

# A contribution of fluorescent lighting to agoraphobia

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**SYNOPSIS** Under three types of artificial lighting 24 women with chronic agoraphobia and 24 female control subjects assessed their mood and bodily symptoms, and their heart rate was measured. One of the three types of lighting was incandescent. The other two were fluorescent, one pulsating in the conventional manner 100 times per second and the other relatively steady. Both were provided by a single fluorescent lamp controlled from one of two circuits. When exposed to the conventional pulsating fluorescent light under double-blind conditions the agoraphobic group showed a higher heart rate and reported more anomalous visual effects in response to an epileptogenic pattern. Control subjects reported more bodily symptoms under the conventional fluorescent light than under the two other lighting conditions.

## INTRODUCTION

Three questionnaire studies (Watts & Wilkins, 1989) investigated the role of stressful visual stimulation in eliciting anxiety in people with agoraphobia. More than a quarter of a sample of agoraphobic subjects reported that fluorescent lighting caused considerable anxiety. The link between visual stimulation and anxiety appeared to be specific: non-visual stimulation was without comparable effect, and agoraphobic groups did not differ from controls with respect to the effects of visual stimulation in eliciting headaches. The effects of visual stimulation were correlated with the extent to which subjects experienced depersonalization and somatic symptoms of agoraphobia, but not correlated with its behavioural or cognitive aspects, or with depression.

Hobbs *et al.* (1984) compared fluorescent with incandescent lighting and found that under fluorescent lighting people with agoraphobia reported greater anxiety (using a check list of affective adjectives). Agoraphobic subjects also showed higher frontalis muscle activity under the fluorescent lighting.

Taken together, the above studies suggest a possible role for fluorescent lighting in con-

tributing to the anxiety of people with agoraphobia. Fluorescent lighting is now known to have other adverse physiological effects. The light usually pulsates in brightness between a maximum and about 60% of maximum twice with each cycle of the a.c. electricity supply, e.g. at 100 Hz. Although this pulsation cannot be seen as flicker, it affects the firing of cells in the retina (Greenhouse *et al.* 1988) and the lateral geniculate nucleus (Eysel & Burandt, 1984). In a double-blind study Wilkins *et al.* (1989) compared two forms of fluorescent lighting that were outwardly indistinguishable. One pulsated in the conventional manner at a frequency of 100 Hz and the other was controlled by a new form of circuitry which removed most of the 100-per-second pulsation. The incidence of eye-strain and headache under the new form of lighting was less than half that under the conventional lighting.

The purpose of the present study was to investigate the anxiety reactions of agoraphobic subjects under fluorescent lighting, and in particular to examine the possible role of light pulsation. Groups of agoraphobic volunteers and control subjects were examined in their own homes and asked to complete various questionnaires and symptom check lists under fluorescent and incandescent lighting. Responses under fluorescent lighting that pulsated in the conventional manner were compared with those

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under a new form of fluorescent lighting that had minimal pulsation. The comparison was made under double-blind conditions in what was ostensibly a study comparing fluorescent and incandescent lighting. It was predicted that any adverse effects would appear under the pulsating fluorescent light, and that the responses under incandescent light and the new relatively steady fluorescent light would be similar.

## METHOD

### Subjects

#### *Agoraphobic group*

Twenty-four women aged 28–69 (mean 50, s.d. 12) suffering from chronic agoraphobia were selected from a group of volunteers and a self-help group in the Edinburgh area. All of the women had experienced panic attacks for a minimum of 3 years (mean 16, maximum 41), beginning at a mean age of 33 (range 17–57). Eighteen of the subjects had taken part in a previous experiment. Twenty-one were married and three were widows. Six reported suffering from depression occasionally. Fifteen were taking medication (10 anxiolytics, 3 anti-depressants and 2 non-psychotropic).

