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Dual Task Performance: The Effects of Task Emphasis and Ear of Input

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DUAL-TASK PERFORMANCE:

THE EFFECTS OF TASK EMPHASIS AND EAR OF INPUT

by

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Abstract

DUAL TASK PERFORMANCE:
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This experiment explored the lateralization of the processing of spatial and verbal information during dual-tasks. This study also investigated the relationship between right ear advantage and spatial ability, degree of handedness, and degree of familial handedness. Thirty-two male subjects performed a spatial rotation task and a dichotic listening task. During half of the dual tasks, subjects concentrated on both tasks equally. During the other half of the dual trials, 16 subjects emphasized the spatial processing task and 16 subjects emphasized the dichotic listening task. The results of this experiment do not support either the independent-hemispheric resources or the task-hemispheric integrity theorization of the lateralization of information processing. The degree of handedness, and the degree of familial handedness were predictor variables for right ear advantage. These two variables may explain some of the inconsistencies found in previous lateralization research.

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Almost all sectors of today's workforce are being changed by the adaptability of microprocessors (Naisbitt, 1982). Where workloads were once primarily physical in nature, today they involve mostly mental workload. As automation increases, the complexity of the mental workload increases. In many modern jobs operators often simultaneously process multiple inputs of information (Wickens, Mountford, & Schreiner, 1981). Unfortunately, increased mental workload has increased the likelihood that an operator will make a serious mistake. Consequences such as air crashes, nuclear incidents, and train accidents attest to a poor match between system complexity and operator capability. In an attempt to improve this match, some researchers are trying to find ways to lessen system complexity. At the same time, other researchers are attempting to increase operator capabilities. In order to understand operator capabilities and limitations, some researchers have focused on defining and studying mental workload. These investigators are attempting to identify the mental resources which all of us have available to perform complex mental tasks.

The concept of mental workload is complex and consequently has many definitions. Ogden, Levine, and Eisner (1979) defined workload as the difference between system inputs and system capabilities. Researchers have often explored mental workload by using a dual-task paradigm. In this paradigm, a subject first performs a single primary task. Then the subject simultaneously performs this primary task with a secondary task. An experimenter compares the subject's primary task performance during the single task to the subject's primary task performance during the dual task. The decrement in the subject's primary task performance, from single to dual task conditions, is a measure of the level of mental work required by the secondary task (Ogden, Levine, & Eisner, 1979). Because many occupations require operators to perform multiple concurrent tasks, the results of such dual-task studies are particularly applicable to work environments.

Multiple-Resources Models

Originally, mental workload was conceptualized as drawing upon a single, limited capacity resource (Ogden et al., 1979). However, this conceptualization seemed to be too simplistic (Friedman, Polson, Dafoe, & Gaskill, 1982). Recently, dual-task performance studies have led to the development of a number of theoretical models which propose multiple resources for information processing (Friedman et al., 1982; Herdman & Friedman, 1985; Polson & Friedman, 1988). These resources are independent, have a limited capacity, and may not substitute for each other (Friedman et al., 1982; Hellige & Longstreth, 1981; Herdman & Friedman, 1985; Wickens, Kramer, Vanasse, & Donchin, 1983). Multiple resource theories suggest that there is a direct relationship between performance and resource composition. The available resources and the relative efficiency of each type of resource for a particular task affect performance (Friedman et al., 1982; Herdman & Friedman, 1985; Pritchard & Hendrickson, 1985). Different tasks require different types of resources. When two tasks draw from a common resource pool, the tasks interfere with each other and performance efficiency decreases. Two tasks can be successfully and efficiently performed simultaneously when they use different resources (Friedman et al., 1982; Herdman & Friedman, 1985; Klapp & Netick, 1988; Polson & Friedman, 1982; Pritchard & Hendrickson, 1985; Wickens, Kramer, Vanasse, & Donchin, 1983; Wickens et al., 1981).

Within the multiple-resources framework two different theories have developed: the task-hemispheric integrity theory and the independent-hemispheric resources model. The primary difference between these two theories concerns the location of resource pools. Task-hemispheric integrity theory proposes that specialized resource pools exist in different hemispheres (Wickens, Kramer, Vanasse, & Donchin, 1983; Wickens et al., 1981). Independent-hemispheric resources theory suggests that each hemisphere contains all the resources necessary for processing and responding to any information it receives, regardless of the functioning of the other hemisphere (Friedman et al., 1982; Herdman & Friedman, 1985; Polson & Friedman, 1982; Pritchard & Hendrickson, 1985).

Task-Hemispheric Integrity Theory

This model proposes that the left hemisphere contains the resources necessary to process verbal information while the right hemisphere contains the resources necessary to process spatial information (Pritchard & Hendrickson, 1985; Wickens et al., 1981; Wickens & Sandry, 1982). Considerable research supports lateralization of information processing (Hannay, 1987; Pritchard & Hendrickson, 1985). First Marc Dax in 1836, and later Paul Broca, proposed that the left hemisphere controls language (Beaton, 1985; Springer & Deutsch, 1989). Other researchers have observed that individuals with right hemispheric brain damage have difficulty with spatial orientation and spatial memory (Springer & Deutsch, 1989). Scientists also found similar results in research conducted on split-brain patients, individuals whose cortical pathways have been severed (Beaton, 1985; Springer & Deutsch, 1989). As the result of these observations, several researchers now feel that each hemisphere has different capabilities and functions. The left hemisphere is proficient at processing language while the right hemisphere processes spatial information (Beaton, 1985; Green, 1984; Hannay, 1987; Klapp & Netick, 1988; Springer & Deutsch, 1989).

Scientific research has also pointed out other differences in the functioning of the hemispheres. Observation of patients who have suffered a stroke has led to the conclusion that the left hemisphere of the brain controls the motor functions of the right side of the body and vice versa (Beaton, 1985; Carswell & Wickens, 1985; Springer & Deutsch, 1989). Also, most sensory information is projected to the hemisphere which is on the contralateral or opposite side of the body. For example, visual information presented to the left visual field principally projects to the right cerebral hemisphere. Similarly, auditory information heard in the right ear travels via the more efficient contralateral pathway to the left cerebral hemisphere (Beaton, 1985; Bryden & Murray, 1985; Carswell & Wickens, 1985; Geffen & Caudry, 1981; Green, 1984; Springer & Deutsch, 1989). Following these lines of evidence, task-hemispheric integrity theory suggests that an individual can perform a dual task more efficiently if each task calls upon the particular hemisphere which is best suited to process that task's type of information.

Furthermore, the model proposes there are three dimensions which are relevant to separate resource utilization. These three dimensions are the modality of input, the stage of processing, and the code of processing. Modality refers to whether the input is visual or auditory. Wickens, Mountford, and Schreiner (1981) suggest that allocating tasks across modalities, such that one task's input is visual and the other task's input is auditory, facilitates dual task performance. However, it is interesting to note that Wickens has recently eliminated modality from his theory (Wickens, Fracker, & Webb, 1988;

Wickens & Liu, 1988). Because auditory input is often discrete or intermittent, it has attention-getting properties which may cause an individual to divert his attention away from a continuous visual task. Also, any visual task which covers more than 2^0 of visual angle requires visual scanning (Wickens et al., 1988; Wickens & Liu, 1988). This scanning may reduce the efficiency of the processing of the visual stimuli. These two factors may have influenced the results of studies which have demonstrated differences between auditory and visual tasks. After a review of the literature, Wickens et al. (1988) conclude that there is not enough evidence to support the idea that different modalities access different resource pools.

The stage of processing dimension involves early versus late processing. Early processing includes operations such as encoding, search, comparison, and rotation. Late processing includes procedures such as response selection and response generation. Research has shown that different stages of processing require different resources. For example, concurrent-performance studies have shown that combined motor and cognitive tasks interfere more with the manual activity of the hands than do cognitive tasks alone (Carnahan, Elliot, & Lee, 1986; Hellige & Longstreth, 1981; Ikeda, 1987). Finally, the code of processing may simply be dichotomized as verbal or spatial. Wickens and Liu (1988) suggest that presenting one task spatially and the other task verbally enhances performance.

Dual-task performance then, is most efficient when the tasks use different codes of processing and stages of processing. In such a dual task, a researcher presents a spatial task, requiring right hemispheric processing, to a subject's left visual field and requires the subject to respond to this task with the left hand. At the same time, the experimenter presents a verbal task, requiring left hemispheric processing, to this subject's right ear and requires the subject to respond to this task with the right hand. Such tasks maintain 'task-hemispheric integrity' because the intake of information and output of a response follows the shortest route (Carswell & Wickens, 1985; Wickens et al., 1981; Wickens & Liu, 1988; Wickens & Sandry, 1982; Wickens, Sandry, & Vidulich, 1983). Theorists base this idea on two premises: (a) Information presented to the right visual field projects to the contralateral left hemisphere, and (b) the contralateral hemisphere controls the motor response (Carswell & Wickens, 1985; Wickens et al., 1981; Wickens & Sandry, 1982; Wickens, Sandry, & Vidulich, 1983).

