stimuli were visible during binocular rivalry. Lower-level stimulus attributes appear to be more important than meaningfulness in directing attention, which is a finding that may have relevance to the design of head-worn displays.

1. Introduction
The development of head-worn displays (HWDs) has significantly increased over the past several decades. An HWD presents pictorial, symbolic, or sensor information to either one or both eyes by way of one or two miniature visual displays mounted on the head via a helmet or other mounting device (e.g., [1-4]). One application of HWDs is the Joint Helmet-Mounted Cueing System (developed by Vision Systems International) for use by the USA Air Force. This HWD involves a see-through monocular HWD, which is used for presenting symbology for targeting and avionics. The displayed information is viewed by one eye at the same time that the pilot views the real world, or a simulation thereof, with both eyes. Monocular HWDs have also been employed for entertainment and other personal uses [4-5].

Despite the potential advantages of HWDs, there can be problems with their use [2,3]. One reason that HWDs may cause problems is that they can create binocular rivalry (BR). BR results when the two eyes receive different imagery that precludes binocular fusion. BR refers to a state of competition between the eyes, such that one eye inhibits the visual processing of the other [6,7]. The visibility of the images fluctuates between the two eyes, with one eye's view becoming visible while some or all of the other eye's view is invisible (i.e., suppressed). The visibility fluctuates over time, and may cause perceptual confusion. BR is an important topic of study because it represents a visual process by which information or signals may be missed while using an HWD [2,8].

Despite widespread acknowledgement in the applied vision literature of the potential for BR to cause problems with HWDs (e.g., [2,4]), there has been relatively little systematic, applied research on factors that may minimize the occurrence of BR under real-world operational conditions [8,9]. In the present study, we were particularly interested in the effects on BR of the meaningfulness of the stimuli presented to the two eyes, since in many real-world situations, observers often view meaningful objects and scenes while wearing an HWD. We were also interested in the role of attention in controlling the BR process because in many real-world situations voluntarily minimizing the effects of BR would be advantageous, and attentional control could be one method for doing so. Moreover, BR and attention may interact in that greater attentional control may be more easily obtained with more meaningful stimuli.

In the basic vision literature, the effects on BR of the meaningfulness or emotional significance of visual stimuli has been controversial. In early studies, it was reported that erect faces dominated more than inverted faces during BR [10,11]. However, it has been noted [9] that low-level stimulus features, such as luminance and contrast, were not controlled in those studies. Yu and Blake [12] reported that recognizable stimuli, such as faces, predominated more in BR than did nonsense patterns, even when the rivalry stimuli were equated for spatial frequency, luminance, and contrast. Taken together, the available results suggest that meaningfulness may be important in the control of the BR process.

In a related study, Blake [13] (see also [14]) employed a dichoptic reading paradigm in which one eye viewed a stream of meaningful text while the other eye viewed a stream of less-meaningful text. Blake found that, during BR, observers could not prevent the meaningful text from being suppressed by the less-meaningful text during some portions of the viewing period. That finding suggested that meaningfulness was not a major determinant of BR. However, Blake's investigation, unlike the other studies mentioned above, involved linguistic meaningfulness rather than pictorial meaningfulness (e.g., pictures of faces), and it may be that the meaningfulness of these two types of stimuli affect the rivalry process differently.

The effect of attentional control of BR has also been controversial. Lack [15] reported that rivalry could be controlled by selective voluntary attention. Ooi and He [16] reported that suppression was prematurely terminated when observers attended to a rival stimulus relative to when the observers attended to a non-rival stimulus. Chong *et al.* [17] found that dominance durations during BR could be extended by about 50% when observers performed an attentionally demanding task involving one of the stimuli. However, the increase in duration reported by Chong *et al.* may have been a by-product of divided attention. Winterbottom *et al*. [18] found no evidence that observers were able to control rivalry alternations in a simulated HWD set-up (i.e., symbology versus natural imagery). Also, when patterns contain perceptually connected (bound) features (i.e., structural commonalities within stimuli) [16,19], those features may be suppressed collectively, and this may be under attentional control

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14. ABSTRACT
Selective attention increased the time that members of a pair of both simple (gratings) and more complex (movie clips) dichoptic stimuli were visible during binocular rivalry. Lower level stimulus attributes appear to be more important than meaningfulness in directing attention, which is a finding that may have relevance to the design of head-worn displays.

