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Hemispheric Laterality, Imaging Ability, and Hypnotic Susceptibility

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A Sensory Imagery Utilization Questionnaire (SIUQ) was deployed in two experiments. In Experiment 1, three right- and three left-hemisphere mediated cognitive tasks were examined to determine if sensory imagery utilization affected performance. In addition, imaging ability was considered in the performance of the tasks. Results indicated that right-hemisphere tasks produced higher SIUQ scores when contrasted to left-hemisphere tasks. In addition, vivid imagers performed in a superior fashion compared to poor imagers. In Experiment 2, imaging ability and hypnotic susceptibility level were considered as possible interactive variables in the utilization of sensory imagery. Results showed that imagery utilization was superior for those judged to be both vivid imagers and high in hypnotic susceptibility. Implications of these results for the future study of sensory imagery utilization are discussed.

Historically, there has been an assumption that mental imagery is a product of the functioning of the right cerebral hemisphere. For example, J. Hughlings Jackson (1874) believed that the posterior lobe of the right hemisphere was the seat of the revival of images. Also, empirical support for a right hemisphere locus for imagery mediation has come from observations on patients with neurological insults including stroke (see Jones-Gotman & Milner, 1978; Springer & Deutsch, 1989). For instance, Humphrey and Zangwill (1951) described three cases where individuals had sustained mortar wounds to the right, posterior parietal region. All three individuals experienced a subjective loss in visual memory and had marked impairment on tests requiring visualization. One of the individuals reported that he had previously been a good visualizer, but now reported that his visual images were difficult to evoke and were now comparatively dim.

However, Ahsen (1981, 1985) and Erlichman and Barrett (1983) have argued against the exclusivity of the right hemisphere in the construction and mediation of images. They believe that both hemispheres may be

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equally capable of these processes, even though each hemisphere might *differ* in its ability to utilize or interpret images.

Some evidence for this position was provided by Farah (1984). In an investigation involving subjects with reports of loss of mental imaging ability following brain damage, she found that subjects with an image - generating deficit showed a consistent trend in lesion site. The majority of her subjects had most or all of their damage in the posterior left quadrant of the brain. Such evidence would seem to argue against an exclusive right-hemisphere dominance for mental imagery production and mediation.

The possibility of image generation also being mediated in the left hemisphere is further supported by Farah, Gazzaniga, Holtzman, and Kosslyn (1985) in a study on a split-brain patient. In a letter-detection classification task presented laterally to each hemisphere, it was found that both hemispheres appeared to be involved in the processing of information that did not involve the utilization of imagery. However, only the left hemisphere appeared to be involved in the performance of a task when imagery utilization was involved.

In another study, Farah, Peronnet, Weisberg, and Monheit (1989) found that the generation of mental images from memory is accompanied by a characteristic pattern of electrophysiological activity. The act of generating an image from memory caused changes in event-related-potentials (ERPs) which were maximal on the scalp areas over the left visual cortex, thus providing further evidence for the possibility that imagery can be mediate in the left hemisphere.

Erlichman and Weiner (1980) conducted a study where subjects performed different covert mental tasks while EEGs were recorded from right and left tempo-parietal loci. Some of the tasks were chosen with the intent of engaging either verbal or visuo-spatial processes; some were unstructured and could have elicited any EEG pattern. After each task, subjects orally rate the degree to which the tasks required covert verbalization, affect, visual imagery, and concentration. It was found that higher verbal and concentration ratings were associated with relatively greater left hemisphere activation; stronger imagery and affect were associated with greater right hemisphere activation. Also, data suggested that verbal thinking may have affected EEG activity in the left hemisphere more than in the right hemisphere.

Erlichman and Weiner maintained that if any generalization can be drawn from their findings, it is that EEG asymmetry is very responsive to the presence or absence of verbal processes, but may be indifferent to the presence or absence of visuo-spatial processes, at least the process of visual imagery. The investigators suggested that the reason EEG asymmetry is more sensitive to variation in verbal processing is that it may be more lateralized. And they found that verbal ratings were more strongly associated with left integrated amplitude; in contrast, the imagery ratings were about equally associated with integrated amplitudes in both hemispheres. Thus, Erlichman and Weiner conclude that imaging may be a function of the operations of both hemispheres, and which hemisphere is dominant may often be a function of the type of task the subject is asked to perform or to mediate with imagery.

