

METHODS

Subjects: There were two groups (yoga and control) of 30 subjects each. The subjects of both groups were matched for age and sex, with ages ranging from 18 to 42 years (group average age \pm SD, 28.8 ± 6.1 years) and 6 female subjects in each group. All subjects had normal vision without correction.

Apparatus: The degree of optical illusion was measured using the Muller-Lyer apparatus (Anand Agencies, Pune, India). The Muller-Lyer lines though of equal length, appear unequal due to the two different types of arrows drawn at both ends of the line: close-ended arrows making an acute angle or open-ended arrows making an obtuse angle with the shaft. In the apparatus used for the present study the line on the left was of fixed length and had close-ended arrows at either end giving it an illusory shorter appearance. In contrast the length of the line on the right could be varied. This line had open-ended arrows at either end which made it appear longer.

Assessment procedure: The experimenter manipulated the length of the line according to the subject's specifications. The exact position at which the subject perceived the two lines to be of equal length was noted, i.e. subjective reading ("sr"). The difference between the "sr" and the reading at which the lines were actually of equal length, gave the degree of illusion ("di"). Each subject was assessed in two types of trials ("in" and "out"), ten each, given alternately. For "in" trials the examiner adjusted the length from maximum (200 mm) till the subject, seated 1.8 m away, perceived the length to be equal to the fixed line (160 mm). For "out" trials the procedure was reverse, the adjustable line was kept to minimum length and the length was gradually increased till the subjects perceived the length to equal that of the fixed line. In

both cases the difference (in mm) between actual length of the line and the perceived length was noted as the degree of illusion ("di").

Design of the study: subjects of both groups were assessed at the beginning and end of a month. During the month subjects of the yoga group received training in yoga, whereas control group subjects carried on with their routine activities.

Yoga training: The yoga group received training in physical postures (asanas, 90 min), yoga voluntary regulated breathing (pranayama, 60 min), meditation (60 min), lectures on the theory of yoga (60 min), as well as visual cleansing exercises (trataka, 30 min). During trataka and meditation, subjects were given instructions to focus the gaze on a specified object, followed by defocusing. During asanas and pranayama practice subjects were asked to "focus" their attention (on their breathing or body sensations), followed by "defocusing".

Data analysis: The data were analyzed using the two factor ANOVA, where Factor A = Yoga versus Control group; Factor B = before versus after. Separate two factor ANOVA were performed for the data obtained during "in" and "out" trials. The Tukey multiple comparison test was used to test for significant differences between group average values.

RESULTS

The two factor ANOVA (Factor A = Yoga versus Control groups and Factor B = before versus after) revealed significant differences ($P < .001$, all cases) for both factors as well as the interaction between them (A X B), for "in" and "out" trials, calculated separately. See Fig. 1 for group average values of the degree of illusion ("di"), in mm. The Tukey test results are summarized in Table I.

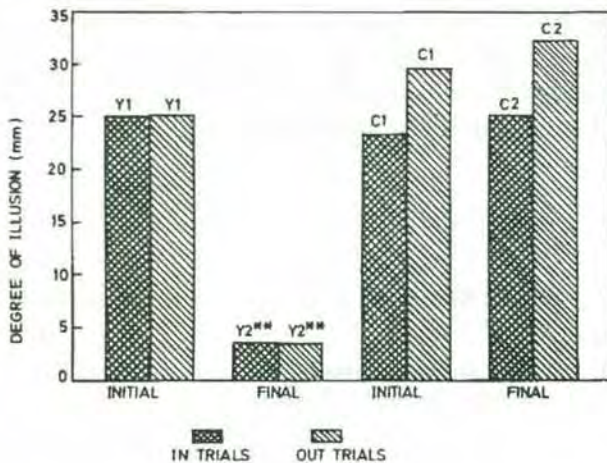


Fig. 1: Group average degree of illusion ("di" in mm) in yoga (Y) and control (C) groups at initial (1) and final (2) assessments, during both "in" and "out" trials. ** = P<.001, Tukey test (Y2 versus Y1, or Y2 versus C2, or Y2 versus C1). The standard deviation (SD) values for the Y group at 1 and 2 testings were 1.4 and 1.0, respectively, for both trials. For the C group the SD values at 1 and 2 assessments were 1.7 and 1.5 respectively ("in trials") and 1.1 and 1.9 respectively ("out trials").

DISCUSSION

The present study showed that a month of yoga training caused a significant decrease in the degree of optical illusion perceived using the Muller-Lyer lines. For "out" trials the decrease was 86.4% and for "in" trials it was 86.0%, hence the average decrease was 86.2%. A previous report described how focusing the gaze reduced the optical illusion by 79% (3). In the present study subjects of the yoga group were trained for a month in yoga practices which involved actually focusing and defocusing the gaze on a specified object (as in trataka or meditation), or "focusing - defocusing" the attention on the breathing/body sensations (as in asana and pranayama practice). Hence the combination of focusing followed by defocusing appears to be more effective in reducing the degree of illusion compared to focusing alone.

TABLE I: Tukey test results (q values) before (B) or after (A), yoga (Y) or control (C) sessions.

Comparison	Out trials	In trials
BY versus AY	15.42**	16.77**
BC versus AY	9.03**	18.22**
AY versus AC	21.07**	18.30**
BY versus BC	2.51	1.44
BY versus AC	2.72	1.52
BC versus AC	2.20	1.51

**P < .001, where q (.001), 116, 4 = 5.48; (derived value of q)

Retinal, cortical and cognitive-judgmental factors influence the perception of a geometric illusion (2). At the retinal level mutual inhibition of spatially adjacent neural units account for the perception of an illusion involving intersecting lines (4). A cortical "satiation" model has been proposed to explain the role of cortical factors in perceiving an illusion (5). It states that if a specific cortical locus is continuously stimulated the neural substrate becomes refractory and hence difficult to activate. This refractoriness spreads spatially to include nearby neural units. If a test line is presented so that the activation caused by it overlaps the refractory region, the response will be inaccurate and may result in an illusory perception.

Where there is a decrease in the degree of illusion perceived over a short period it is generally understood that retinal or cortical factors would not contribute to the change which would be mainly due to cognitive-judgmental factors (6). Changes within a month fall into this category, as opposed to changes taking place over one or more years. Cognitive-judgmental factors involve the way

in which the subject interprets incoming visual information based on experiences, hypotheses and strategies of judgment. Hence in the present study the training in focusing-

defocusing through yoga for a month may have influenced the cognitive-judgmental factors of the subjects, to significantly reduce the degree of illusion perceived.

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