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"... what is good about experimental psychology -- its concern for controlled observation and for understanding the conditions of the occurence of phenomena -- should be part of the conscience of all clinical psychologists. Where all psychologists should join ... is in the naturalist's love of phenomena and of their investigation."

G.S. Klein
1970, p. 426

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# THE EFFECT OF SUBLIMINAL VISUAL MATERIAL ON AN AUDITORY SIGNAL DETECTION TASK

## Introduction

### Statement of the Problem

Subliminal perception, the hypothesis that a person can be affected by stimuli of which he is unaware, has been a topic of lively debate for over a century. The length and vigor of the controversy testifies to the hypothesis' important place in one of psychology's most basic theoretical questions, whether unconscious mental processes exist and influence behaviour. Consequently research on subliminal perception has been a battlefield upon which behaviourists and more psychodynamically oriented psychologists, experimentalists and clinicians, have frequently met to decide the validity of the concept of the unconscious.

Antagonism between these forces was never more intense than in the middle decades of this century. It was the time of the New Look which represented a concerted effort to investigate the influence of internal events such as values, sets, expectations, and motivation on the perception of external stimuli (Erdelyi, 1974). As well as challenging Behaviourism's dictum that intervening variables between stimulus and response could not be properly researched, the New Look also sought to demonstrate the influence of psychodynamic defenses against emotional stimuli presented below threshold. The vociferous reaction against the New Look was directed mainly toward criticism of methodology, and by the late

1950's the New Look, including subliminal research, appeared to have been invalidated.

The last decade, however, has seen a growing amount of acceptance for the subliminal perception hypothesis (Dixon, 1971; Nisbett & Wilson, 1977) made possible, argues Erdelyi (1974), by the advent of the information processing approach to cognitive activity. This cybernetic orientation made possible the investigation of various structures such as long-term memory, storage, and buffer areas with which developed the idea of complex discriminations and evaluations taking place prior to, and even without, conscious awareness (Treisman, 1964; Deutsch & Deutsch, 1963; Nisbett & Wilson, 1977; Shevrin & Dickman, 1980). With a new respectability gained from this highly experimental approach, the debate over subliminal perception has expanded from an argument over its existence to parametric investigations of its nature.

A number of psychologists have postulated that stimuli received at subliminal levels meet a qualitatively different fate compared to supraliminal stimuli. Two of the foremost advocates of this idea are Spence and Holland (1962) who argued against the assumption that the effect of a stimulus depends upon the strength of the stimulus. They proposed that

> "...reduction of awareness changes the patterning of cognitive activity.... when awareness is reduced, certain restrictions on thought are removed; more rather than fewer associative pathways become available and thought is freer to range over a greater number of associates."

Closely aligned with the Spence-Holland theory is the position of Klein (1970) who suggests that one of the unique characteristics of subliminal perception is its capacity for unconscious registration of embedded visual material. According to Klein the Gestalt view, that recessive interpretations of a visual stimulus have no psychological reality while the dominant configuration is being experienced, is incorrect. Klein argues instead that in conditions of low awareness the distinction between figure and ground breaks down and allows for the unconscious registration of various interpretations of the stimulus.

In view of the importance of this assertion, an experiment was conducted to assess whether registration of visually subliminal embedded material affects performance on an auditory detection task. Furthermore, this investigation was carried out within the framework of signal detection theory (Green & Swets, 1966) which has not historically been used in subliminal perception research, but which, according to Dixon (1971), has the potential for marshalling even stronger support for the existence of subliminal perception. Theoretical and methodological foundations for the present research are reviewed below.