Erlichman and Weiner (1980) included amongst their covert tasks five which they believed involved processes typically associated with the left hemisphere: (1) *multiplication,* where subjects were instructed to take the number 2 and subvocally raise it to the highest power before being asked to stop; (2) *letter/speech,* where subjects were asked to compose a letter or speech subvocally about some topic of interest; (3) *foreign counting,* or counting in a foreign language; (4) *verbal counting in English,* where subjects were asked to count subvocally starting from 1 to whatever number they reached when asked to stop, and (5) *verbal long-term memory,* where subjects were asked if there was any poem, speech, or any other verbal composition that could be recalled from memory, and then to repeat the composition subvocally.

Five tasks were also chosen which Erlichman and Weiner believed involved the right hemisphere: (1) *music without words,* where subjects were asked if there was any nonvocal or orchestral melody with which they were familiar and that they could mentally produce; subjects were then asked to concentrate on hearing that melody in their minds for 2 minutes, not humming it but rather hearing it; (2) *visual kinesthetic imagery,* where subjects were asked to visualize themselves doing some form of bodily action, either dancing or playing a sport, not as a spectator, but rather from the vantage point of a participant; (3) *visual long-term memory,* where subjects were asked to recall from memory pictures, places, faces, visual scenes from a movie, or rooms in their home or apartment; (4) *body feelings,* where subjects were asked to relax and concentrate on bodily feelings, for example, concentrating on internal organs, blood flowing through veins and arteries, then on the limbs, and (5) *visu-*

al counting, where subjects were asked to visually count as high as possible by imagining a blackboard and writing the numbers on it. After each number, subjects were to visualize the number being erased before the next number was written on the board.

With evidence showing that imagery is apparently being mediated in both hemispheres, it appears from the results reported by Erlichman and Weiner that the right hemisphere primarily mediates sensory imagery (see also Klein & Armitage, 1979; Seamon & Gazzaniga, 1973). If this is the case, then it might be possible to develop a questionnaire that would help to distinguish sensory imagery as mediated by the right hemisphere from cognitive imagery as mediated by the left hemisphere. Such a questionnaire was developed for the purpose of this study.

With a questionnaire available to determine sensory imagery utilization, higher scores on such should be produced compared to when cognitive imagery is being utilized. To make this determination, three of Erlichman and Weiner's sensory imagery tasks and three of their cognitive imagery tasks were used. If higher scores are obtained in response to a sensory imagery task, then such can further illustrate, as predicted by Erlichman and Weiner, that both hemispheres can mediate imagery, albeit in a selective manner as a function of the type of task being performed.

Experiment 1

Method

Subjects

Thirty volunteers from introductory psychology classes served as subjects. These individuals were chosen after responding to items on the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973, 1989) in a mass-testing of 204 subjects. The mass-testing occurred separate from the experiment and volunteers were not aware that their previously obtained scores contributed to their being chosen as subjects. Fifteen were chosen for scoring in the upper one-third of respondents on the VVIQ (vivid imagers); 15 were chosen for scoring in the lower one-third of respondents (poor imagers).

Tasks

Six tasks were presented to subjects in a random order by an experimenter who was blind with respect to imagery scores on the VVIQ. All tasks were performed for 2 minutes each while subjects relaxed with eyes closed. The exact duration of a task was not conveyed to subjects so as not to artificially influence paced responding. The left-hemisphere tasks were a multiplication task, a letter/speech composition task, and a counting task. The right-hemisphere tasks consisted of a kinesthetic imagery task, a visual long-term memory task, and a body feelings task. These tasks were chosen because according to Erlichman and Weiner, they were highly rated for EEG asymmetry index scores.