<u>Independent-Hemispheric Resources Theory</u>

This theory suggests that lateralized performance effects exist simply because one hemisphere may be more efficient at processing one type of information than the other (Friedman et al., 1982; Polson & Friedman, 1982). The authors do acknowledge that a few tasks, particularly the actual vocalization of speech, require hemispheric specific resources. However, most tasks can be performed entirely within one or the other hemisphere (Friedman et al., 1982; Polson & Friedman, 1982). This model assumes that each hemisphere has complete control over its resources and does not share these resources with the other hemisphere. Each hemisphere is capable of the central processing, encoding, and response selection for any type of information, from any sensory modality (Friedman et al., 1982; Green, 1984; Herdman & Friedman, 1985; Polson & Friedman, 1982).

Independent-hemispheric resources theory proposes that one important method for investigating multiple resources is via changing task emphasis. When dual tasks require overlapping resources, changing task emphasis causes a change in the resource allocation and results in performance tradeoffs. On the other hand, if two tasks require resources from different hemispheres, then performance does not change as a result of changing task emphasis (Friedman et al., 1982; Klapp & Netick, 1988; Polson & Friedman, 1982).

It is important to mention one additional dimension of the independent-hemispheric resources model. Independent-hemispheric resources theorists propose that subjects who show a right visual field dominance primarily process centrally presented visual information in their left hemisphere (Polson & Friedman, 1982). These researchers propose that, in order to test multiple-resources theories, subjects should be screened for right visual field/left hemispheric advantage. Other research has indicated a relationship between eye dominance and right ear advantage

(Bryden, 1988). Right handed subjects who showed a right visual field dominance had a stronger right ear advantage than individuals with a left visual field advantage.

Theoretical Implications

Both the task-hemispheric integrity theory and the independent-hemispheric resources model predict that during a dichotic listening task a right ear advantage occurs. However, they base their assumptions on different premises. The task-hemispheric integrity theory proposes that the left hemisphere alone processes verbal information. The reason there is a right ear advantage is that the path from the right ear to the left hemisphere is shorter than the path from the left ear to the right hemisphere and then to the left hemisphere for processing (Geffen & Caudry, 1981; Wickens et al., 1981; Wickens & Sandry, 1982; Wickens, Sandry, & Vidulich, 1983). In comparison, the independent-hemispheric resources theory simply suggests that the left hemisphere may be more efficient at processing verbal information than the right hemisphere, not that the right hemisphere can't process the verbal information at all (Friedman et al., 1982; Herdman & Friedman, 1985; Polson & Friedman, 1982).

Task-hemispheric integrity theory predicts that during single tasks the most accurate motor response to verbal input occurs with the left hand. Whether the verbal input is to the left or right ear, the left hemisphere processes the verbal information. This theory states that in single-tasks situations, where only one hemisphere is processing information, better resource utilization occurs if the two tasks draw from different hemispheres (Wickens et al., 1981; Wickens & Sandry, 1982; Wickens, Sandry, & Vidulich, 1983). Because the left hemisphere processes the verbal information, the right hemisphere should generate the motor response. Independent-hemispheric resources theory predicts that, during the single dichotic listening task, the hemisphere opposite the ear of input processes the verbal input. Therefore, this theory makes no clear predictions as to which hemisphere produces the fastest motor response to the verbal stimuli.

In the dual-task paradigm, in which the researcher presents a dichotic listening task to the left ear and a visual spatial task to both eyes, the two theories suggest different levels of performance. Task-hemispheric integrity theory proposes that, relative to single-task performance, hits decrease and reaction time increases. Left ear input must travel to the right hemisphere first and then to the left hemisphere for processing. However, the right hemisphere's resources are being utilized to process spatial information. This processing of the spatial information degrades the response to the verbal stimuli. On the other hand, independent-hemispheric resources theory suggests that right-eye dominant individuals primarily process centrally presented spatial information in the left hemisphere. At the same time, during left ear verbal input the right hemisphere processes the verbal stimuli. Because no resource competition occurs, there should be no decrease in the number of hits or an increase in reaction time in comparison to single-task performance.

By contrast, in a similar dual task with verbal input to the right ear, according to task-hemispheric integrity theory, verbal input travels directly to the left hemisphere and spatial input travels directly to the right hemisphere. No resource competition exists and the level of performance does not decrease from single to dual tasks. By comparison, according to independent-hemispheric resources theory, the left hemisphere processes the centrally presented spatial information. At the same time, the left hemisphere processes the right ear verbal input. This situation leads to a direct resource competition. Performance during this dual task should decrease in comparison to single-task performance.

When considering the most efficient input of information and subsequent motor response, the theories again differ. The task-hemispheric integrity position suggests that a subject executes a dual task most efficiently during right ear verbal input with a right hand response and a simultaneous left hand response to the central, visual, spatial stimuli. The independent-hemispheric resources position suggests that during right ear input a subject will exhibit poor performance, in comparison to left ear input, because the left hemisphere processes both the verbal and spatial information.

Finally, as stated earlier, independent-hemispheric resources theory proposes that changing task emphasis, in a dual-task condition, is an important methodology for distinguishing overlapping resource demands. During a dual task when a researcher presents the verbal input to the right ear, each theory predicts a different outcome when task emphasis is switched. According to task-hemispheric integrity theory, the left hemisphere is processing the verbal input and the right hemisphere is processing the spatial information. Because no resource competition exists, a performance tradeoff does not occur. On the other hand, independent-hemispheric resources theory indicates that the left hemisphere experiences resource competition because the left hemisphere is processing the verbal input and is also the primary processing center for the visual spatial input. Therefore, changing task emphasis results in performance tradeoffs.

By comparison, during the dual task in which verbal input is to the left ear, task-hemispheric integrity theory suggests that the verbal information must first travel to the right hemisphere, where spatial processing is occurring, and then to the left hemisphere for processing. Because the right hemisphere is processing the spatial information, this hemisphere delays or degrades the response to the verbal information. However, independent-hemispheric resources theory suggest that the right hemisphere processes the verbal information while the left hemisphere processes the spatial information. Because the tasks draw upon different hemispheres, no resource competition exists and a performance tradeoff does not occur.

Research Purpose and Hypotheses

The purpose of this research is to examine differences in dual-task performance to test these multiple-resources theories. In particular, this research seeks to determine the effects on dual-task performance of changing the subject's emphasis from a verbal to a spatial task and vice versa.

The design for this experiment involves presenting a subject with a dichotic listening task, a spatial processing task, and a dual task involving simultaneous execution of each task. The dichotic listening task is a non-invasive technique which researchers have validated as a test for hemispheric dominance of the processing of verbal information (Beaton, 1985; Bryden, 1988; Bryden & Murray, 1985; Geffen & Caudry, 1981). The spatial task calls for the subjects to rotate mentally a histogram. This study used this task because it places demands upon resources available for the central processing of spatial information (Fischer & Pellegrino, 1988; Shingledecker, 1984; Voyer & Bryden, 1990). Because the video monitor presented the spatial task centered on the screen, the visual stimuli projected to both hemispheres.

This study related seven prime conditions in which the two theories make predictions. Concerning the single tasks, this study examined two predictions:

1. There will be a right ear advantage (REA). Geffen and Caudry (1981) point out that only approximately 16% of those individuals who are right handed process speech in the right hemisphere. Also, as stated earlier, Bryden (1988) found that right visual field dominance has a strong relationship to right ear advantage. Only right handed, right-eye-dominant individuals participated in this study. Furthermore, using stepwise regression, a subject's degree of handedness and his familial handedness predict right ear advantage. Kee and Bathurst (1983) found that familial handedness patterns influence speech lateralization. Right handed subjects who had at least one parent who was left handed were less lateralized for verbal processing than right handed subjects who had two right handed parents.

2. According to task-hemispheric integrity theory, regardless of the ear of input, during the single dichotic task, the left hand produces a more accurate response. This study did not make any predictions, based on independent-hemispheric resources theory, regarding the hand used, during single or dual-task conditions.

In the dual-task paradigm there were five pertinent conditions which pitted the two theories against each other:

1. When the experimenter presents verbal input to the left ear and spatial stimuli to both hemispheres, task-hemispheric integrity theory proposes that dual-task performance is poorer than single-task performance.

Independent-hemispheric resources theory suggests that no performance decrement occurs from single to dual tasks.

2. When verbal input is to the right ear, task-hemispheric integrity theory suggests that no resource competition occurs and performance does not decrease relative to single-task performance. Independent-hemispheric resources theory suggest that resource competition does occur. This competition results in a decrease in performance in the dual task compared to the single task.

