

MCGUINNESS, D. & LEWIS, I. (1976) Sex differences in visual persistence: Experiments on the Ganzfeld and afterimages. *Perception*, 5, pp. 295-301.

Perception, 1976, volume 5, pages 295-301

Sex differences in visual persistence: experiments on the Ganzfeld and afterimages

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Received 8 December 1975

Abstract. Sex differences were investigated in two experiments on visual persistence: the Ganzfeld and the afterimage. Males were found to hold visual sensation longer than females, particularly in the Ganzfeld where there was little overlap of scores. Variability of experience in the Ganzfeld was also greater for males and they commonly reported 'blank-out' effects while females did not. There was further evidence from both experiments that females are more responsive to the long-wave region of the frequency spectrum.

1 Introduction

The superior visuospatial ability exhibited by males is now well-established (Maccoby and Jacklin 1974; McGuinness 1976a; Harris 1976). The data reviewed in these papers suggest the possibility that males are predominantly visual in sensory orientation, and that visual cues will be salient when in conflict with other sensory input. However, despite the knowledge that males excel in certain types of cognitive visual processing, this has evoked little interest in sex differences in basic sensory capacity. It is known that males excel in both dynamic and static visual acuity (Burg and Hulbert 1961; Burg 1966; Roberts 1964).

Apart from these data only one other study (McGuinness 1976b) has looked in detail at primary visual processes in men and women. Results showed that again acuity is superior in males, and is superior whether or not subjects wear corrective lenses. Far more males were found in the category 'superior-to-normal'. Males were found to be less tolerant in a brightness judgement task, while females were more sensitive in tasks involving scotopic vision.

One of the more unusual results of this study was the finding that females have higher visual persistence for a moving light source, but only in the dark. The source subtended 7 deg of visual angle and thus engaged primarily parafoveal and motion detector systems. It was concluded that the greater visual persistence in females in the dark could be due to superior rod vision, but that there was no evidence that this facility transfers to daylight conditions. This result was coincident with results from an undergraduate lab session on the Ganzfeld, in which it was discovered that 'blank outs' (see Cohen 1960) were reported only by male subjects and never by females. This result, plus the data of Brownfield (1965) which showed that males have longer afterimages, suggested that a controlled experiment on visual persistence might clarify these sex differences.

Two experiments are reported, one on the Ganzfeld, in which the technique of Hochberg et al (1951) was used, and the second on the afterimage in which a photoflash technique was used.

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2 Experiment 1

2.1 Method

2.1.1 *Subjects.* The subjects in both experiments were twenty males and twenty females, aged 18–23 years, all selected from disciplines outside psychology. The subjects were naive concerning the nature of the experiment, and were paid for their participation.

2.1.1 *Apparatus.* A Kodak Carousel slide projector was placed on a table 3.33 m from the subject's viewing position. Half of the subjects saw a red light (Wratten filter number 25) and half saw green (Wratten number 58). Luminance levels were 18 foot-candles for the red and 74 foot-candles for the green as measured by a Megatron Luxmeter (DA 10). Table-tennis balls, cut in half and shaped to the subject's eyes, were attached by adhesive (Dow Corning Medical Adhesive B) after his/her eyelashes had been lightly glued to the eyelid. A timer (Bioscience Module 540) activated an advance-signal generator and a tone beep sounded at 15 s intervals.

2.1.3 *Procedure.* All subjects were screened with the full Ishihara colour blindness test (Ishihara 1963) prior to the start of the experiment, and all produced perfect scores. After the screening, subjects were seated opposite the slide projector, and the table-tennis balls were secured. Each subject was given several minutes to adjust and was checked thoroughly to determine whether any stray light or discontinuities were visible. When the subject was ready, the room lights were extinguished and the subject sat in the dark for 3 min. The subject was told that a coloured light would be switched on and that at 15 s intervals he/she would hear a tone beep. When the tone sounded he/she was asked to report the colour or colours he/she saw at that exact moment. The experiment continued until a complete cessation of colour lasting 2 min occurred, or until a 20 min time period had elapsed. At the end of the experiment the filter was removed and the subject was flooded with white light (150 foot-candles).

Subjects were allowed to rest for 10 min before the second experiment.