The left-hemisphere tasks with accompanying instructions were as follows:

> (1) *Multiplication.* "In your mind or subvocally, please take the number 3 and raise it to the next highest power (for example, 3 x 3 = 9, 3 x 3 x 3 = 27, etc.). Please continue doing this until I ask you to stop."
>
> (2) *Letter/Speech Composition.* "In your mind or subvocally, please compose a letter or speech about current events in the Soviet Union. Please continue doing this until I ask you to stop."
>
> (3) *Counting.* "In your mind or subvocally, please count as high as you can by 6s until I ask you to stop (for example, 6,12,18, etc.)."

The right-hemisphere tasks and instructions were as follows:

> (1) *Kinesthesia.* "In your mind, see yourself participating in a tennis match. Please continue doing this until I ask you to stop."
>
> (2) *Long-Term Memory (LTM)."* In your mind, see yourself as an actor (actress) in a movie or TV program with which you are familiar. Please continue experiencing this until I ask you to stop."
>
> (3) *Body Feelings.* "In your mind, experience what it would be like if you had a tingling sensation in your right arm. Please continue experiencing this until I ask you to stop."

Following the completion of each task, subjects were asked to respond to items on the Sensory Imagery U tilization Questionnaire (SIUQ; see Appendix).

The 10 items on the questionnaire were chosen from an original group of 19 items because in a pilot study consisting of 11 subjects (unselected for imaging ability), total responses on the questionnaire appeared to discriminate between performance on a left-hemisphere task (verbal counting in English) and a right hemisphere task (visual counting) as defined by Erlichman and Weiner (1980). Specifically, subjects exhibited higher scores or greater sensory imagery utilization when performing the right hemisphere task, $t(10) = 2.38$, $p < .05$.

Also, the 10 items were presented in a different, random order following each task to preclude subjects from forming a response pattern across the six administrations. Following the completion of the tasks and questionnaires, subjects participated in a post-experimental interview where the experimenter ascertained the subjects' reactions to the study, including any strategies that subjects employed in the performance of the tasks.

Results and Discussion

A 2 (Imaging Ability, Vivid or Poor) x 3 (Right-Hemisphere Tasks) analysis of variance (ANOVA) was conducted on the questionnaire scores. This produced a significant Imaging Ability main effect, $F(1,28) = 27.94$, $p < .001$; vivid imagers had higher questionnaire scores compared to poor imagers. However, a main effect for Right-Hemisphere Tasks was not found, $F(2,56) = 1.79$. Thus, as can be seen in the top portion of Figure 1,

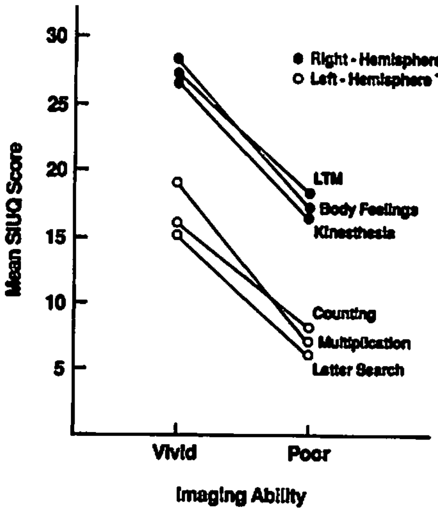

Figure 1. Mean SIUQ scores on right- and left-hemisphere imagery tasks for vivid and poor imagers.

regardless of the type of right-hemisphere task used, subjects responded in a similar fashion on the Sensory Imagery Utilization Questionnaire. Finally, the interaction of the two factors was not significant, $F(2,56) = 1.48$.

The preceding ANOVA was also conducted for Left-Hemisphere Tasks. And as with the previous ANOVA, a significant Imaging Ability main effect was found, $F(1, 28) = 19.85, p < .01$; vivid imagers had higer questionnaire scores compared with poor imagers. Also, a significant Left-Hemisphere Tasks main effect was not found, $F(2, 56) = 1.97$, indicating that subjects responded in a similar fashion on the questionnaire regardless of type of left-hemisphere task used (see bottom portion of Figure 1). Finally, the interaction of the 2 factors was not significant, $F(2, 56) = 2.01$.