## Historical Review of the Literature

The history of the controversy over subliminal perception is one of psychology's longer and more colourful chapters. The research aimed to demonstrate or negate its existence spans over seventy years, and the debate shows little sign of abating. Dixon describes the paradoxical nature of the controversy aptly in the introduction to his exhaustive book on the topic, Subliminal Perception: The Nature of a Controversy (1971, p. vii):

> "If the importance of a hypothesis can be gauged from the number of experiments in which it has been tested, then that of subliminal perception must rank as one of the most important in the history of the science; but if its importance were to be judged on the basis of the attention given it in textbooks on psychology, then it would surely feature at 'the bottom of the charts'.... If the hypothesis...is valid, then it has profound implications not only for the psychophysiology of memory, perception, emotion, motivation, and dreams, but also for the nature of consciousness itself. If, on the other hand, it is not valid, then the hundreds of experiments and thousands of working hours devoted to this topic constitute the most monumental waste of time in the history of psychology."

The academic acrimony which has accompanied the debate over subliminal perception has probably been fanned by public scrutiny and the legislative action taken to ban subliminal messages in television advertising (McConnell, Cutler, & McNeil, 1958). Even at the present time two books on the subject are enjoying widespread popularity: Subliminal Seduction (1973) and Media Sexploitation (1976), both by W.B. Key.

A more fundamental reason for the contentiousness of the debate, however, is that subliminal perception has brought the major schools of thought in psychology into direct conflict. On the one side has been Behaviourism with its emphasis on observable behaviour and its rejection of investigation of internal structures and events. At the turn of the century William James (1890, p. 163) was warning that

> "the unconscious is the sovereign means for believing whatever one likes in psychology and of turning what might become a science into a tumbling ground for whimsies."

Adopting the functionalist emphasis on observable behaviour, behaviourists have traditionally regarded intervening mechanisms between stimulus and response as unacceptable research material. To more psychoanalytically oriented psychologists, however, demonstrations of intervening mental processes taking place outside of awareness -- and subliminal presentation of material appeared to guarantee such a lack of awareness -- seemed to offer good support for Freud's theory of the unconscious. Thus, much of the intensity of the controversy can be credited to psychology's perennial struggle with its most basic question -- whether or not to attempt the scientific divining of the "black box".

A number of phenomena are included under the umbrella of the term subliminal perception. In its most general sense subliminal perception means that a person can be affected by stimuli of which he is unaware. "Unaware" may be construed in many ways, however, so Dixon (1971, p. 12) limits the phenomena of subliminal perception to those circumstances wherein the subject is unable to be aware of stimulation: 1) the energy or duration of the stimulus is below the level at which the subject ever reported awareness in a threshold determination task, but the subject nevertheless responds; 2) the subject responds to a stimulus of which he confesses complete unawareness; 3) the subject reports being stimulated but claims that he has no awareness or knowledge of what the stimulus was.

Satisfactory experimental criteria indicating that subliminal perception has taken place are for Dixon (1971): 1) a subject's contingent responses to stimulation below the level at which he reported hearing or seeing anything; 2) a subject's retrospective report that he heard or saw nothing of the experimental stimulus; 3) responses contingent on stimulation, of which the subject confesses unawareness, that differ qualitatively from responses elicited by the same stimulus presented above the predetermined threshold. For Dixon it is this third category which is the most important because, as he explains (1971, p. 18):

> "...not only does it ensure that the subject was unaware of the stimulus, but also establishes subliminal perception as a phenomenon in its own right, something more than a watered down version of supraliminal perception."

Thus Dixon, like Spence and Holland (1962), places special importance on the idea of qualitative differences between the fate of supra- and subliminal stimulation.

Subliminal perception was not, as Dixon (1971) points out, an invention of the Freudian school. The idea of the imperceptible having an effect in nature in general and in human behaviour in particular had been broached by the ancient Greek philosophers. In the Renaissance Montaigne (1580) claimed that no two experiences were exactly the same because of imperceptible differences which occur. Leibniz in the seventeenth century, however, was the philosopher who most clearly anticipated the idea of subliminal perception (as quoted in Dixon, 1971, pp. 7-8): "In a word it is a great source of error to believe that there is no perception in the soul besides those of which it is conscious."