#### *Control group*

Twenty-four women aged 31–79 (mean 65, s.d. 10) were recruited from a Women's Institute in Gloucestershire. None of the women experienced panic attacks and none had any psychiatric illness. Eighteen were married and six widowed, and 11 were taking medication of various kinds, none of which was psychotropic.

### Procedure

All subjects were examined in their own homes. A brief description of the experiment was given, stating that the aim was to determine whether people who suffer from agoraphobia are bothered by some types of lighting and not others. The subject's signed consent was obtained, and they were introduced to visual analogue scales and asked to complete three scales relating to present feelings of hunger, sleepiness and thirst as practice.

All subjects completed Kellner's (1987) symp-

tom questionnaire and Marks & Mathews' (1979) fear questionnaire. Agoraphobic subjects were then asked to describe their panic attacks in response to six questions relating to occurrence, associated symptoms and precipitating factors.

The curtains were closed and the room lights turned off. A 1.2 m 40 watt fluorescent tube (Thorn cool-white) was positioned out of sight about 0.5 m behind the patient at shoulder level. The circuitry within the lamp holder could be switched to conventional circuitry or that producing minimal pulsation (Thorn high-frequency control gear). The switch positions were not known to the experimenter. The conventional circuit provided light that fluctuated between a maximum and about 55% of that maximum at a principal frequency of 100 Hz (measured with a V-lambda-corrected photodiode). The modulation (difference in maximum and minimum luminance as a proportion of sum of luminance) was therefore 29%. A high-frequency circuit provided light with a modulation of no more than 7% at 100 Hz. The time-averaged luminance of the surface of the lamp when it was controlled by the two circuits was closely matched. The ends of the lamp were covered by opaque material for a distance of 0.1 m so as to attenuate 50 Hz modulation from the dark spaces in front of the cathode. The incandescent light was provided by an 'Anglepoise' reading lamp directed at the working surface.

The lighting conditions (conventional pulsating fluorescent light, new fluorescent light with minimal pulsation and incandescent light) were presented in a random order, balanced across subjects. Six tasks were undertaken under each lighting condition and they are listed below. Tasks numbered 3–5 were questionnaires based on 10 cm scales as described below.

(1) Subjects performed a letter-cancellation task lasting one minute. The task was used to occupy the subject so as to assess any effects of adaptation to the lighting.

(2) Subjects reported the visual illusions they saw in an epileptogenic pattern (Wilkins *et al.* 1984). Gaze was directed for 30 s at a red dot at the centre of a black and white grating of horizontal lines. The grating was printed on paper and had a space-averaged luminance of about 20 cd/m<sup>2</sup> under all three lighting con-

ditions. It had a square-wave luminance profile, contrast 0.7 and was circular in outline, with a diameter of 0.18 m. When viewed from 0.4 m it had a spatial frequency of 3 cycles per degree. After 30 s the subject was asked whether they experienced any of the following visual effects: colours (red, green, yellow, blue), diamond shapes or lattice shapes; shimmering; blurring; dazzle; glare; lines that seemed to bend; fading; blobs and flickering. She was also asked to rate the unpleasantness of the pattern on a 10 cm scale.

(3) All subjects were asked to record how they felt using a Present State Questionnaire consisting of 10 visual analogue scales, the poles of which were based on the following: dizzy, tense, trembling, odd vision, sick, headache, faint, heart beating harder or faster, panicky, short of breath.

(4) Agoraphobic subjects completed a similar 3-item scale based on the individual sensations that each subject had reported experiencing during their panic attacks. These symptoms varied considerably from one individual to another, particularly in the way they were expressed, but included 'difficulty in speaking'; 'eyes feel irritated'; 'legs feel weak'; 'tight band round the head' and so forth.

(5) All subjects then rated five of the most commonly reported sensations of depersonalization (Dixon, 1963): 'Other people seemed changed or unfamiliar'; 'Things that I have been used to now begin to seem strange'; 'My body seems detached from me'; 'It seems as though there is a wall or veil between me and other people'; 'I feel like a stranger to myself'.