Given that the specific type of left-hemisphere task or type of right-hemisphere task did not influence questionnaire scores, subsequent analyses were conducted with data averaged across the three right-hemisphere tasks and across the three left-hemisphere tasks.

An Imaging Ability (Vivid or Poor) x Averaged Tasks (Right or Left-Hemisphere) analysis of variance (ANOVA) was conducted on the questionnaire scores. This produced a significant Imaging Ability main effect, $F(1, 28) = 23.85, p < .001$; vivid imagers had higher questionnaire scores compared to poor imagers. A main effect for Tasks was also found, $F(1, 28) = 24.94, p < .001$; right hemisphere tasks produced higher questionnaire scores compared to left-hemisphere tasks. The interaction of Imaging Ability x Tasks was not significant, $F(1, 28) = 1.26$.

With respect to analyses of post-experimental interview data, vivid and poor imagers did not describe significantly different strategies being used for performing the various right- or left hemisphere imagery tasks. However, vivid imagers reported utilizing imagery more often than poor imagers, $X^2 = 13.38, p < .001$. This, of course, would be expected and is validation for the VVIQ. Also, subjects reported that they seemed to rely more on imagery for completing three of the tasks. The tasks to which subjects referred were the right-hemisphere mediated ones ($X^2 = 11.37, p < .001$ for LTM, $X2 = 18.94, p < .001$ for Body Feelings, and $X^2 = 21.17, p < .001$ for Kinesthesia). And, of course, this is reflected in the results presented in Figure 1. Thus, post-experimental information was useful only to confirm the obtained results and to establish validity for the VVIQ and the SIUQ.

After using three of Erlichman and Weiner's right-hemisphere tasks and three of their left-hemisphere tasks, it is clear that performance on the Sensory Imagery Utilization Questionnaire (SIUQ) differentiates the two groups of tasks. That is, when subjects were asked to respond to right-hemisphere tasks, their scores on the SIUQ were greater than when asked to respond to left-hemisphere tasks. Thus, the former seemed to require greater use of sensory imagery than did the latter, supporting the contention by Erlichman and Weiner to this effect.

It is also interesting that the specific type of right- or left-hemisphere task did not appear to matter, at least with respect to illustrating the role of sensory imagery utilization. And the categorization of tasks as a function of hemispheric influence and control as specified by Erlichman and Weiner appeared to be valid. As can be seen in Figure 1, the right hemisphere tasks clustered at the top and the left-hemisphere tasks clustered at the bottom.

Thus, those who have advocated that imagery is mediated in both hemispheres appear to have gained support from the results of Experiment 1. And while the SIUQ is designed primarily to tap sensory imagery Utilization, it also serves to segregate, as Figure 1 illustrates, tasks that use such from those that appear to use something else, probably cognitive imagery utilization. As a result, the SIUQ appears to be a useful tool for determining if a specific imagery task is one that involves the use of sensory processes or one that utilizes cognitive processes.

In addition to segregating sensory imagery tasks from cognitive imagery tasks, Experiment 1 found that subjects classified as vivid imagers perform differently on the tasks compared to poor imagers. Specifically, for both sensory and cognitive imagery tasks, vivid imagers scored higher on the SIUQ compared to poor imagers. Thus, regardless of the type of imagery task being used, vivid imagers are more adept at utilizing imagery.

However, a number of previous studies (e.g., Crawford, 1979, 1981; Crawford & Allen, 1983; Wallace, 1990) have reported that imaging ability is often related to hypnotic susceptibility level. For example, in a study concerned with the ability of subjects to form gestalt closures of fragmented stimuli, Wallace (1990) found that the greatest number of correct closures was reported by those who were both high in hypnotic susceptibility and vivid in imaging ability. Thus, while imaging ability appears to be an important factor in contributing to performance on the SIUQ, it is also possible that the hypnotic susceptibility level of subjects might also contribute to the performance. Experiment 2 examined this possibility.