3. Across the various combinations of the dual-task inputs and motor response, task-hemispheric integrity theory suggests that the right hand produces the best response to right ear verbal input. Independent-hemispheric resource theory suggests that right ear input results in poor performance. This is due to the simultaneous processing of the spatial and verbal stimuli in the left hemisphere.

4. When verbal input is to the right ear, task-hemispheric integrity theory suggests changing task emphasis does not result in performance tradeoffs. Independent-hemispheric resources theory proposes that a tradeoff occurs. Subjects should show the greatest REA during the dichotic-emphasis condition. The next best REA should occur during the equal-emphasis condition. The poorest REA should occur during the spatial-emphasis condition.

5. When verbal input is to the left ear, task-hemispheric integrity theory suggests that a performance tradeoff occurs. The best REA should occur during the

dichotic-emphasis task. The equal-emphasis task shoud have the next best REA. Finally the spatial-emphasis task should have the poorest REA. Independent-hemispheric integrity indicates that a performance tradeoff does not occur.

Method

Subjects

This study tested 32 right-handed male subjects between the ages of 18 and 30. The subjects were undergraduates at Old Dominion University. The experimental session lasted approximately 1 and 1/2 hours. The subjects received two credits, which they could apply toward their grade in a Psychology course.

Right Visual Field Dominance. Each subject was tested for right visual field advantage. Subjects were asked to stand, directly in front of me, approximately ten feet away from a wall. On this wall there was a small black dot at eye level. I observed the subjects as they pointed to the dot, with one hand and then with their other hand. Half of the subjects used their right hand first. The other half of the subjects used their left hand first. Each subject aligned their hands with one eye or the other. The eye with which the subject aligned his hands was considered his dominant eye (Springer & Deutsch, 1989). Only subjects who aligned their hands with their right eye participated in the remainder of the study. Those subjects who were not included in the rest of the study received one research credit which they could apply toward their class grade in a Psychology course.

Materials and Apparatus

A set of Koss SST/5 (Model TD-W330) Digital Ready headphones connected to a JVC stereo cassette player and a Realistic Integrated Stereo Amplifier (SA-150) presented the dichotic listening task. An IBM compatible personal computer, with a hard drive and two floppy-disc drives, controlled the task. A Lafayette Instruments voice-actuated relay signaled the computer to begin each trial and time the presentation of the stimuli. Subjects used a single button keypad to respond to the spatial stimuli. When a subject pressed the button a relay switch closed and the computer recorded the reaction time. Then the computer reset the timing mechanism and presented the next stimulus. If the subject did not press the button, the timer automatically reset after an elapsed period of two seconds. The computer recorded this lack of response as a miss. An Epson LX-800 printer recorded the raw data, reaction time, and non-responses. The computer also stored this data on a floppy disc.

A Samsung Monitor (Model CD-1451 D/52GA) presented the spatial rotation task centered on the screen and located approximately 24 inches from the subjects. A Commodore-64 computer system (Model 1541), with a single floppy-disc drive, controlled the task. The software used to present the stimuli was the V2.0 version of the Criterion Task Set (CTS). Researchers at the Air Force Aerospace Medical Research Laboratory developed this task battery

(Shingledecker, 1984). An Epson LX-800 printer printed each subjects' reaction times, hits, and misses. The software also recorded this data on a floppy disk. Subjects used a two button keypad to begin each trial and to respond to the visual stimuli. One of the buttons was labeled 'same' and the other button was labeled 'different'.

Dual Task. Subjects responded to each of the tasks in the dual-task trials with separate keypads as described above. The spatial task was presented on the Samsung monitor while the verbal stimuli were simultaneously presented through the Koss headphones. I viewed the spatial task on a second Samsung monitor located in a room adjacent to where the subjects performed the trials. The dichotic listening task was synchronized with the spatial processing task by starting the dichotic listening tape when the first spatial stimuli appeared on this second Samsung monitor.

Handedness Questionnaire. In order to assess handedness as a variable all subjects filled out the Annett Handedness Questionnaire. This form queried the subjects as to which hand they use to perform such routine motor functions as writing, throwing a ball, hammering a nail, or using scissors. The handedness score was obtained by dividing the number of questions to which the subject responded that he used his right hand by the total number of questions. The first items of the Annett Handedness Questionnaire also asked subjects if any member of their immediate family was left-handed.

Tasks

Dichotic Listening Task. The dichotic stimuli were presented in a manner similar to that used by Bryden and Murray (1985). Subjects were presented with pairs of vowel-consonant syllables (da, pa, ga, ca, ta, ba) which utilized stop consonants. One syllable was presented to one ear while a different syllable was simultaneously presented to the other ear. Each mono-syllable was paired with every other mono-syllable. Thus, there were 15 possible pairings of syllables. These 15 pairs were presented to each ear over a 1 min interval. The stimuli were presented for 270 ms with a 2 sec interstimulus interval. The subjects were instructed to listen for the target syllable 'ca'. This syllable was randomly intermixed with the other syllables and was presented 15 times to each ear. Subjects pressed a button on a keypad if they heard the target syllable. Each experimental trial lasted three minutes and a total of 90 vowel-consonant pairs were presented.

Spatial Processing Task. Students viewed pairs of histograms. As Figure 1 shows, the monitor presented

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Insert Figure 1 about here

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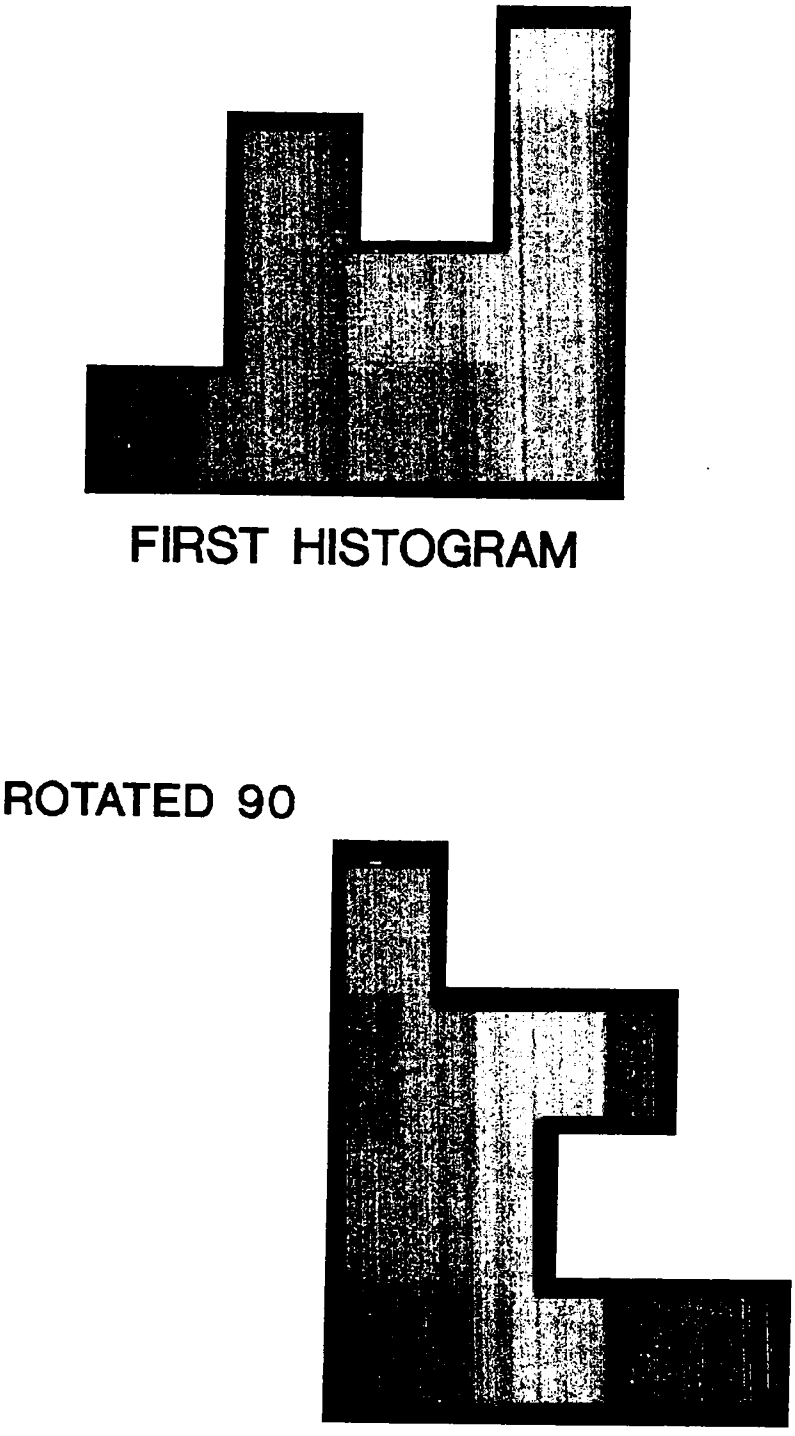
the first histogram in each pair in an upright position. The second histogram was presented and this comparison stimulus was rotated either 90 or 270 degrees. Subjects were asked if this second histogram matched the first in spatial



<u>Figure 1</u>. Stimuli presented during the spatial rotation task.

configuration. Each set of histograms was composed of four bars which varied in height from one to four units. No two bars were the same height. Each initial histogram was presented for 3 seconds. The second histogram remained on the screen until the subject responded or for 2.5 seconds. Subjects were presented with 32 to 42 pairs of histograms during each three minute trial.