Two centuries later Freud (1957) revolutionized man's conception of himself with his theory of the unconscious wherein much of mental and emotional life took place outside of the bounds of awareness. Freud's keys to opening up and understanding this unknown area were free association and dream analysis. Both constituted states of lowered awareness in which the defenses of the ego and superego were surmounted. But the aspect of Freud's theory which is most apropos to the present research is his idea of day residues.

Freud (1900/1954, p. 554) proposed that five kinds of material, or day residues, were carried over from the day's activities into dreams:

> "1) what has not been carried to a conclusion during the day owing to some chance hindrance; 2) what has not been dealt with owing to the insufficiency of our intellectual power -- what is unsolved; 3) what has been rejected and suppressed during the daytime. To these we must add 4) a powerful group consisting of what has been set in action in our Ucs. by the activity of the preconscious in the course of the day; and finally 5)

> the group of daytime impressions which are indifferent and have for that reason not been dealt with."

Although Freud did not deal specifically with stimuli reaching the individual at subthreshold levels, his ideas of "indifferent impressions" and the repression of above threshold stimuli lay the theoretical groundwork for much of the New Look controversy which took place decades later.

Erdelyi's (1974) review article on the New Look is an excellent source for understanding the issues and timbre of that mid-century concerted effort to open up the forbidden "black box" and investigate the role that internal motives, values, expectations, and needs played in the perceptual process. Objections to the attempt were vociferous and frequently aimed at the studies involving subliminal perception. Of the criticisms leveled against the subliminal perception hypothesis in general and perceptual defense in particular, one of the most perplexing was that of the logical paradox. How, asked critics, can one decide what to perceive without first perceiving it? A preconscious selection process brought to the minds of many behaviourists visions of homunculi scanning and editing incoming stimuli before consciousness of them was "allowed". At worst it seemed to be accepting the ancient idea of demons; at best it seemed like giving recognition to Freud's theory of the unconscious and all its pseudoscientific talk of energy dynamics. Eriksen's (1960, p. 298) reaction to serious psychologists dabbling with such concepts was typical:

> "The science of personality is not furthered by the frequent tendency of psychologists to discuss the 'unconscious' with all the ambiguity and reverence that religions accord to the soul. There is a great need to spell out explicitly the assumed characteristics of the unconscious and to search for explanations of so-called unconscious phenomena in terms of more commonplace psychological variables. To do so may destroy the titillating mystery that the unconscious seems to hold but then that is the business of science."

By the late 1950's fears about homunculi and concerted attacks against "flawed" methodology combined with other factors to undermine the thrust of the New Look work, including support for the subliminal perception hypothesis. Other factors cited by Dixon (1971) which led to a decrease in acceptance of the hypothesis included negative public reaction to reports of the commercial use of subliminal messages in advertising (McConnell et al., 1958), fears about academic respectability, and the realization that traditional methods of threshold determination were not as accurate as thought. The latter statement refers to the advent of signal detection theory (SDT) in the 1950's which, in expounding the importance of response criteria in threshold determination, argued that there was no such thing as a true physiological limen (Dixon, 1968) and that subliminal studies were thereby confounded (Sheyrin and Dickman, 1980). This issue, which is very pertinent to the present study, will be addressed in more detail below.

For Erdelyi (1974), however, the waning of support witnessed in the late 1950's was fundamentally due to the conceptualization of perception as a unitary event in which no place for preselective processes was credited. It was this preconception about perception along with the Zeitgeist of the 1950's which more than any other factor caused the demise of the New Look. But this preconception was itself on the verge of becoming obsolete.

Beginning with Broadbent's Perception and Communication in 1958, the new wave of theory and experimentation described as the information processing approach to cognitive activity began to embrace a new view of perception as a complex sequence of internal events taking place, for the most part, outside of the bounds of awareness. As information flows into the system from the external world, selectivity as to what components of the stimuli will be brought into consciousness can be conceptualized as occuring in various locations in the system.