(6) The subject's pulse was measured by palpating the wrist for 30 s.

The order of the tasks numbered 1 and 2 above was balanced across subjects within lighting conditions. The remainder of the tasks were undertaken in the above order.

Before the session ended, subjects were asked six standard questions in response to which they indicated whether they disliked fluorescent lighting, flashing lights, or bright lights, whether they could detect a difference between the two occasions the fluorescent light had been turned on, and what medication, if any, they had taken that day.

## RESULTS

Marks & Mathews' (1979) fear questionnaire provides sub-scales which indicate avoidance of specific activities away from home, avoidance of social situations, and fear of blood-injury. On these subscales the means for the agoraphobic group were respectively 5.4 (s.d. 1.89), 3.1 (s.d. 1.3) and 2.4 (s.d. 1.8), 7.8, 2.2 and 1.7 standard deviations above the corresponding means for the control group. Kellner's (1987) symptom questionnaire gives scales for anxiety, depression, anger-hostility and somatization (attention to bodily changes). On these scales the agoraphobic group averaged 7.9 (s.d. 5.9), 5.3 (s.d. 4.5), 2.8 (s.d. 2.9) and 6.0 (s.d. 4.7) respectively; 3.7, 3.1, 2.0 and 5.2 standard deviations above the means for the control group.

Subjects' responses to the 10 cm scales tended to be skewed, clustered either at the negative pole or at some point along the scale. For this reason symptoms were scored as 'present' when the response was more than 5 mm from the negative pole, and 'absent' otherwise.

On the present state questionnaire the average number of symptoms 'present' is shown in Fig. 1. Agoraphobic subjects reported more symptoms than controls (Mann-Whitney  $P < 0.005$ , 2-tail), consistent with their higher somatization scores. They reported fewer symptoms under incandescent lighting than under fluorescent lighting, whether conventional (Wilcoxon,  $P < 0.001$ ) or high frequency ( $P < 0.009$ ). Control subjects also reported fewer symptoms under incandescent lighting than under fluorescent, but only when the fluorescent lighting was conventional ( $P = 0.026$ , 1-tail), and not when it was high-frequency ( $P = 0.394$ ). The difference between the two forms of fluorescent lighting was significant for the control subjects ( $P = 0.026$ , 1-tail) but not for the agoraphobic subjects ( $P = 0.224$ ). When taken individually, none of the symptoms on the present state questionnaire differed significantly between lighting conditions.

The personalized symptom list (used only with the agoraphobic group) did not discriminate between lighting conditions. The number of symptoms of depersonalization was very low for both groups, and also failed to show any difference between lighting conditions.

Fig. 2 shows the number of anomalous visual

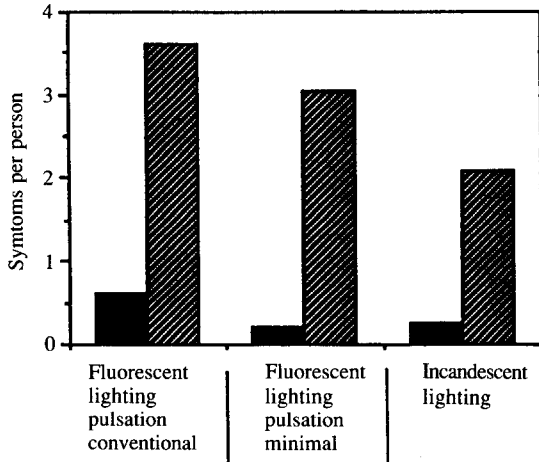


FIG. 1. Number of symptoms reported on the present state questionnaire under three lighting conditions. (■, Control group; ▨, agoraphobic group.)