Dual Task. Subjects were presented with the dichotic listening task and the spatial processing task simultaneously. All of the subjects received the equal emphasis condition in which they responded to both the dichotic listening task and the spatial processing task equally. All subjects also performed a dual-task trial in which they emphasized one task more than the other. One half of the subjects emphasized the visual task but continued to perform the dichotic listening task to the best of their ability. The other half of the subjects emphasized the dichotic listening task while trying to do their best on the spatial task. The order of presentation of the trials was randomized using a partially counterbalanced Latin square design (Bordens & Abbott, 1988).

Emphasis Manipulation. In order to induce subjects to emphasize one task over the other, or to maintain equal task emphasis, each subject was awarded points based on his performance.

For the dichotic listening trials the subjects had an opportunity to identify 30 target syllables. During the spatial processing trials subjects could correctly identify 42 pairs of histograms as either matching or different.

During the single dichotic listening trial subjects received ten points for each correct identification of a target word (hit), for a possible point total of 300. During each single spatial trial subjects received eight points for each correct choice (hit) for a possible total of 326 points. The total points available for the two single-task trials was 636 points.

During the equal-emphasis dual-task trials, subjects received ten points for each verbal target hit and 8 points for each correct spatial processing choice. During the dual task in which the dichotic listening task was emphasized, subjects received 15 points for each verbal target hit and four points for each correct spatial processing decision. Finally, during the dual task in which the subject emphasized the spatial task, the subjects received five points for each identified verbal target and 11 points for each correct spatial comparison. This procedure allowed the subjects a dual task maximum point total of 1240 points after two dual-task trials. The maximum available points for all trials was 1876 points.

Experimental Variables

Independent Variables. The independent variables for this study included the hand used for the motor response, the ear of input of the verbal stimuli, the task emphasis, and the level of task (single, unbiased dual, and biased dual). Additionally, handedness, familial handedness, spatial ability, and response hand were expected to be predictor variables of right ear advantage. In order to further explore the relationships among handedness, familial handedness and task performance, correlations were calculated between the dichotic listening task data and handedness, as well as familial handedness. Similar correlations were also calculated on the spatial rotation task data. Familial handedness was a dichotomized variable and handedness was a continuous variable.

Dependent Variables. There were two sets of dependent variables in this study. The dependent measures for the dichotic listening task were median reaction time, measured in milliseconds; the number of hits, or correct identifications of target words; and the number of false alarms. The variables used for the correlations included handedness, familial handedness, hits, and median reaction time.

The dependent measures in the spatial rotation task also included median reaction time, measured in milliseconds; the number of hits; and the number of misses. These variables were also used in the correlations which examined handedness and familial handedness.

Experimental Design

For the dichotic listening task data, this study used a 2 (hand of response) x 2 (ear of input) x 2 (task emphasis) x 3 (single task, unbiased dual task, and biased dual task) mixed design with subjects nested in hand of response and task emphasis (see Appendix A). A multivariate analysis of variance (MANOVA) was conducted across the dependent variables to test for any overall effects for hand of response, ear of input, task emphasis, and task level. Separate ANOVAS were performed on the median reaction time data, the number of false alarms, and the number of hits.

For the spatial rotation task data, this study used a three-way (hand x task emphasis x level of difficulty) mixed design with subjects nested in hand and task emphasis. In order to test for any overall effects of hand, emphasis, or task level, a MANOVA was calculated on the dependent variables. Again separate ANOVAS were conducted for median reaction time, hits, and misses.

A stepwise regression analysis was performed to determine if spatial ability, handedness, response hand, and\or familial handedness predicted REA. Two criterion variables were developed as measures of REA. One criterion variable, median REA, was calculated as the difference in response time to right ear input versus left ear input. Median reaction time was used for this variable. A similar measure, hits REA, was used for the other criterion variable. This variable was calculated as the difference in the number of hits between the response to right ear input and left ear input. Again, the predictor variables were spatial ability, handedness, response hand, and/or familial handedness. Spatial ability was based on the subject's total score on the single spatial task. Handedness was determined by subject's total score on the Annett Handedness Questionnaire. Response hand refers to the hand which subjects used to respond to the verbal stimuli. Familial handedness was also determined by the Annett Handedness Questionnaire. Subjects were placed in one of two familial handedness categories based on their response to two questions on this questionnaire. Subjects with all right handed first degree relations were categorized as belonging to a familial dextral (right-handed) group. Subjects with at least one left handed relative in their immediate family were categorized as belonging to a familial sinistral (left-handed) group.

Procedure

After arriving at the laboratory, each subject was read an information sheet (see Appendix B) which informed him about the purpose of the study, the general nature of the tasks he was to perform, and the length of the experimental sessions. Subjects were informed that the individual who had the highest score across all the trials would receive $20. Subjects read and signed the consent form (see Appendix C) and then completed the Annett Handedness Questionnaire (see Appendix D). Subjects were then screened for right visual field dominance. If a subject did not demonstrate right-eye dominance he was dismissed from the rest of the experiment. The reason for their exclusion from the remainder of the study was explained to each student. These students were offered one credit for their participation in the experiment.

Next, subjects received specific instructions about the dichotic listening and spatial processing tasks. After answering their questions, I took each subject through two complete series of practice trials. The subject performed two 3-minute trials for the single spatial task, the single dichotic task, the equal-emphasis unbiased dual task, and the dual task in which he emphasized either the dichotic or spatial task. Each subject practiced the emphasis situation which he performed in the experimental trials. Between each 3 minute practice trial, subjects had a one minute rest period and the I answered any of their questions. Upon completion of the practice session, subjects had a five minute rest period before the actual experimental sequence began. During the experimental trials, the subjects again performed each of the four tasks (a single spatial task, a single dichotic task, an equal-emphasis dual task, and a biased dual task) for three minutes with a one minute rest interval. During both the dichotic listening tasks, one half of the subjects responded to the verbal stimuli with their left hand and the other half of the subjects responded with their right hand. During the spatial tasks, one half of the subjects responded to the task with their left hand, and the other half of the subjects responded to the task with their right hand. The entire experimental session required approximately 1 and 1/2 hours.

Results

Dichotic listening task

MANOVA. The MANOVA indicated a significant overall effect for task $F(6,108) = 4.889$, $p<.0002$; and for ear $F(3,26) = 10.559$, $p<.0001$.

Hits. The results of the ANOVA for hits are shown in Table 1. A significant main effect was found for hand,

Insert Table 1 about here

$F(1,28) = 4.42$, $p<.05$. The average number of hits was higher when subjects used their right hands than when they used their left hands. A significant main effect was also found for ear, $F(1,28) = 5.30$, $p<.05$. The number of hits was higher when the verbal input was to the right ear rather than to the left ear. Finally, a significant main effect was found for task, $F(2,56) = 6.82$, $p<.05$. A Tukey post hoc test indicated that the number of hits during the single task was significantly different from the number of hits during the biased and unbiased dual tasks. The dual tasks were not significantly different. Figure 2 shows that the number of hits during the single task was greater than

Insert Figure 2 about here

during the dual-task conditions. There were no other significant main or interaction effects.

