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An initial investigation of bright light and depression: A neuropsychological perspective

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The effects of bright and dim light on finger-tapping rate and on focused and nonfocused dichotic listening performance were evaluated in 21 nondepressed and 21 mildly depressed women. Previous research had proposed decreased left hemisphere (LH) activation in clinically depressed subjects, and pilot data projected a selective activating effect of ambient light on the LH. It was expected that those in the depressed group would have lower base rates of finger tapping, with right-hand rates affected most. The effect for groups was not significant. Bright light exposure was expected to increase the right-hand tapping rate in both groups, with a pronounced effect on depressed subjects. Group × effector × context interactions were not significant. Depressed subjects were expected to have a decreased right-ear advantage (REA) for dichotic consonant-vowel combinations; a main effect of groups was nonsignificant, but in the hypothesized direction. The depressed group also found it more difficult, but not reliably so, to focus attention on stimuli entering the right ear. Neither group experienced the predicted increase in REA in the bright light context. However, the expected increase in the depressed group's ability to shift focus to the right ear was seen. Longer periods of light exposure, male subjects, and clinically significant populations may yield statistically significant results.

Early lesion studies found that left hemisphere (LH) damage resulted in dysphoric "catastrophic reactions" (Heilman & Satz, 1983; Ruckdeschel-Hibbard, Gordon, & Diller, 1986). This phenomenon was also demonstrated through the use of a fast-acting barbiturate to anesthetically deactivate the cerebral hemispheres (the Wada test). The catastrophic-depressive reaction has most often been seen in patients subjected to LH deactivation (Heilman, Watson, & Bowers, 1983). Electronic evaluation of brain activity has also suggested LH involvement in depression. For example, Davidson, Schaffer, and Saron (1985) discriminated between subjects scoring high and those scoring low on the Beck Depression Inventory (BDI) by using resting EEG power. The researchers found that the depressed subjects displayed a significant decrease in left frontal activation.

Behavioral performance tasks such as dichotic listening and tachistoscopic tasks have also suggested LH dysfunction in depression. For example, Johnson and Crockett (1982) and, earlier, Moscovitch, Strauss, and Olds (1981) found that on dichotic listening tasks, unipolar depressed subjects had a decreased right-ear advantage (REA) for verbal stimuli. The same subjects showed a reduced right-visual-field advantage for verbal stimuli presented tachistoscopically.

Light exposure has been suggested for use in the treatment of depression in the psychiatry literature. Wehr, Skwerer, Jacobson, Sack, and Rosenthal (1987) demonstrated a significant reduction of Hamilton Rating Scale scores in winter depression (i.e., seasonal affective disorder) patients who received two 4-h light exposures for a period of 7 days. Cited in this study are previous articles which demonstrated decreased depression measure scores with increased light exposure and subsequent reversal of effects when the light exposure was discontinued (e.g., Hamilton scores increased following removal of the treatment). Meesters et al. (1991) found that using daily bright light exposure during the first signs of mood decrease in a population with a history of "winter depression" actually prevented the development of major depressive episodes in subjects who were compared with no-treatment controls.

Boray, Gifford, and Rosenblood (1989) investigated the possibility that full-spectrum light, which more closely matched the spectrum of natural sunlight, has a more pronounced effect on mood and cognitive performance. The results indicated that quantity of light was more important than quality, and that 40-W cool-white, warm-white, and full-spectrum fluorescent bulbs were equally effective at increasing arousal and pleasure scores on standardized self-report scales (Mehrabian & Russell's pleasure/arousal scales). More recently, Veitch, Gifford, and Hine (1991) found demand characteristics to be the salient factor in producing differences in mood under cool-white versus full-spectrum light conditions, rather than characteristics of the particular bulbs.

The purpose of the present study was to evaluate the effects of bright light exposure on behavioral neuropsychological measures of laterality in depressed and nondepressed subjects. It was predicted that depressed subjects, in comparison with nondepressed subjects, would evidence decrease left relative to right cerebral function-

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ing, and that bright light exposure would selectively increase LH functioning.