15. SUBJECT TERMS
Head-worn displays; Selective attention; Binocular rivalry; Visual suppression; Dichoptic stimuli; Attention; Display design;

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[20] since perceptual binding occurs for meaningful stimuli (e.g. objects forming a scene). Moreover, moving stimuli are known to dominate over static stimuli [6], and this effect has been used to support the role of attention in BR; that is, it is assumed that motion captures attention [21].

In the present study, we investigated the role of attentional control on the BR process by using static and dynamic stimuli that varied in meaningfulness. Specifically, scenes from two different movies, one seen by each eye, were used to determine whether observers could control the resulting BR by explicitly attending to one or the other of the movies. To examine the effects of stimulus meaningfulness on the BR process, we compared the BR between the two movies to that occurring between two simple spatial frequency grating patterns.

2. Method

2.1. Observers

Eight observers, who varied in age from 20 to 40 years, participated in the study. All observers had normal or corrected to normal vision as determined by visual acuity, depth perception, color vision, and phoria measurements made using an Optec Model 2000P Vision Tester (Stereo Optical Co., Inc., Chicago, IL).

2.2. Stimuli and Apparatus

The stimuli were black-and-white video clips of either gratings or movie scenes. The stimuli were either static or dynamic. The static video clips were obtained by repeating a single frame of the associated stimulus (frame rate = 60 Hz). The stimuli were about 24° in diameter at a viewing distance of 0.43 m, and their mean overall luminance was about 25 fL. The gratings were either vertical or horizontal and their spatial frequency was about 0.42 cycles/deg. The dynamic gratings moved either left to right or top to bottom at about 0.3 cycles/sec. The movie scenes were obtained from either a science fiction (SciFi) movie (*The Day the Earth Stood Still*) or a boxing (Boxing) movie (*Kings of the Ring, Four Legends of Heavyweight Boxing*). Four, 20-sec segments, corresponding to two static and two dynamic stimuli, were obtained from each movie. A stereoscope (Figure 1) was used to present one stimulus to each eye.

2.3. Procedure

For the subjective measure of BR alternation, each observer indicated, by pressing either the left or right button of a joystick, which stimulus was visible at a given time during the 20-sec trial. When neither stimulus predominated, the observer was instructed to press neither button. In certain blocks of trials, the observer was instructed to attempt to attend to one or the other stimulus. In each experimental session, each of the four stimulus combinations was presented twice to each eye. Each experimental session consisted of 16 trials and lasted about 8 min. A total of two sessions were run for each observer in each condition.

3. Results

As shown in the top panels of Figures 2 and 3, when there were no instructions as to which stimulus to attend, there was no significant difference in predominance for horizontal or vertical gratings (repeated-measures ANOVA, $F_{1,7}$=0.54, p=0.49) or for the SciFi or Boxing movies ($F_{1,7}$=2.2, p=0.18).

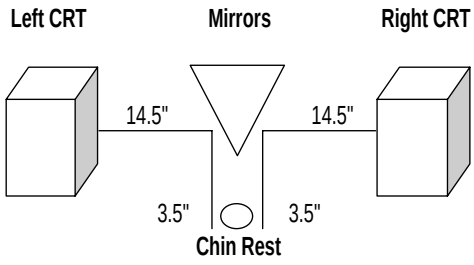

Figure 1. A diagram of the stereoscope used to present dichoptic imagery.