In Erdelyi's (1974) schema, for example, a whole range of exploration is made possible because perception is expanded from the simplistic S-R model to a multi-faceted process. The influence of values, sets, defense mechanisms, etc., is subsumed under the title of long-term memory while short-term memory becomes the area of consciousness. Essentially, long-term memory becomes the filter through which all stimuli flow. The conceptual framework of information processing, therefore, has dispelled fears about homunculi and brought renewed open-mindedness towards the idea of subliminal perception.

But while the hypothesis has gained increasing support in general, the question of there being unique qualities in subliminal perception has been of minor concern in the literature. It is, indeed, the special province of those theorists and researchers who are most closely allied to the psychoanalytic orientation, for while cognitive psychologists like Erdelyi (1974) may speak comfortably about preconscious filters and schemata, it is the Freudian Pscholôgists who have traditionally explored and expounded the unique qualities of unconscious mental processes.

For Klein (1970, p. 266), who professes a rare devotion to both clinical practice and perceptual research, the main thrust of subliminal perception work has missed the truly exciting issues to be investigated:

> "These basic issues are, first, that an incidental stimulus may activate meanings (or trace systems or schemata) quite <u>independent</u> of those that are pertinent to the main directions of a person's thought at a given moment; second, that such independently or even subliminally activated meanings will affect <u>different</u> levels of behavior and different modes of experience than those to which conscious selective effort is directed; third, that the incidentally or subliminally activated meanings may have <u>delayed</u> effects, persisting and affecting behavior in situations and states of consciousness quite removed from those in which the excitations originally occurred; and fourth, that such incidental stimuli may acquire special properties by the very fact

> of their peripheral status in the field of stimulation, making it possible for such subliminal activation to have distinctive effects on thought as compared to stimuli that claim full attention."

Research which has addressed these issues forms a body of literature which is very relevant to the present study. One part of this corpus of experiments originates from the early work of Poetzl (1917) who found details of a slide shown at 1/100 of a second in the subsequent dream content of his subjects. In addition to discovering the influence of the slide material in dreams, Poetzl concluded that <u>only</u> the unreported details of the slide found their way into the dream content. Except for one study by Allers and Teller (1924) which used word associations to retrieve unnoticed content from pictures flashed at 4/100 of a second, the work of Poetzl went virtually unnoticed until Fisher (1954) undertook to replicate the 1917 experiment. Again it was found that tachistoscopically exposed stimuli did indeed appear in subsequent dreams. Other studies have followed using various methods of content retrieval such as imagery (Fisher, 1956; Luborsky & Shevrin, 1956), Rorschach responses (Silverman & Silverman, 1964), and drawings (Fiss, Goldberg, & Klein, 1963; Haber & Erdelyi, 1967). Word associations were used in the Allers and Teller (1924) and Spence and Holland (1962) experiments.

The latter study, which has drawn more theoretical and methodological criticisms (Worrell & Worrell, 1964; Bruel, Ginsburg, Lukomnik, & Schmeider, 1966; Jung, 1966) than the others, contains one of the best attempts to illuminate the nature of sub- versus supraliminally stimulated cognitive activity. Spence and Holland argued that reduced awareness allows a greater spread of associations to the stimulus whereas with conscious attention the percept is restricted to one train of thought. In their experiment three groups of subjects were asked to learn and recall a list of words containing some associates to the word "cheese". Before being given the list, one group had been shown the word "cheese" subliminally, one group had been shown it supraliminally, and the third shown nothing. The results supported their predictions in that the subliminal group produced the most "cheese" associates. Thus Spence and Holland concluded that awareness can have a limiting effect, i.e., that stimulus intensity, awareness, and effect are not necessarily on the same continuum. Or to recall Dixon's proposition, subliminal perception is not merely a "watered-down" version of supraliminal perception.