METHOD

Subjects

The subjects for this study were 42 female college students from introductory psychology courses at Virginia Polytechnic Institute and State University. They were divided into two 21-subject groups according to a predefined cutoff score of 10 or above on the BDI for the depressed group and below 10 for the nondepressed group. The average BDI score of the depressed group was 13.5 (SD = 6.20), and the average BDI score of the nondepressed group was 3.5 (SD = 3.72). The depressed group average age was 17.9 (SD = 4.88), and the nondepressed group's was 17.6 (SD = 4.61). All subjects were screened to exclude neurological, auditory, or visual impairment and reading disability.

Apparatus

The study was conducted with the subject in a light-controlled area defined by the immediate vicinity of a desk and chair surrounded by flat white, opaque material. Light level was maintained at approximately 300 lx for the low-light and pretesting periods, and at a level of between 2,000 and 2,500 lx for the high-light condition; a total of three shop lights with two 40-W Sylvania F40 rapid-start bulbs each and a ceiling-mounted light bank with two additional 40-W Sylvania bulbs were used. Light levels were measured at the level of the subject's eyes and at a distance of 90 cm from the center of the light source.

Finger tapping was recorded with the use of a single-throw key switch connected to a counting console consisting of two independent, high-speed, liquid crystal counting modules. Event recording and monitoring took place outside of the subject's field of view, and soundless switches on the monitoring module and a quiet time-activated relay bank were used.

The dichotic listening stimuli were 30 pairs of concurrently delivered (0-msec lag time) voiced consonant-vowel (CV) syllables (ba, da, ga, ka, pa, and ta) on a computer-synthesized tape prepared at the Kresge Hearing Research Laboratory. The stimuli were presented at about 75 dB (A) on a Magnavox AQ5090 dual-channel tape player connected to Koss K-6 stereo headphones. The interstimulus interval was approximately 6 sec, and the CV syllables were presented in nonidentical pairings. The six CVs were visually displayed for response identification as 2-cm black uppercase letters on a 96×144 cm index card in two rows of three pairs and displayed at a distance of about .5 m.

Procedure

The procedure was approved by the Institutional Review Board and Human Subject Committee of Virginia Polytechnic Institute and State University, and an informed consent form was read and signed by each subject. First, group testing with the BDI was used to develop a subject pool for the depressed and nondepressed groups. The subjects were then randomly selected from the pool.

During the subsequent individual testing, information such as the name, age, and birthdate of the subject was garnered, along with any history of neurological, auditory, or visual deficit. Subjects with a self-reported positive history of neurological dysfunction, hearing, visual, or reading difficulty (exceptions being corrected vision or hearing) were excluded from the experiment. Next, the examiner said, "I am going to ask you a series of questions. I want you to think about each question as if you were going to perform the task right here. Then answer using the words 'right,' 'left,' or 'either.' I will be standing behind you while you answer." Then the Self-Report Lateral Preference Inventory examination was administered orally, with the examiner remaining out of the subject's visual field. Only subjects scoring +7 or better on this instrument were used for the study. Additional questions on family sinistrality were included. Each subject took the BDI again before testing to verify the subject's affective state and document any changes since the group testing and selection. The examiner then set up the appropriate lighting conditions according to the counterbalancing table, and the subject was allowed to adapt to the conditions in the testing environment.

For the finger-tapping task, the subject was asked to close her hand into a fist and to tap a key with her index finger by using only a finger motion. The key was located on the subject's midline. Both of the subject's arms were resting on the desk. In the initial training phase, the subject was asked to practice with both hands until she attained coordinated and rapid performance.

Once the subject had achieved rapid and accurate performance with each hand, the examiner said, "When I say 'begin,' I want you to tap as quickly as possible until I tell you to stop. Ready? Begin." Following a 5-sec delay, a counter was activated automatically and data were gathered for 20 sec. Tapping was then discontinued.

The order of testing the left and right hands was counterbalanced between subjects within each context. In addition, the context order was counterbalanced between tasks.

For the dichotic listening task, three sets of 30 CV trials were given with the headphone placement (i.e., right and left speakers) altered across subjects. First, a card containing the phonemes was placed in front of the subject, and the following instructions were given:

> You are going to put on these headphones, and when the tape begins, you will hear two sounds. One sound will come in one ear, and a different sound will come in the opposite ear. It will be like two people talking to you at the same time. I want you to tell me exactly what you hear. With your right hand, point to the sound you hear on the chart. Then take your hand away and look up at the curtain in front of you. Do you have any questions? [pause to answer questions] There will be a few instructions at the beginning of the tape and then it will start. You may put on the headphones.