Shown in the middle and lower panels of Figure 2 is the effect of attentional instruction on the average time that each grating stimulus predominated under the four stimulus conditions. Attentional instruction increased the predominance of the grating stimulus to which the observer was instructed to attend ($F_{1,6}$=21.6, p=0.003), an effect that did not vary between the static and dynamic grating stimuli ($F_{1,6}$=0.34, p=0.58). Similarly, as shown in the middle and lower panels of Figure 3, attentional instruction increased the predominance of the movie to which the observer was instructed to attend ($F_{1,6}$=15.0, p=0.008), an effect that did not vary between the static and dynamic movie stimuli ($F_{1,6}$=0.28, p=0.61). For the movies ($F_{1,6}$=7.6, p=0.03), but not the gratings ($F_{1,6}$=1.45, p=0.27), observers were more likely to report predominance for dynamic stimuli than for static stimuli.

Finally, a comparison of the data of Figures 2 and 3 indicated that there was no significant difference between the gratings and movies in the degree to which instructions affected binocular rivalry ($F_{1,6}$=3.92, p=0.095). [The lesser degrees-of-freedom in these latter tests is due to missing data for one observer under some of the conditions tested.]

4. Discussion

The data of Figures 2 and 3 indicate that selective attention can increase, by about 30%, the relative time that the members of a pair of dichoptically presented images are visible. Furthermore, this was found to be true for both simple and relatively complex imagery. These results are consistent those of several studies that found that BR could be controlled by voluntary attention [15-17,19,20], but inconsistent with the finding of Winterbottom [18] who found no evidence for the attentional control of BR. However, the two stimuli in the Winterbottom [18] study were graphics (simple shapes and alphanumeric elements as found in aircraft HWDs) and a natural scene (simulation of low-level flight). The difference between the two stimuli may explain the failure to obtain an effect of attention on BR.

The present results may have practical implications for the use of HWDs in high-performance aircraft wherein HWD imagery is often superimposed on a complex out-the-window scene. In that case, the information presented on the HWD may be either static or dynamic, whereas the out-the-window scene would most likely be dynamic. In this situation, the fact that the meaningfulness of stimuli does not affect attentional control may offer a practical advantage in that if neither image predominates inherently, pilots may more easily shift their attention voluntarily to information or