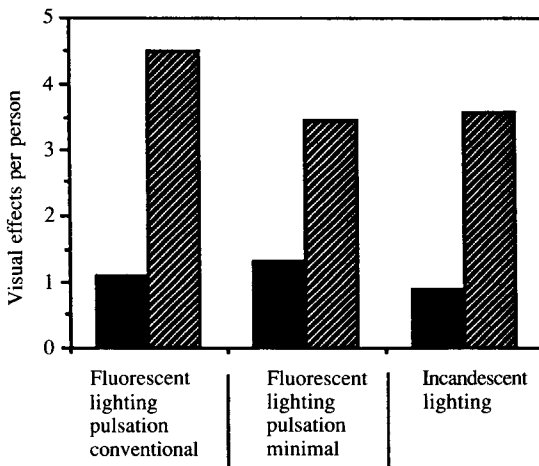


FIG. 2. Anomalous visual effects reported in response to an epileptogenic pattern under three lighting conditions. (■, Control group; ▨, agoraphobic group.)

effects reported in response to the epileptogenic pattern under the three lighting conditions. For the agoraphobic group, but not for the controls, the number of visual effects reported when observing the striped pattern was greater under conventional pulsating fluorescent light than under high frequency ( $P = 0.015$ , 1-tail) or incandescent light ( $P = 0.042$ , 1-tail). The number of effects reported when the test was administered after a period of adaptation to the

lighting (i.e. when the illusions test was given after the letter cancellation task) did not differ from those obtained when the illusions test was given first. There were no differences in the rated unpleasantness of the pattern.

The heart rate under the two conditions of fluorescent lighting is shown for agoraphobic and control groups in Fig. 3. Each point represents the subject and position of the point is determined by the heart rate measured under the two lighting conditions. Points below the diagonal therefore represent those subjects for whom the heart rate was elevated under pulsating light. An analysis of variance of heart rate under the two fluorescent lighting conditions showed a significant main effect of lighting ( $P = 0.03$ ), indicating that the conventional pulsating fluorescent lighting was associated with a higher heart rate. The interaction between lighting and subject groups did not reach significance. When the data from the subject groups were analysed separately, the difference between the conditions was significant for the agoraphobic subjects ( $P = 0.015$ , 1-tail) but not for controls. There were no significant differences between the high-frequency fluorescent light and incandescent light for either group.

Thirteen of the 24 agoraphobic subjects and 5 of the 24 control subjects reported that they found fluorescent light unpleasant. These subjects are represented by filled data points in Fig. 3. As can be seen, the data for these subjects showed the same pattern as those for the remainder. Nine of the 24 agoraphobic subjects reported that they could detect a difference between the two presentations of fluorescent light, and gave a variety of reasons, such as more pronounced visual effects for conventional fluorescent lighting (3 subjects), difficulty in focusing (2), feeling detached (1), brighter light (2), dimmer light (1). One subject reported light-headedness with the high-frequency light. Five of the 24 control subjects said they could detect a difference, 3 reporting the conventional light as dimmer, and 1 as brighter, and one subject complaining that it made her feel ill.

## DISCUSSION

The physiological and psychological effects of conventional fluorescent lighting and a new form with minimal pulsation were compared