Table 1

Source Table for Mean Number of HITS on the Dichotic Listening Task

Source of Variance F	df	Anova SS	F Value	PR >
BETWEEN SUBJECTS				
HAND	1	52.08	4.42	0.04
EMPHASIS	1	20.02	1.70	0.20
HAND X EMPHASIS	1	12.00	1.02	0.32
WITHIN SUBJECTS				
TASK	2	36.54	6.82	0.00
EAR	1	65.33	5.30	0.03
TASK X EAR	2	1.17	0.24	0.79
MIXED FACTORIAL				
HAND X TASK	2	8.17	1.52	0.23
HAND X EAR	1	0.52	0.04	0.84
EMPHASIS X TASK	2	1.54	0.29	0.75
EMPHASIS X EAR	1	0.33	0.03	0.87
HAND X EMPHASIS X TASK	2	11.63	2.17	0.12
HAND X EMPHASIS X EAR	1	15.19	1.23	0.28
HAND X TASK X EAR	2	5.79	1.19	0.31
EMPH X TASK X EAR	2	0.29	0.06	0.94
HAND X EMPHASIS X TASK X EAR	2	3.38	0.69	0.51
SOURCES OF ERROR				
SUBJECT(HAND X EMPHASIS)	28	329.88	NT	
SUBJECT X TASK(HAND X EMP)	56	150.13	NT	
SUBJECT X EAR(HAND X EMP)	28	345.29	NT	
SUB X TASK X EAR(HAND X EAR)	56	136.71	NT	

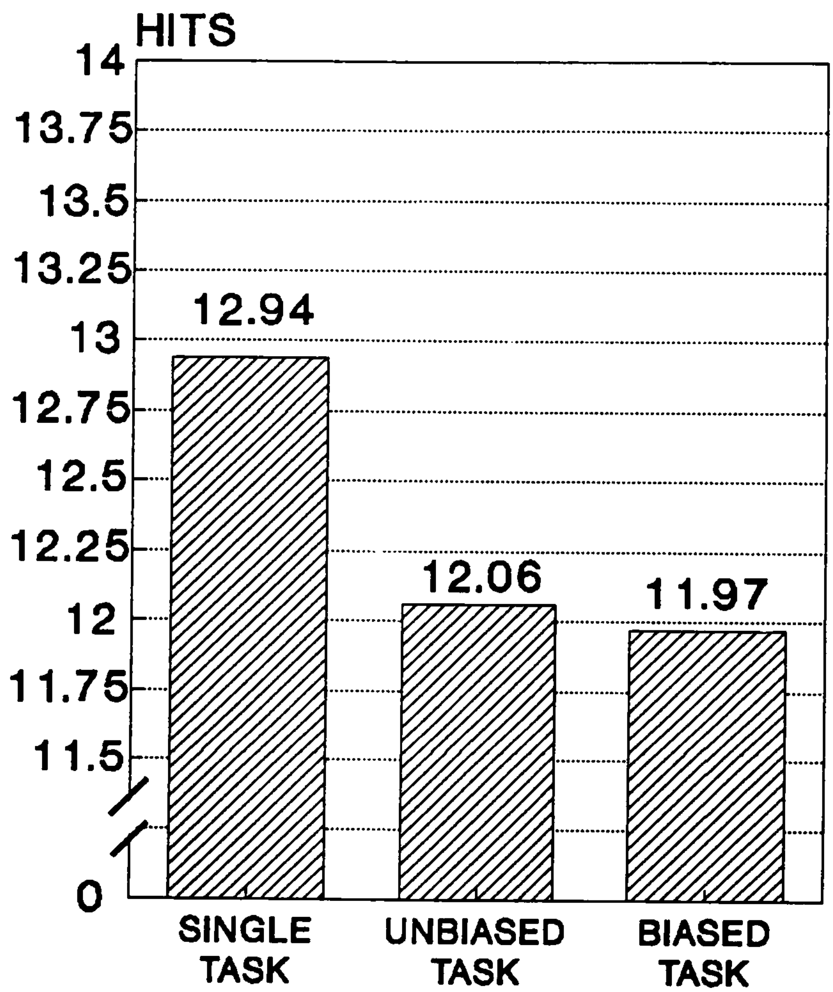


Figure 2. Mean number of hits during the dichotic listening task as a function of single, biased, and unbiased tasks.

Median Reaction Time. The analysis of the median reaction times are presented in Table 2. A significant

Insert Table 2 about here

main effect was found for task, $F(2,56) = 3.36$, $p<.05$. However, the Tukey post hoc test did not indicate any significant differences among tasks (see Figure 3). Again

Insert Figure 3 about here

a significant main effect was found for ear, $F(1,28) = 20.98$, $p<.0001$. Median reaction time was lower when the stimuli were presented to the right ear than when the stimuli were resented to the left ear.

False Alarms. No significant main or interaction effects were found for the false alarm data.

Right Ear Advantage. The stepwise regression investigated spatial ability, response hand, degree of handedness and familial handedness to determine if any of these factors predicted REA. Because this was an exploratory stepwise regression analysis, the alpha level was set at .10. For the criterion variable of REA based on hits, only the predictor variable handedness, $F(1,30) = 3.28$, $p< .08$ satisfied the criteria for entrance as a predictor variable. Handedness accounted for 6.84 percent of the variance. For the criterion variable of REA based on median reaction time,

Table 2

Source Table for MEDIAN REACTION TIME on the Dichotic Listening Task

Source of Variance	df	Anova SS	F Value	PR > F
BETWEEN SUBJECTS				
HAND	1	656.38	0.02	0.89
EMPHASIS	1	2829.01	0.09	0.77
HAND X EMPHASIS	1	7141.88	0.22	0.64
WITHIN SUBJECTS				
TASK	2	58606.79	3.36	0.04
EAR	1	95096.51	20.98	0.00
TASK X EAR	2	15055.17	1.64	0.20
MIXED FACTORIAL				
HAND X TASK	2	19469.29	1.12	0.33
HAND X EAR	1	92.13	0.02	0.89
EMPHASIS X TASK	2	15735.54	0.90	0.41
EMPHASIS X EAR	1	10135.55	2.24	0.14
HAND X EMPHASIS X TASK	2	23892.67	1.37	0.26
HAND X EMPHASIS X EAR	1	5907.42	1.30	0.26
HAND X TASK X EAR	2	4428.04	0.48	0.62
EMPHASIS X TASK X EAR	2	8832.88	0.96	0.39
HAND X EMPHASIS X TASK X EAR	2	357.88	0.04	0.96
SOURCES OF ERROR				
SUB(HAND X EMPHASIS)	28	908175.39		NT
SUBxTASK(HANDxEMPHASIS)	56	488718.04		NT
SUB X EAR(HANDxEMP)	28	126915.23		NT
SUBxTASKxEAR(HANDxEMP)	56	256717.71		NT

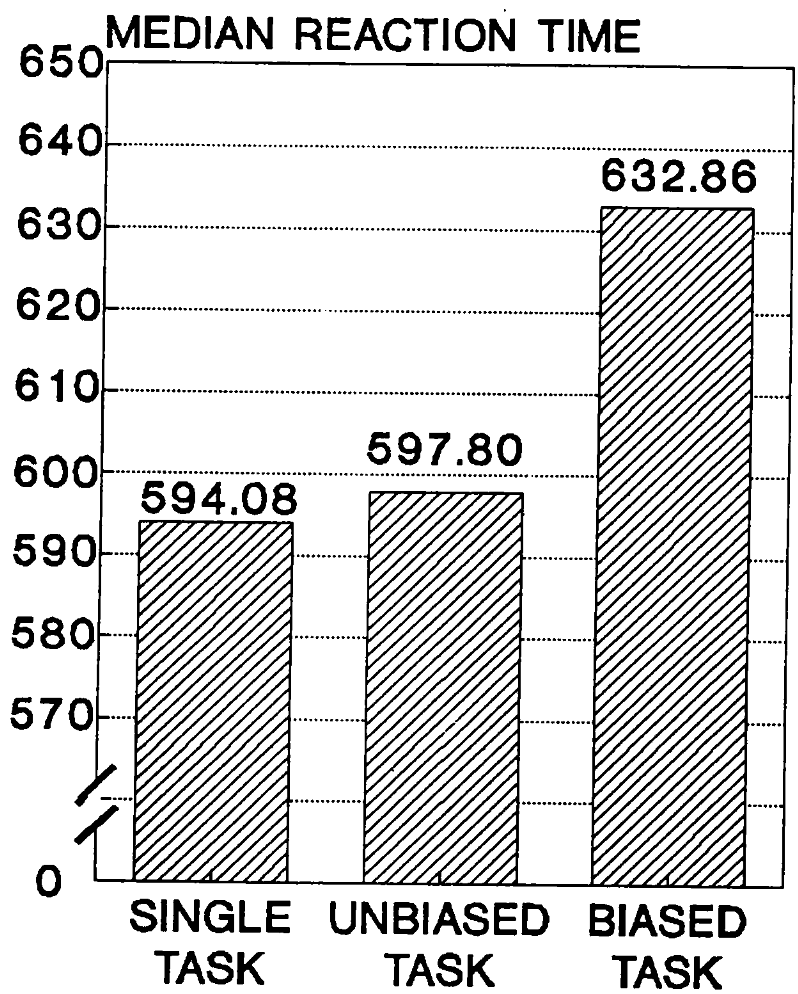


Figure 3. Mean median reaction time during the dichotic listening task as a function of single, biased, and unbiased tasks.

the predictor variables of familial handedness, $F(1,30) = 12.37$, $p < .002$; and handedness, $F(2,29) = 4.57$, $p < .04$; were significant. Familial handedness accounted for 26.8 percent of the variance, and handedness accounted for 7.8 percent of the variance.

Familial Handedness and Handedness. Familial handedness showed a correlation of -0.1718 with the dependent variable hits and -0.0418 with the dependent variable median reaction time. Handedness demonstrated a correlation of 0.1124 with the variable hits and 0.1261 with median reaction time.