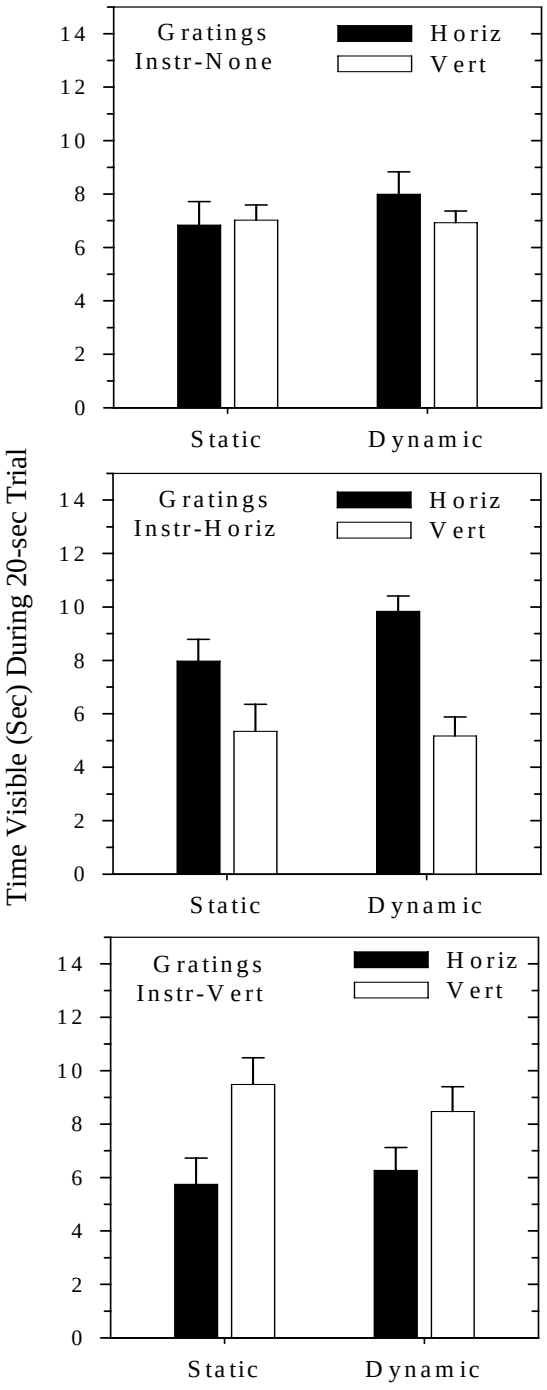

Figure 2. Time that the horizontal grating presented to one eye or the vertical grating presented to the other eye was visible during a 20-second trial. Upper panel: No instructions given as to which grating to attend. Middle panel: Observers were instructed to attend to the horizontal grating. Lower panel: Observers were instructed to attend to the vertical grating. The data are the average of eight observers, although there were missing data for one observer under some conditions. Error bars indicate ±1 standard errors of the mean.

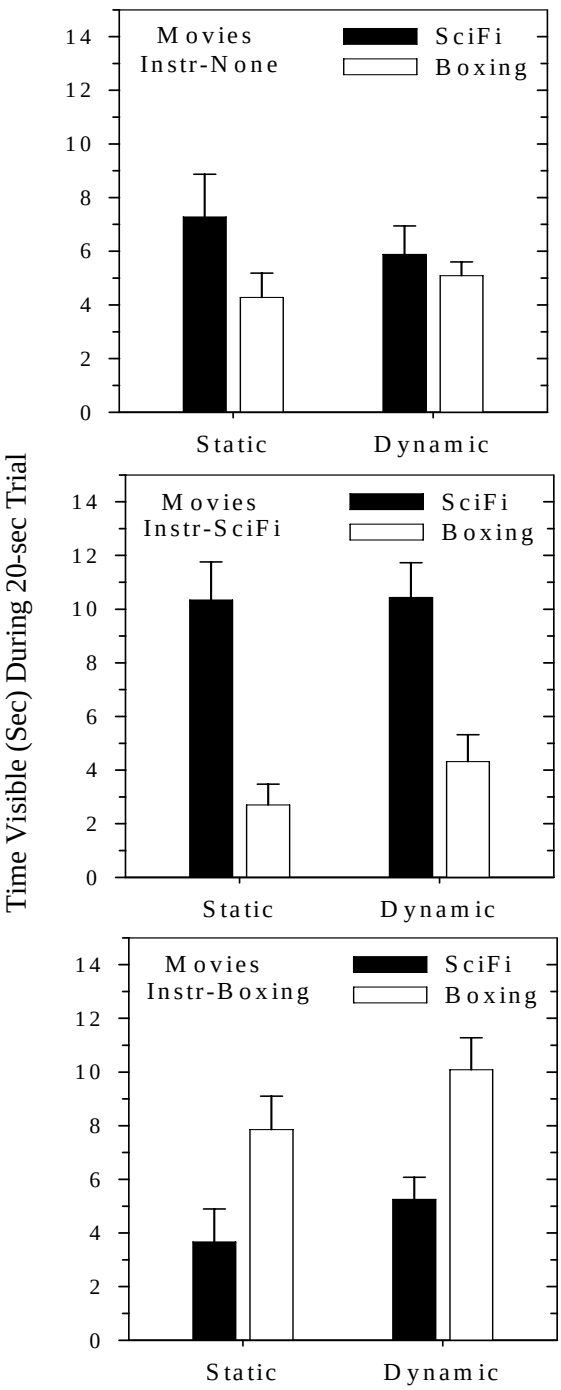

Figure 3. Time that the SciFi movie clip presented to one eye or the Boxing movie clip presented to the other eye was visible during a 20-second trial. Upper panel: No instructions given as to which movie clip to attend. Middle panel: Observers were instructed to attend to the SciFi-movie clip. Lower panel: Observers were instructed to attend to the Boxing-movie clip. All data are the average of eight observers. Error bars indicate ±1 standard errors of the mean.

objects of interest. However, it seems that pilots may not be able to attend completely to one view only. It should be noted that our study included simple BR conditions with one rivalrous stimulus to each eye, while in operational aircraft the graphical information is often presented to one eye only while both view, and binocularly fuse, the same out-the-window scene. It is known that BR is less under these latter conditions [22].

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