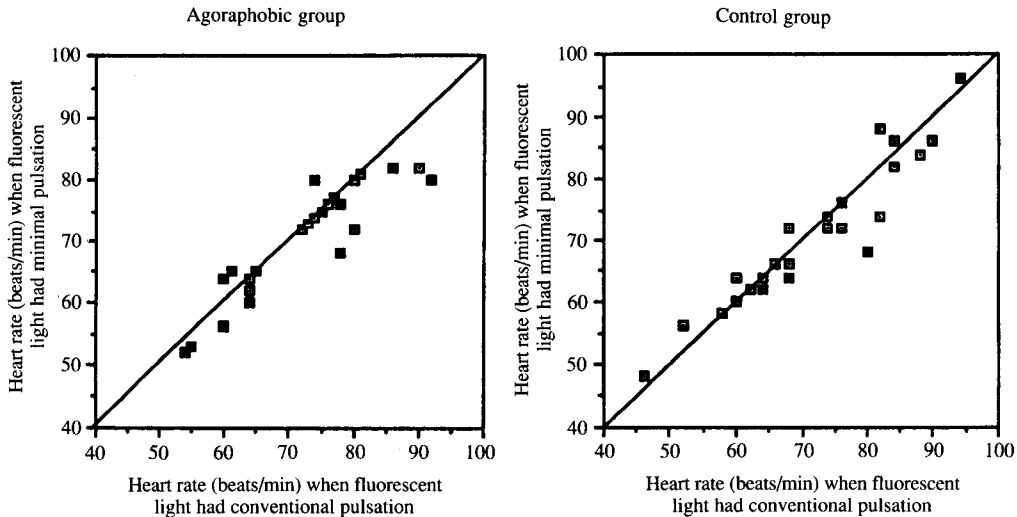


FIG. 3. Heart rate under two types of fluorescent lighting. Each point represents a subject, and those below the diagonal, subjects whose heart rate was greater under conventional fluorescent lighting than under that with minimal pulsation. Solid points represent subjects who disliked fluorescent lighting.

under conditions in which subjects were unaware that they were exposed to two types of fluorescent lighting, and the experimental worker had no knowledge as to which type was which.

The results indicate that conventional pulsating fluorescent lighting produces a response in the nervous system which is not registered as a sensation of flicker but ultimately is responsible for a variety of bodily symptoms.

Hobbs *et al.* (1984) reported that agoraphobic subjects showed greater frontalis muscle activity under fluorescent lighting than under incandescent lighting. In the present study heart rate was higher under conventional pulsating fluorescent light than under the two forms of relatively steady lighting (new fluorescent lighting and incandescent lighting). The difference was significant for the agoraphobic group but not for controls. It is possible that people with non-specific anxiety may show a reaction similar to those with agoraphobia.

Stressful visual patterns which normally induce a variety of anomalous visual effects were more likely to do so under pulsating fluorescent light, but only for agoraphobic subjects, perhaps because of a greater visual sensitivity similar to that reported by Watts & Wilkins (1989).

More of the agoraphobic subjects than controls found fluorescent lighting generally un-

pleasant, confirming the results of Hobbs *et al.* (1984) and Watts & Wilkins (1989). The agoraphobic group in the present study may therefore have expected more aversive symptoms under the fluorescent lighting than under incandescent, and it might be for this reason that symptoms were increased under both types of fluorescent lighting relative to incandescent. No such expectations would have been held with respect to anomalous visual effects, which is perhaps why the increase in such effects occurred only under conventional pulsating fluorescent light. Control subjects, who were generally less affected by fluorescent lighting and had no reason to expect to feel ill, showed a higher incidence of symptoms only when the light pulsated, indicating that this aspect of fluorescent lighting was responsible for their symptoms. The demonstration of adverse symptoms in control subjects after only 10 minutes exposure will in future studies facilitate the rapid evaluation of the stimulus characteristics responsible for the non-visual effects of pulsating light.

Watts & Wilkins (1989) have found that a substantial proportion of patients with agoraphobia report that fluorescent lighting precipitates panic attacks. The present findings would support their claim in so far as pulsating

fluorescent light increases heart rate in these subjects. It is possible that some agoraphobia begins when symptoms associated with anxiety are elicited by supermarket lighting.

The most common variety of fluorescent lamps are halophosphate lamps which pulsate more at the blue/green end of the spectrum than at the red. At the red end the phosphor retains the light between cycles of the electricity supply (Wilkins & Clark, 1990). It is therefore possible to remove much of the pulsation from these lamps with specially tinted glasses (Wilkins & Wilkinson, in preparation). It will be interesting to see whether these glasses can assist people with agoraphobia.

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