Other studies have been reported that claim to demonstrate how stimuli presented below threshold are susceptible to primary process thinking whereas secondary process thought is more likely to be associated with supraliminal stimuli. Studies by Shevrin and Luborsky (1961) and Shevrin and Fisher (1967) seemed to show primary process thinking at work in rebus effects. Fisher and Paul (1959), Paul and Fisher (1959), and Eagle, Wolitsky, and Klein (1966) found similar results using embedded figures. In each case it appeared that the meaning derived from the stimulus differed according to whether it was presented sub- or supraliminally. The clinical research of Silverman (1976) similarly suggests that wish-related stimuli only intensify psychopathology when shown to various clinical populations in below-threshold conditions rather than above-threshold conditions.

All of this evidence would seem very tempting indeed, except that methodologically these studies, perhaps with the exception of Haber and Erdelyi's (1967) tightly-controlled experiment, can be substantially challenged. As Eriksen (1960) pointed out in his review article on subliminal perception, these Poetzl-type experiments which depend on relaxed states of awareness such as free association, doodling, dreaming, and imaging for dependent measures are open to the possibility of artifacts in three ways. For one, many studies have not used a base rate in order to compare blank presentations with visual content presentations. Secondly, there has been the problem of the subjects' confidence level in the intentional versus low awareness retrieval tasks. When intentionally trying to recall the stimulus, subjects may have reported elements they were certain about whereas in imaging or free associating subjects would have felt freer about guessing. Finally, Eriksen criticized loose criteria for determining the connection between elements in the stimulus picture and elements in dreams, images, drawing, etc. How, for example, is one to determine if a car in the stimulus is represented by a wagon in a dream? Furthermore, if a subject reports water in the stimulus he may then image a boat not necessarily because he subliminally perceived a boat but because there is a frequent association of the two items.

A study by Eagle et al. (1966) serves as a good example for the criticisms offered by Eriksen (1960). Eagle et al. used as an experimental stimulus a tree with a perceptually recessive duck and as a control the same tree with the duck's outline eliminated to determine whether, when shown at a subliminal level, an unreported concealed figure would nevertheless emerge in following imagery. Experimental subjects were instructed to view the stimulus, presented at 10 milliseconds, and wait for an image of a "nature scene" to come to mind and then to draw it. Control subjects were shown the tree without the duck and asked to image and draw. Eagle et al. found that significantly more of the experimental group produced duck-related drawings than did the controls.

Eagle et al. argued that the instructions to image a nature scene were necessary to "prime" associations to the duck. But it may be argued that associations to tree and tree-plus-duck have much common ground with nature-scene and that distinctions made between those groups of words are dubious at best. Their conclusions, while based on questionable methodology, nevertheless express important theoretical considerations which should not stand or fall on the basis of one study (p. 837):

> "...the stimulus potency of the concealed figure as meaningful content is not ruled out by its being experientially weak or never consciously perceived. One possibility is that some response evoked by a

> picture which contains a concealed figure will include content provoked by that figure. According to this view, the actually reportable percepts are only a segment, although the dominant one, of an ensemble of responses and associations activated by the entire configuration."

The importance of this hypothesis, therefore, extends out of psychoanalytically-based research into the present mainstream of cognition-oriented psychology, a direction which Dixon (1971) and Erdelyi (1974) have advocated. It addresses the question of how we recognize what we see (the dominant configuration) as a result of preconscious processes of analysis. It asserts that consciousness, guided by attention, is of limited capacity and that complex discriminations must perforce be carried out outside of the bounds of awareness (Deutsch & Deutsch, 1963; Posner, Klein, Summers, & Buggie, 1973). Finding evidence of registration of embedded material not consciously perceived would provide, therefore, an interesting piece of information about the puzzling netherworld of preconscious processes. And because it can guarantee the absence of conscious awareness, subliminal research is particularly suited to the task.