Spatial Rotation Task

MANOVA. The MANOVA indicated a significant overall effect across hits, misses, and median reaction time for task, $F(10,104) = 4.510$, $p<.0001$ for Wilks' Lambda.

Hits. The results of the ANOVA for hits are shown in Table 3. A significant main effect was found for task,

Insert Table 3 about here

$F(2,56) = 9.89$, $p<.05$. As Figure 4 shows, a Tukey post hoc

Insert Figure 4 about here

test indicated that the number of hits during the single task was significantly different than the number of hits during the biased and unbiased dual tasks. The biased and unbiased dual tasks were not significantly different from each other.

Table 3

Source Table for the Mean Number of HITS on the Spatial Rotation Task

Source of Variance	df	Anova SS	F Value	PR > F
BETWEEN SUBJECTS				
HAND	1	1.76	0.05	0.82
EMPHASIS	1	5.51	0.16	0.69
HAND X EMPHASIS	1	15.84	0.47	0.50
WITHIN SUBJECTS				
TASK	2	112.56	9.89	0.00
MIXED FACTORIAL				
HAND X TASK	2	9.77	0.86	0.43
EMPHASIS X TASK	2	21.65	1.90	0.16
HAND X EMPHASIS X TASK	2	11.44	1.01	0.37
SOURCES OF ERROR				
SUB(HAND X EMPHASIS)	28	950.79	NT	
SUB X TASK(HAND X EMP)	56	318.58	NT	

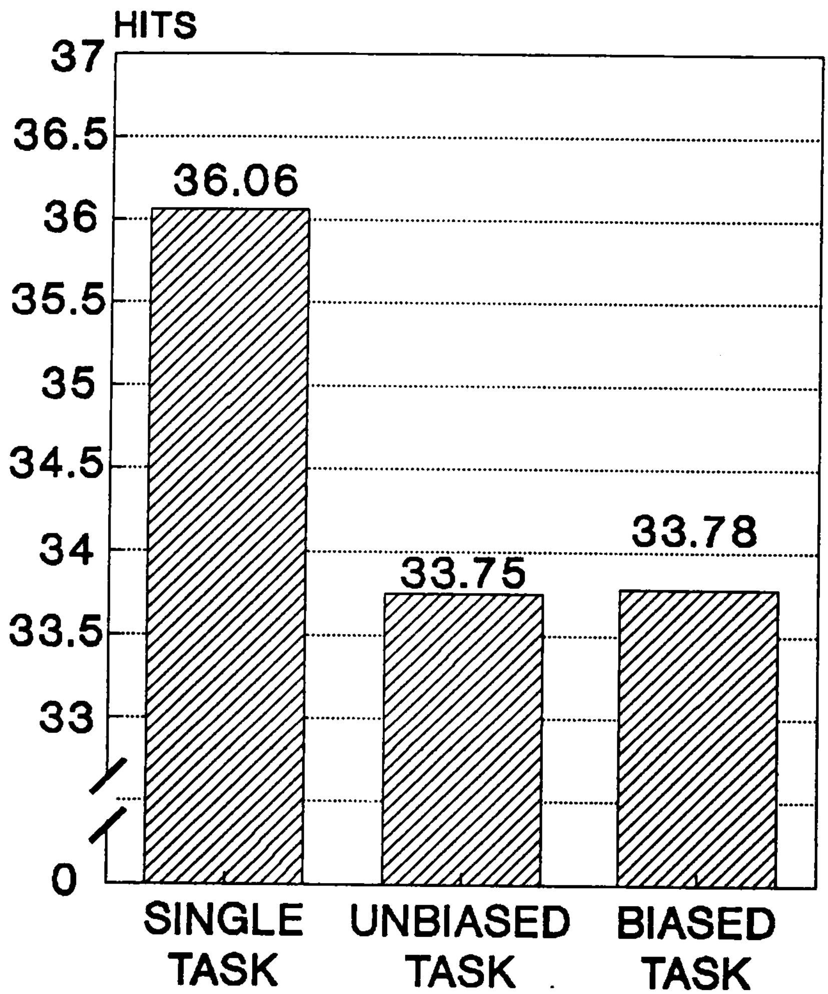


Figure 4. The mean number of hits during the spatial rotation task as a function of single, biased, and unbiased tasks.

number of hits during the single task was greater than during the dual-task conditions. There were no other significant main effect or interaction effects.

Misses. A significant main effect was found for the number of misses on the spatial tasks. The ANOVA table is presented in Table 4. A Tukey post hoc test indicated that

Insert Table 4 about here

single-task performance was significantly different from performance on both dual tasks (see Figure 5). The biased and unbiased dual tasks did not differ from each other.

Insert Figure 5 about here

Median Reaction Time. The analysis of the median reaction times is presented in Table 5. A significant

Insert Table 5 about here

main effect was found for task, $F(2,56) = 5.43$, $p<.05$. Again, the Tukey post hoc test indicated a significant difference among tasks. As Figure 6 shows, median reaction time was higher on the single task than in either dual-task

Insert Figure 6 about here

Table 4

<u>Source Table for the Mean Number of MISSES on the Spatial Rotation Task</u>

Source of Variance	df	Anova SS	F Value	PR > F
BETWEEN SUBJECTS				
HAND	1	5.51	0.40	0.53
EMPHASIS	1	23.01	1.68	0.21
HAND X EMPHASIS	1	5.51	0.40	0.53
WITHIN SUBJECTS				
TASK	2	120.33	19.04	0.00
MIXED FACTORIAL				
HAND X TASK	2	2.58	0.41	0.67
EMPHASIS X TASK	2	8.08	1.28	0.29
HAND X EMPHASIS X TASK	2	14.08	2.23	0.12
SOURCES OF ERROR				
SUB(HAND X EMPHASIS)	28	384.21	NT	
SUB X TASK(HAND X EMP)	56	176.51	NT	

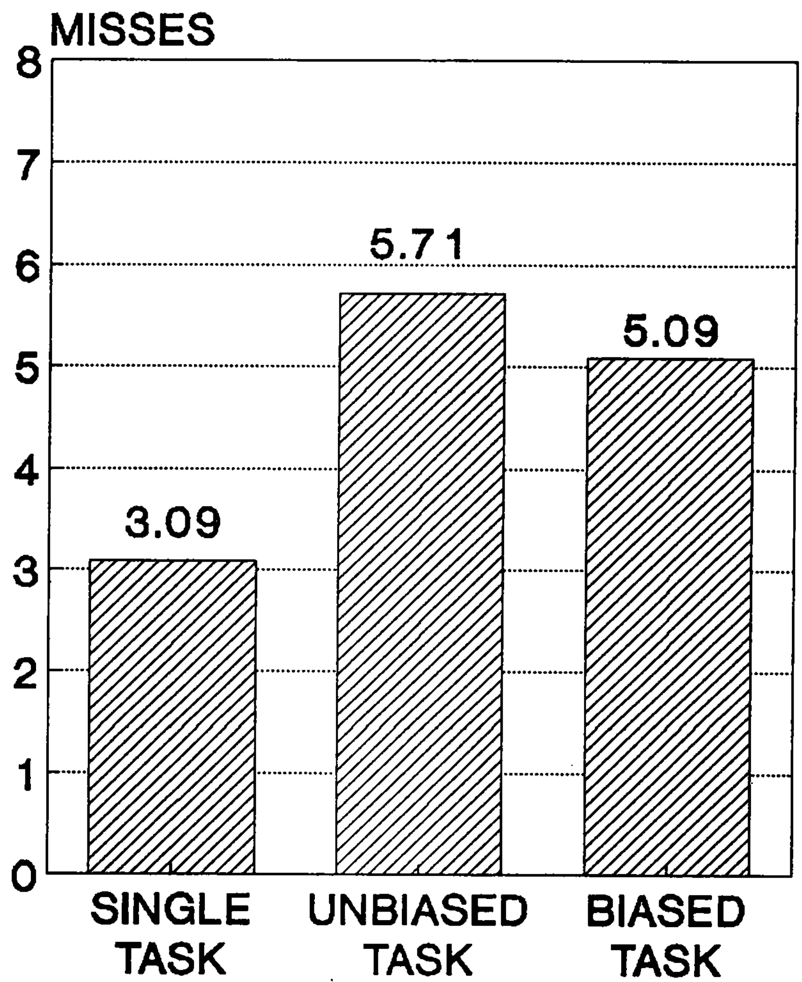


Figure 5. The mean number of misses during the spatial rotation task as a function of single, biased, and unbiased tasks.