Experiment 2

Method

Subjects

Forty-eight volunteers from introductory psychology classes and who did not serve in Experiment 1 participated here. These individuals were chosen after responding to questions on the VVIQ and to the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS: A; Shor & Orne, 1962). These tests were given in separate administrations.

Procedures

A mixed-design Imaging Ability (vivid or poor) x Hypnotic Susceptibility Level (high or low) x Task (left or right hemisphere) was used. To be considered high in hypnotic susceptibility, subjects must have scored between 10 and 12 on the Harvard scale. They must also have passed the amnesia task, a strong indicator that subjects are indeed high in hypnotic susceptibility. Low was defined as scoring between 0 and 2 and not passing the amnesia item. Vivid imagery was defined as scoring in the top one third of respondents on the VVIQ; poor imagery required one to have scored in the bottom one-third of respondents. Scoring was reversed from the manner described by Marks where a low scored indicated vivid imagery.

The imaging procedures here were identical to those in Experiment 1 except that only two tasks were used, one that examined left-hemisphere imaging (multiplication) and one that examined right-hemisphere imaging (kinesthesia). Use of a single task to examine imaging processing in the hemispheres was justified since responding on the SIUQ was not affected by type of left-hemisphere or type of right-hemisphere task (see Figure 1). The aforementioned tasks are described in Experiment 1 and were presented to subjects in a random order. In addition, utilization of imagery was assessed with the SIUQ.

Subjects were individually tested by an experimenter who was blind with respect to imaging ability and hypnotic susceptibility of participants. In addition, since the Harvard scale is a group-administered test, hypnotic susceptibility was confirmed with the individually-administered Stanford Hypnotic Susceptibility Scale, Form C (SHSS: C; Weitzenhoffer & Hilgard, 1962). Such confirmation was established, $r(46) = .58$, $p < .001$. High scores on the HGSHS: A were associated with high scores on the SHSS: C. The mean scores on the SHSS: C for highs and lows were 10.9 (SD =1.4) and 1.8 (SD =1.0), respectively.

Results and Discussion

An analysis of variance (ANOVA) performed on the questionnaire scores indicated a significant effect for hypnotic susceptibility level, $F(1, 44) = 45.15$, $p < .001$. Imaging ability also significantly affected responses, $F(1, 44) = 55.03$, $p < .001$. In addition, the interaction between hypnotic susceptibility level and imaging ability was significant, $F(1, 44) = 43.83$, $p < .001$ (see Figure 2). Type of task, whether right- or left hemisphere mediated as defined by Erlichman and Weiner, also produced a significant effect, $F(1, 44) = 91.44$, $p < .001$. However, this variable failed to interact with any of the other variables.

Newman-Keuls analyses between the various means indicated that the performance of subjects who were both vivid imagers and high in hypnotic susceptibility was significantly greater ($p < .001$) than that of any of the other three groups. This was true for the right-hemisphere task (top portion of Figure 2) and for the left-hemisphere task (bottom portion of Figure 2). In addition, for both right- and left-hemisphere tasks, the performance of subjects who were both poor imagers and high in hypnotic susceptibility was not significantly different from the performance of those who were both poor imagers and low in

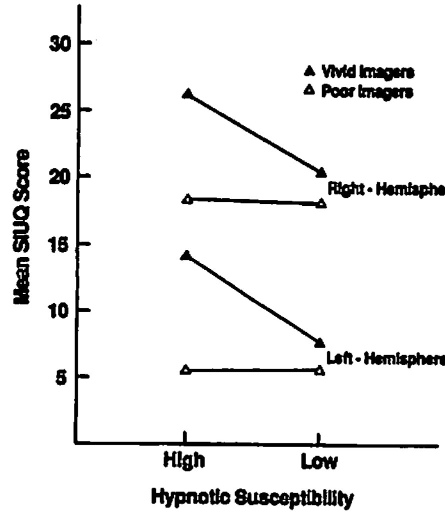

Figure 2. Mean SIUQ scores on a right- and a left-hemisphere imagery task as a function of imaging ability and hypnotic susceptibility level.

hypnotic susceptibility.