2.2 Results

(i) *First change of colour.* A 2×2 analysis of variance was carried out to determine whether there were any significant differences between sexes or between the two colours for the time taken for the stimulus colour to change to another primary colour. No significant effects were observed ($F < 1$ in all cases).

(ii) *First loss of colour.* A report of no colour or 'white'. Scores for males and females were nonnormally distributed and a Mann-Whitney test was substituted for an analysis of variance. The only significant effect was found for colour; the green stimulus produced a more rapid offset of sensation than red ($z = 3.50$, $p < 0.005$, two-tailed). The overall means for both sexes were 9.15 s for green and 15.25 s for red. This result occurred despite the fact that luminance levels were higher for green than for red.

(iii) *Total loss of colour.* Again, because of a nonnormal distribution of scores, results were analyzed with a Mann-Whitney test. The sex difference was found to be highly significant ($z = 4.98$, $p < 0.00005$, two-tailed); males showed far less loss of sensation than females. Females also showed a colour effect, holding red longer than green ($U = 5$, $p < 0.02$), while there was no significant difference for male subjects ($p > 0.20$). The range over both colours for the time to the disappearance of the stimulus was 17.15–20.00 s for males, and 1.45–20 s for the females. A plot of mean scores is illustrated in figure 1.

(iv) *Return of colour after 'blank out'.* The frequency of males and females reporting a return of colour following a 'blank out' (colour loss) is presented in table 1. A chi-square analysis showed these data to be significant at $p < 0.02$, with only a few

297 females experiencing the blank-out effect. The pattern for colour disappearance for females was highly predictable and consisted of a simple uniform fading over time. For the male subjects the pattern was not predictable. The return of colour was frequently as vivid as the original stimulus and many subjects reported a return of a slightly paler hue than the original colour. Four male subjects also saw the colour complementary to the stimulus colour.

(v) *White light*. All subjects reported seeing the complementary colour when white light was projected, including those subjects who were already seeing the complementary colour with the coloured filter in position

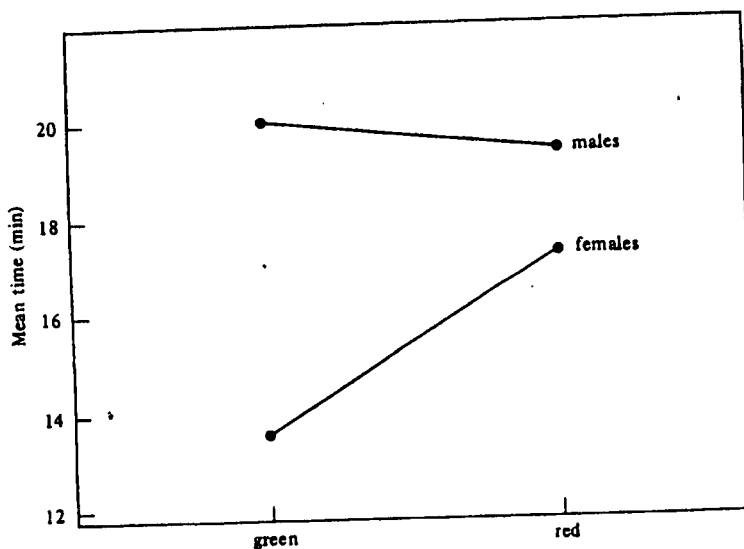


Figure 1. Mean time for total loss of colour in males and females.

Table 1. Number of subjects experiencing return of colour after 'blank out'.

	Blank out	No blank out
Males	11	9
Females	3	17

3 Experiment 2

3.1 Method

3.1.1 *Apparatus*. A Phillips 500 W photoflood lamp (99.4 foot-candles) was placed behind a perspex screen onto which was pasted a black cross (16.5 cm x 16.5 cm). The subject was seated 3.33 m from the screen. A tone beep was timed at 30 s intervals.