Table 5

Source Table for MEDIAN REACTION TIME on the Spatial Rotation Task

Source of Variance	df	Anova SS	F Value	PR > F
BETWEEN SUBJECTS				
HAND	1	196430.27	2.80	0.11
EMPHASIS	1	197698.88	2.82	0.10
HAND X EMPHASIS	1	6725.13	0.10	0.76
WITHIN SUBJECTS				
TASK	2	77016.01	5.43	0.01
MIXED FACTORIAL				
HAND X TASK	2	22474.27	1.58	0.21
EMPHASIS X TASK	2	3489.59	0.25	0.78
HAND X EMPHASIS X TASK	2	306.51	0.02	0.98
SOURCES OF ERROR				
SUB(HAND X EMPHASIS)	28	1966334.93	NT	
SUB X TASK(HAND X EMP)	56	397489.29	NT	

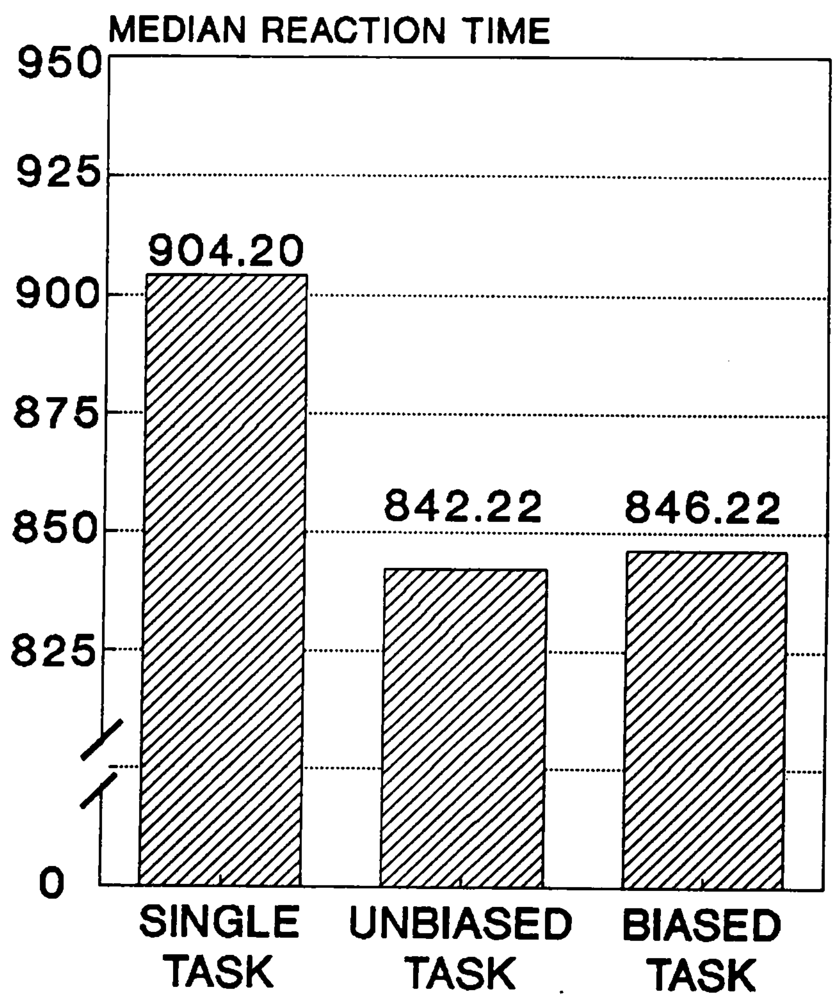


Figure 6. Mean median reaction time during the spatial rotation task as a function of single, biased, and unbiased tasks.

conditions. Again, the biased and unbiased dual tasks did not differ from each other

Handedness and Familial Handedness. Familial handedness showed a correlation of 0.1768 with hits, and -0.0413 with misses, and -0.0115 with median reaction time. Handedness demonstrated a correlation of -0.0966 with hits, 0.0593 with misses, and 0.0797 with median reaction time.

Discussion

The hypothesis that subjects would exhibit a right ear advantage was supported. Subjects scored more hits with a lower reaction time when the input was to the right ear as opposed to when the input was to the left ear. The stepwise regression analysis indicated that the degree of handedness, as well as familial handedness, were significant predictor variables for the degree of REA.

Task-hemispheric integrity theory suggests that during the single dichotic task more accurate performance occurs when using the left hand. This study did not support this position. There was no task by hand effect.

Each theory predicted that under specific dual-task conditions performance would be worse than single-task performance. Task-hemispheric integrity theory suggested a dual-task decrement during the left ear verbal input condition. Conversely, independent-hemispheric resources theory suggested the decrement would occur during right ear input. Neither position was supported. There was no significant task by ear effect for any of the dependent variables.

The task-hemispheric integrity model posits that the most accurate response occurs when a subject uses the right hand to respond to right ear verbal input. This position was not supported. No significant hand by ear effect was found.

An important manipulation of this study involved comparing spatial task emphasis to dual-task emphasis. According to independent-hemispheric resource theory, during right ear input the left hemisphere processes both the spatial and verbal input. Because the same limited resource is used to process both inputs, changing task emphasis should result in a performance tradeoff for the tasks. According to task-hemispheric integrity theory, different hemispheres process the information. Accordingly, changing task emphasis should not result in a performance tradeoff. During left ear input, task-hemispheric integrity theory suggests a decrease in dual-task performance, relative to single tasks, because the right hemisphere must process the spatial input and transfer the verbal input to the left hemisphere. Independent-hemispheric resources theory suggests that different hemispheres process the different stimuli and therefore no resource competition occurs. Unfortunately, the emphasis manipulation in this experiment did not work. Subjects concentrated on dichotic task in some trials and the spatial task in other trials. The results of the ANOVA indicate there was no significant difference in performance between the spatial-emphasis trials and the dichotic-emphasis dual tasks. Spatial performance was essentially the same regardless of which emphasis condition was performed. Asking the subjects to change their concentration from one trial to the next may have been too confusing. Rather than having subjects change task emphasis, it might have been better to make task emphasis a between-subjects variable.

One limitation of this study was the inability to examine the spatial rotation task data with regard to the ear of input of the verbal stimuli. During all trials the verbal target consonants were randomly presented to either ear. Because the two tasks, verbal and spatial, were run on separate computers and analyzed separately, it was not possible to inspect the hand response during the spatial task as the verbal input was varied from the left to right ear. A better way to perform the trials would have been to have the subjects concentrate on one ear throughout each individual trial. In this way it would be possible to compare ear of input, hand of response for verbal input, and hand of response for spatial input.

Additionally, this study may contain a confound. The study tested subjects for their degree of handedness. The Annett Handedness Questionnaire also queried subjects about the existence of immediate family members who were left handed. These two sets of data were collected in order to test their predictability for REA. None of the subjects were screened from the study based on the information from the questionnaire. Fourteen of the 32 subjects demonstrated either a lower degree of handedness or had a member of the immediate family who was left handed. By coincidence 6 of these 14 subjects were placed in one experimental condition. As Geffen and Caudry (1981) point out approximately 16% of all right handed individuals process speech in the right hemisphere. Furthermore, Kee and Bathurst (1983) suggest that familial handedness patterns influence speech lateralization. Right handed subjects who have one immediate family member who is left handed may be less lateralized for verbal processing than right handed subjects who have no right handed family members. The stepwise regression analysis of this study found a significant relationship between both handedness and familial handedness and REA. Because of this significant relationship, correlations were calculated between handedness and each of the dependent variables. Similar correlations were also calculated between familial handedness and each of the dependent variables. However, neither handedness nor familial handedness demonstrated correlations any higher than .18, with any of the performance measures. Despite these low correlations, handedness and familial handedness may have influenced the performance data. This influence may have diminished the expected lateralization effect.

The spatial rotation task was chosen because it required spatial rotation processing (Shingledecker, 1984). Spatial rotation is assumed by some researchers to require right hemispheric resources (Wickens et al., 1981; Wickens & Sandry, 1982.) However recent research suggests that there may be individual differences in the degree of lateralization for spatial processing. Fischer and Pellegrino (1988) have pointed out that spatial rotation may be broken down into component processes such as encoding, search, rotation, comparison, and motor response. These researchers suggested that some components of the spatial rotation task may be performed by different hemispheres. They found a left hemisphere superiority for spatial processing. Fischer and Pellegrino (1988) also suggested that the experience of the subjects may influence the degree of lateralization for spatial tasks. All of the subjects in their experiment were experienced with spatial rotation tasks. In a subsequent study, Voyer and Bryden (1990) found that low spatial ability subjects demonstrated a right hemisphere advantage while high spatial ability subjects demonstrated a left hemisphere advantage. The regression analysis in this did not find a significant relationship between spatial ability and REA. However, the data for this experiment were collected after the subjects were allowed two practice trials on each of the four tasks. This practice, as well as any individual difference in the degree of lateralization, may still have obscured any hemispheric effect.