As in Experiment 1, performance on the SIUQ differed as a function of whether subjects were responding to a right- or to a left-hemisphere task. With a test basically assessing utilization of sensory imagery, performance was superior for a right-hemisphere task. And this was the case regardless of the classification of subjects according to imaging ability and/or hypnotic susceptibility level.

Interestingly, subjects who were classified as being both vivid imagers as well as high in hypnotic susceptibility level performed in a superior fashion for both right- and left hemisphere tasks. This finding is similar to one reported for the performance of gestalt closure tasks (see Wallace, 1990). Thus, it is not necessarily imaging ability per se that produces the differences in performance on the SIUQ as described in Experiment 1. Rather, to some extent, the subjects' ability to concentrate and to focus on the task at hand, as attributes of hypnotic susceptibility, also contributes to their superior performance.

If performance on the SIUQ is an interactive effect of imaging ability and hypnotic susceptibility level, as appears to be the case by the results depicted in Figure 2, then sensory imagery utilization appears to be enhanced for those individuals who are best able to concentrate on the required tasks. And this is the case regardless of whether the tasks are considered to be right- or left-hemisphere mediated.

General Discussion

Based on the results of the two experiments, it appears that imaging is mediated by both the right- and left-hemispheres of the brain. Thus, our results tend to support the findings of Erlichman and Weiner (1980) as well as results reported by Ahsen (1981, 1985) that imaging is a function of the operations of both hemispheres. Further, which hemisphere is dominant in processing imagery appears to be dictated by the type of task the subject is asked to perform. If the task is one involving sensory utilization, the right hemisphere appears to be mediating the imagery; if the task is one involving cognitive utilization, then the left hemisphere appears to be involved in the processing of imagery.

Further, although evidence has been provided that imagery is mediated by both hemispheres, it appears that the imaging ability of subjects as well as their hypnotic susceptibility level also plays a role in determining performance on the SIUQ. While this questionnaire was designed primarily to determine a subject's sensory imagery utilization (as reflected in the results reported in Figure 1), it is clear from the results reported in Figure 2 that such utilization is influenced by individual differences. Subjects who are vivid imagers and who are also high in hypnotic susceptibility score significantly higher on the SIUQ (for both right- and left-hemisphere tasks) compared to other subject groups. Thus, sensory imagery utilization is enhanced when subjects are most easily capable of forming vivid images (see also Wallace, 1984, 1988, 1991) and are further able to concentrate on the imagery task they are being asked to perform. The latter is generally considered a strong correlate of hypnotic susceptibility (see Atkinson & Crawford, 1992; Crawford, Allen, & Kiefner, 1983; Crawford, Brown, & Moon, 1987; Wallace, Knight, & Garrett, 1976; Wallace & Patterson, 1984).

Future research concerned with studying individual differences in imaging ability, hypnotic susceptibility, and the processing/mediating of imagery may wish to consider using the SIUQ. As is evident from the results reported, it is a useful questionnaire for discriminating right- and left-hemisphere imagery utilization. And where such is a variable being considered, performance on the SIUQ may help explain some of the cognitive and personality sources of variability in such experiments.

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APPENDIX

Sensory Imagery Utilization Questionnaire

For each item, please give a rating response as follows:

+3 Very strongly agree
+2 Strongly agree
+1 Moderately agree
0 Neutral
-1 Moderately disagree
-2 Strongly disagree
-3 Very strongly disagree

Write the corresponding number to the left of each item.

___ 1. I accomplished the task as requested.
___ 2. I used imagery in performing the task.
___ 3. When I produced images in my mind, they were vivid.
___ 4. When I produced images, they stayed in my mind.
___ 5. I find it useful to use imagery in the completion of a task.
___ 6. Imagery is important for a task of this nature.
___ 7. For me, accomplishing this task required imagery.
___ 8. The task I completed seemed very real.
___ 9. The task I completed seemed easy.
___ 10. I completed the task in a serious manner.