3.1.2 *Procedure*. Subjects were seated for 5 min in the dark facing the screen. They were told that when the experimenter signalled 'Ready' they were to fixate the centre of the cross and remain motionless for 5 s without blinking or moving their eyes. When the photoflood was switched off, they were then to turn to face the blank wall and to describe their visual experience after each tone beep. Subjects were given some indication as to the type of visual changes that might occur, such as seeing colours, fragmentation of the stimulus, and a reversal of figure and ground. They were asked to report all visual events as faithfully as possible. It was decided to add

a control for eye blinks. When subjects first reported the loss of the visual image, they were asked to close their eyes for 1 s. After a second loss they were asked to blink hard. The experiment was concluded when this instruction failed to produce a recurrence of the image. This control was employed to eliminate differences between those subjects who might spontaneously blink and those who would not.

3.2 Results

(i) *First report of loss of image.* Subject variances were found to be significantly different ($F = 4.05, p < 0.05$) and the results were analyzed by means of a Mann-Whitney U test. The sex difference was significant ($z = 1.70, p < 0.05$, one-tailed) with men taking longer to report the disappearance of the stimulus. The mean scores, however, were similar—4.84 min for the males, 4.17 min for the females.

(ii) *Time to total loss of image.* Results were analyzed by a Mann-Whitney test with findings similar to those above ($z = 1.60, p < 0.05$, one-tailed). The mean time for the total loss of the image by males was 10.64 min (range: 5–17 min) and by females 9.13 min (range: 2–15 min).

(iii) *Time to a report of a negative afterimage.* Most subjects (fifteen males and nineteen females) reported a negative afterimage in which the black cross appeared white or pale cream against a black background. The times for subjects were 2.61 min for the males and 2.15 min for the females. These results are not significant ($z = 0.71, p > 0.20$). Fragmentation effects were also reported by nearly all subjects.

(iv) *Experience of colour.* 'Flight of colours'. All subjects except two males saw colour, but the time for the disappearance of the flight of colours was not significantly different between the sexes ($z = 0.74, p > 0.20$). The overall mean time for the colours to disappear was 4.25 min.

Males reported a narrower range of colours than females and fewer colours overall. Males: 2.75 colours; females: 3.25 colours. Table 2 shows the numbers of subjects reporting each colour. The purple or violet category is arbitrarily given on the far left. Pure violet is a short wave frequency colour, while purple is a combination of short-wave blue and long-wave red. It is not possible to determine from subjective reports which category is involved.

The data in table 2 indicate that after stimulation by white light the sexes are somewhat differentially responsive across the frequency spectrum. Every female reported a colour in the long-wave range: red or pink, while only half the males did so. Sixteen females reported these colours first, as compared to three males. The other colours were reported with fairly equal frequency but there is a suggestion that the colour receptors are somewhat different between the sexes. The males more commonly report blue, green, and yellow, while the most common responses for females are blue, yellow, and red. A frequency test (Fisher test) was employed to determine whether or not there was a sex difference in reporting high-frequency colour (red or pink). This result was significant at $p < 0.005$.

Table 2. Number of subjects reporting colours during afterimage.

	Violet	Blue	Blue/Green	Green	Yellow	Orange	Red/Pink
Males	8	11	4	9	10	1	10
Females	5	13	7	4	11	1	20

4 Discussion

In the Ganzfeld experiment three main effects of sex were found. Firstly, males had a far greater persistence of colour overall. Secondly, whereas males showed little difference in their responses to red and green, females held the sensation of red significantly longer than the sensation of green, despite the fact that luminance levels were higher for the green stimulus. Finally, males had more variety in their visual experience—colours faded and reappeared; they saw colours unrelated to the stimulus colour and colours complementary to the stimulus colour. No female ever reported an unrelated or complementary colour, and only three reported a return of the stimulus colour after 'blank out'.

The timing effects reported here suggest that the common figure given for loss of sensation in a Ganzfeld—3–6 min—(Cohen and Cadwallader 1958; Hochberg et al 1951) may have been obtained because the experiments were terminated at the first 'blank out'. Cohen (1960) reports the complete absence of seeing in about 10–20 min. Weintraub's data (1964) suggest that the persistence of colour can extend up to 40 min, while Helson (1964) notes that, with high levels of intensity, colour disappearance may not occur. The implication of intensity levels in the timing effects of the Ganzfeld could suggest that the sex difference might result because luminance levels appear higher to males than to females. In a test of subjective brightness McGuinness (1976b) found that males set far lower intensity levels to a verbal criterion than females. Apparent brightness is greater in males and could explain why the stimulus persists. However, this interpretation is seriously challenged by the fact that it cannot explain the *magnitude* of the sex difference found in the Ganzfeld as opposed to the afterimage experiment.