Further study of this subject may be facilitated by a number of measures:

1. Subjects should concentrate on only one ear of input during each trial. This would allow a comparison of the subject's response to the spatial task when the verbal input is changed from the right ear to the left ear.

2. Subjects should be screened for their degree of handedness and familial handedness. Kee and Bathurst (1983) found a significant relationship between familial handedness and lateralization and this study supports their research. In any experiment with few subjects in experimental cells, individual differences in the degree of lateralization may influence the results.

3. Task emphasis should be made a between-subjects experimental variable. Changing task emphasis is viewed as an important methodology by some researchers (Friedman et al., 1982; Klapp & Netick, 1988; Polson & Friedman, 1982). However, asking each subject to change emphasis from one dual task to another may be too confusing. It may be easier if each subject is asked to perform only one type of dual task.

4. Subjects should be classified according to their level of spatial rotation ability. Furthermore, any practice which subjects receive, in the spatial rotation task may influence spatial ability. Therefore, the amount of practice given to subjects should be included as an experimental variable.

Either task hemisphere integrity theory or independent-hemispheric resources theory may be correct for the majority of right handed males. However, this study did not find sufficient evidence to support one theory over the other. It may be that there are a number of factors such as spatial ability, handedness, and familial handedness which influence an individual's degree of lateralization and hemisphere of processing. These individual differences may present inconsistent and confusing results in lateralization research. Research which controls for these factors, or includes them as variables, may explain these inconsistencies.

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Appendix A

Experimental Design

		EAR OF INPUT			
		RIGHT EAR		LEFT EAR	
		1	2	1	2
	DICHOTIC	3	4	3	4
	EMPHASIS	5	6	5	6
RIGHT		7	8	7	8
HAND					
RESPONSE		9	10	9	10
	SPATIAL	11	12	11	12
	EMPHASIS	13	14	13	14
		15	16	15	16
		17	18	17	18
	DICHOTIC	19	20	19	20
	EMPHASIS	21	22	21	22
LEFT		23	24	23	24
HAND					
RESPONSE		25	26	25	26
	SPATIAL	27	28	27	28
	EMPHASIS	29	30	29	30
		31	32	31	32

A 2 (hand of response) X 2 (ear of input) **X 2 (emphasis)** X 3 (task-single, biased, unbiased) **mixed design with subjects nested in hand of response and emphasis.**

Appendix B

Task Instructions

You are eligible to participate in this study if you are between the ages of 18 to 30 years of age, have 20/20 vision (corrected or uncorrected) and have normal conversational hearing.

The general purpose of this experiment is to examine the effects of practice and difficulty level on the performance of two simultaneous tasks. If you are interested in more specific details of this study I will be glad to explain them to you after you complete this experiment.

There are no expected harmful psychological or physical effects of this experiment.

You are completely free to leave this experiment now or at any time after you begin.

If you have any questions or complaints concerning the conduct or content of this experiment you may address these concerns to me directly, to my advisor Dr. Freeman, and/or to Dr, Adkins, who is the head of the Psychology Department's Committee for the Protection of Human Subjects.

While you are performing the trials your score will be recorded. The individual who has the highest point total at the end of the experiment will receive $20.

Single Dichotic Listening Task

You will be asked to listen to a tape recording of a series of monosyllables. These mono-syllables da, pa, ga, ca, ta, ba, will be presented to both ears, through a set of headphones, at the same time. One of the monosyllables 'ca', C A is designated as the target. When you hear the target, in either ear, you will respond by pressing a red button on a black box. You will respond to all the verbal targets with your left (right) hand. The tape will run for 3 minutes. During this trial you will be given 10 points for each correct identification of a target syllable for a possible point total of 300. At the end of three minutes you may relax for a minute. I will tell you your point total and answer any of your questions before we begin the next trial. This is a practice trial, your points during the practice trials are for feedback and will not count towards your final score. Do you have any questions?

Single Spatial Task

You will also view a series of bar graphs which will be presented on the television screen. Each bar graph or histogram will have four bars of different heights. The first bar graph will be presented in an upright position. After a few seconds this bar graph will disappear. A second bar graph will appear on the screen. This bar graph will be lying on its side, pointed either to the left or the right. The bars of the second graph may have changed size or position, that is, the order may be different. You will be asked to determine if the second graph in each pair is the same as the first bar graph. If you decide the histograms are the same press the white button marked 'same'. If they are different press the button marked different. After you have responded to a pair of histograms the next pair will be presented. You must respond to each pair. You will be shown approximately 40 pairs of bar graphs. You will respond to all of the histograms with your right (left) hand. This trial will last 3 minutes. During this trial you can earn 8 points for each correct choice for a possible total of 320 points. After the last bar graph the screen will be blank. Relax for a minute. I will come in, tell you how many points you have earned and answer any of your questions. This is a practice trial, your points during the practice trials are for feedback and will not count towards your final score. Do you have any questions now?

Unbiased Dual Task

After you have performed each of these tasks separately you will be asked to perform them together. Try to concentrate on both task equally. This test will last for 3 minutes. During this task you will be awarded 10 points for each verbal target hit and 8 points for each correct spatial processing choice. Again the task will last three minutes with a minute to rest after the task. I will tell you how many points you scored. This is a practice trial, your points during the practice trials are for feedback and will not count towards your final score. Do you have any questions?

Biased Dichotic Dual Task

During this trial you will perform both tasks at the same time. Throughout this trial you should concentrate more on the dichotic listening task. You will receive 15 points for each verbal target hit and 4 points for each correct spatial processing decision. To get the maximum amount of points you must perform both tasks together, but concentrate on the listening tasks. This task will last 3 minutes with a one minute rest period. During this rest period I will answer your questions and tell you your task score. This is a practice trial, your points during the practice trials are for feedback and will not count towards your final score. Do you have any questions?

Biased Spatial Dual Task

During this trial you will perform both tasks at the same time. Throughout this trial you should concentrate more on the spatial rotation task. During this task you will receive 5 points for each identified verbal target and 11 points for each correct spatial comparison. To get the maximum amount of points you must perform both tasks together, but concentrate on the spatial rotation tasks. This task will last 3 minutes with a one minute rest period. During the rest period I will answer your questions and tell you your score. This is a practice trial, your points during the practice trials are for feedback and will not count towards your final score. Do you have any questions now?

Experimental Trials

You have now completed all the practice trials. You may take a 5 minute break if you wish. You are next going to perform each of the trials again. The tasks are in random order so they will not be presented in the same order as you practiced them. I will also not give you feedback after each trial. Other than these two points the tasks will be the same as those you just practiced. Each task will be three minutes long with a 1 minute rest period. Do you have any questions? Your points will count.

Appendix C
Informed Consent

Project Name: ____________Sinister______________________

Investigator:____________Pamela R. Jordan______________

Faculty Advisor:__________Dr. Fred Freeman_____________

Date: ____

This is to certify that I, ___________________________
hereby agree to participate as a volunteer in a scientific investigation as a part of the educational and research program of Old Dominion University.

I understand that the nature of my participation will involve listening to a tape recorded series of monosyllables through a set of headphones and watching a series of bar graphs presented on a television monitor.

I have been informed, and do understand that some details of the study may not have been explained to me at this time. This procedure is sometimes necessary because advance knowledge may affect my answers and the results of this study. I am aware that the exact nature of this study will be explained to me during a debriefing after this session.

I understand that I an free to entirely withdraw from this study without any penalty.

I understand that any data or answers which I provide will remain confidential and that my name will not be associated with the results of this study.

I acknowledge that I was informed about any possible risks to my health and well being that may be associated with my participation in this study.

I have been informed that I have the right to contact the Psychology Department Committee for the Protection of Human Subjects and/or the University Committee should I wish to express any opinion or ask any questions regarding the conduct of this study.

SIGNATURE

____

SOCIAL SECURITY NUMBER ________________________

Appendix D

Annett Handedness Questionnaire

Sex_______________________ Age______________

Is any member of your immediate family (i. e., biological parents, grandparents, brothers/sisters) left handed?__________________________________ If so, please specify your relationship, ____

Please indicate which hand you habitually use for each of the following activities by circling R (for right) or L (for left)

Which hand do you use:

1. To write a letter legibly?
2. To throw a ball to hit a target?
3. To hold a racket in tennis, squash, or badminton?
4. To hold a match while striking it?
5. To cut with scissors?
6. To guide a thread through the eye of a needle (or guide a needle on to thread)?
7. At the top of a broom while sweeping?
8. At the top of a shovel when moving sand?
9. To deal playing cards?
10. To hammer a nail into wood?
11. To hold a toothbrush?
12. To unscrew the lid of a jar?

If you use the RIGHT HAND FOR ALL OF THESE ACTIONS, are there any one-handed actions for which you use the LEFT HAND? Please record them here.

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If you use the LEFT HAND FOR ALL OF THESE ACTIONS, are there any one-handed actions for which you use the RIGHT HAND? Please record them here.

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