After the subject put on the headphones, the examiner started the tape and stood behind and at the subject's midline.

After the first set of phonemes was finished, the tape was turned off, the card changed, and the subject was asked to remove the headphones for new instructions. "This time I want you to listen only to your left ear. Tell me exactly what you hear out of your left ear." These instructions were accompanied by a prompt: the examiner touched the left ear of the subject. The headphones were put on again, and the tape was turned on. Following the second set of phonemes, the tape was stopped, the earphones removed, and more instructions were given: "This time listen to your right ear only. Tell me exactly what you hear out of your right ear." These instructions were accompanied by a prompt: the examiner touched the right ear of the subject. The headphones were put on again, and the tape was turned on. Following the third presentation, the headphones and the card were removed.

The order of testing dichotic listening in the nonfocused condition, the focused left condition, and the focused right condition was counterbalanced between subjects within contexts. Similarly, the context was counterbalanced across subjects.

RESULTS AND DISCUSSION

A mixed design, repeated measures multivariate analysis of variance (MANOVA) with group (depressed vs. nondepressed) as the between-subjects factor was used to analyze the data for the tapping-rate task, with repeated measures on hand (right vs. left) and context (bright vs. dim). For the dichotic listening data, a mixed-design, repeated measures MANOVA with repeated measures on ear (right vs. left), context (bright vs. dim), and condition (nonfocused, focused left, focused right) and with the between-subjects factor of depression group was used. ANOVA assumes homogeneity of variance between experimental groups (Hays, 1988); therefore, all data were evaluated for this criterion. The dichotic listening data met the criterion; however, the tapping rate data did not. A data transformation was implemented with the following formula prior to analysis: $\sqrt{x+1}$.

Tapping Rate

The depressed group was expected to have a slower general finger-tapping rate due to decreased cortical activation with a particular effect on the right hand due to the hypothesized decrease in LH functioning with depression. The difference between groups was not significant [$F(1,40) = 0.18, p < .67$], and the comparison of right-hand tapping rate between groups was not significant [$F(1,40) = 0.34, p < .56$].

The bright light exposure was expected to impact both groups to the extent that the right-hand tapping rate would increase significantly. The depressed group was expected to demonstrate the greatest change, because of a lower base rate. In fact, the difference between the groups' right-hand tapping rates between contexts was not significant [$F(1,40) = 1.53, p < .22$].

Dichotic Listening

It was hypothesized that the depressed group would have a smaller REA than would the nondepressed group, because of decreased LH activation. This was not statistically significant [$F(1,39) = .34, p < .56$].

The hypothesis of reduced arousal of the LH in the depressed group was also expected to result in a reduced ability to shift focus to the right ear in the depressed group as opposed to the nondepressed group. However, this group × condition interaction was not significant [$F(2,78) = 0.11, p < .89$].

The impact of bright light exposure was hypothesized to increase the REA in both groups; however, it was thought that the depressed group would not show as great a change as the nondepressed group would. In fact, neither group experienced a significant change in the REA, and the groups are statistically equal in the group × context interaction [$F(1,78) = 0.32, p < .57$].

The hypothesis that the bright light context would increase the depressed group's ability to shift focus to the right ear was not supported [$F(2,78) = 0.54, p < .58$].

In testing the limits of the dichotic listening paradigm, we have suggested that asking the subject to focus on one ear or the other might increase sensitivity to changes in cerebral activity. We hypothesized that the bright light context would increase the depressed group's ability to focus attention on the right ear. Although the data are in the proposed direction, the difference from the dim condition is not significant. Behavioral and cortical underarousal in the depressed group should have resulted in group differences in the dim light context, and the depressed group had a greater difference between hands in the dim context. Such a state could be the result of hemispheric underarousal in comparison with the more consistent general hemispheric arousal of the nondepressed group. However, nonsignificant results are difficult to interpret.

It is possible that the effects of milder dysphoria used in this experiment are less striking and result in small experimental changes. The experimental paradigm described would be beneficial to the investigation of groups of normal subjects and those with a primary diagnosis of major depression, and it could provide useful data on the recovery of function following treatment. Moreover, the effects of light might be expected to be more potent with men, in whom cerebral laterality may be stronger.

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