Cohen (1960) reports that a 'blank-out' effect was found in five out of sixteen of his observers. The findings of this study suggest that those five subjects would be most likely to be males. Blank-out effects are not altogether understood, but appear to correlate with an increase in alpha rhythm (Cohen 1960; Cohen and Cadwallader 1958). The data of Tepas (1962) implicate eye movements in colour loss, demonstrating a negative correlation between eye movement as measured by EOG and the number of blank outs. Thus a return of colour could be produced by voluntary eye movements such as saccades and blinking. As only males experience a return of colour after a blank out, eye movements might implicate motivational differences between the sexes. As will be seen shortly, the control for eye blinks in the afterimage study rules out a specifically motivational explanation of the sex differences.

Westheimer (1960) also found during the Ganzfeld episode that the refractory state of the eye becomes increasingly myopic and unsteady, thus implicating factors of accommodation and lens muscle activity. It was noted in the introduction that males have significantly better visual acuity than females and acuity is most commonly determined by accommodation facility. It remains a possibility that differences in accommodation could partially account for this result.

In the afterimage experiment the sex difference in persistence was considerably less marked. These results confirm those of Brownfield (1965) who reports a similar magnitude of significance. The afterimage data are critical in evaluating the hypotheses concerning sex differences. Firstly, it was shown that the sex difference in the timing of the first loss of the visual image (no eye-blink control) was nearly identical in magnitude to the sex difference in the second phase during which eye blink was controlled. Secondly, the level of significance found in this study is identical to that of the Brownfield (1965) study in which no control for eye blink was carried out. These factors effectively eliminate an explanation of the sex differences in terms of a motivational hypothesis.

Hochberg et al (1951) concluded from an experiment on monocular stimulation that the Ganzfeld experience derived from peripheral mechanisms. One possible explanation of these differences is that the timing of iodopsin bleaching and regeneration is different in males and females. Slower timing in males across the whole iodopsin cycle could partially account for both sets of data. Slower bleaching would prolong the colour sensation in the Ganzfeld study and slower regeneration would delay the fading of the afterimage. These temporal events, of course, need not match exactly and could account for the difference in magnitude.

However, the *variability* exhibited by the males in the Ganzfeld study tends to implicate more central effects. Seeing unrelated and complementary colours might indicate that higher structures such as the lateral geniculate and visual cortex are engaged. Centrifugal control over primary systems has been clearly demonstrated by Spinelli and Pribram (1966, 1967), who show that the central nervous system can actively prolong or terminate sensory input. If central processes are involved in these sex differences, the implication would be that visual processing is more active in males than in females. A higher degree of centrifugal control might be anticipated in the Ganzfeld situation because of the more profound effect of the total loss of visual experience.

The remaining sex difference occurred during the afterimage study, where it was found that females showed a significantly different distribution of colour receptor effects following stimulation by white light. The reporting of more pinks and reds by females also relates to the first experiment where females held the perception of red longer than green. Both sets of results suggest that the female colour receptors may be shifted more towards the long-wave end of the spectrum. Little difference appears to be found for short-wave sensitivity. This result came as a considerable surprise, as subjects had been screened by the Ishihara test and were expected to have nearly identical colour sensitivity.

An experiment reported by Nichols (1885) also suggests that there are differences between the sexes in discriminating primary colours from pure white. Females were poorer than males at detecting small amounts of red pigment mixed in white magnesium carbonate, but superior in detecting smaller amounts of ultramarine. If red receptors in females, and possibly blue receptors in males, were differentially stimulated by white light this result would be expected to occur. When asked to arrange the phials in order of decreasing saturation, women were generally superior, showing that the acceptance of more red in 'white' was not due to defective discrimination.

It has been suggested (McGuinness 1976b) that females' superior scotopic vision is biologically relevant in that it enables them to find a wandering infant in the dark. Sensitivity to long wave frequencies, should this be confirmed, would be a further asset in this regard, allowing maximum sensitivity at dusk, dawn, and in areas surrounding a dying fire.

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