The purpose of the present investigation was to assess whether embedded visual material which is not identifiable at a supraliminal level of presentation could nevertheless have effects on a cross-modal detection task indicating that subliminal registration took place. As discussed above, dependent measures involving dreams, imaging, free association, and other modes of unstructured response are not without substantial problems. Recently other dependent measures of registration have been reported that involve less subject response control, a topic which has plagued the perceptual defense literature (Erdelyi, 1974). Corteen and Wood (1972) and O'Grady (1977) have, for example, used GSR response as an indicator of registration of subliminally presented words. Kostanov and Arzumanov (1977), pursuing an earlier line of research by Shevrin and Fitzler (1968), analyzed averaged evoked potentials in response to perceived and unperceived neutral and emotional words.

A further refinement in the methodological assessment of subliminal perception incorporated into the present study has come from the theory of signal detection (SDT). Green and Swets (1966) state that perception is a combination of two inextricable factors, physiological sensitivity and response bias, indexed by d' and Beta respectively. In other words, a subject's decision to respond "yes" or "no" to the question of whether he perceived something (a signal) depends not only upon the physical qualities of the stimulus, surrounding noise, and the receiving organ of sense, but also upon the expectations and pay-offs which may accrue to the subject. Calculation of the two response measures depends upon the use of two classes of trials, those with and those without the signal to be detected. The proportion of "yes" responses over the numbers of trials-with-signal (a hit) is used in the calculation of d'. The proportion of "yes" responses to the number of trials-without-signal, or noise alone, (a false alarm) is utilized in the calculation of Beta, thus giving an indication of the subject's willingness to guess.

Given the interdependence of d' and Beta as proposed by SDT, the question of whether true physiological thresholds exist (Swets, 1961) was raised as a challenge to the subliminal perception research (Dixon, 1968, 1971). If there are no true limens, it was argued, then the distinction between sub- and supraliminal stimuli becomes meaningless. But as Dixon points out, SDT like other methods is concerned with awareness thresholds not physiological thresholds. Moreover, it enables the researcher to separate out physiological sensitivity from response criteria. This was not the case with classical psychophysical methods of threshold determination. If d' could be shown to change as a function of input of which the subject professed unawareness without any demonstratable changes in Beta, then there was even stronger evidence for the existence of subliminal perception in general and perceptual defense or vigilance in particular. Dixon (1971, p.17) concludes:

> "In summary, then, it can be said that, for 'subliminal' theory, SDT has been the ugly duckling which turned into a swan. What at first seemed to cast grave doubt on the validity, indeed meaningfulness, of the subliminal perception concept has turned out to be its staunchest ally."

Dixon (1971) supports this enthusiasm by describing some studies which, though few in number, have used the signal detection paradigm to demonstrate sensory effects of subliminal stimulation. Broadbent and Gregory (1967) and Dorfman (1967) both found to their surprise that d' and not Beta significantly changed in perceptual defense experiments using auditory and visual subliminal stimuli respectively.

Of more interest to the present research, however, are the findings of two other studies involving the use of signal detection in cross-modal experiments. Zwosta and Zenhausern (1969) based their study on the work of Symons (1963) who found that simultaneous auditory, gustatory, thermal, olfactory, and proprioceptive stimulation each increased sensitivity in a visual task using the method of limits. Although Symons had some reservations about experimenter effects, he nevertheless favored the explanation that stimulation in one modality primed the cortex to receive signals in other modalities thereby lowering thresholds.

Zwosta and Zenhausern (1969) extended the work of Symons by investigating accessory stimulation at sub- and supraliminal levels using a signal detection paradigm. They proposed to determine whether the intersensory facilitation effect was attributable to changes in sensitivity or to changes in the subject's response criterion. Using seven levels of auditory accessory stimulation, from no noise up to 15 decibels above threshold, Zwosta and Zenhausern found that d' for the visual detection task was significantly increased at the two extreme levels of auditory stimulation, -15 decibels and +15 decibels. As in Broadbent and Gregory (1967) and Dorfman (1967), Beta did not change significantly.

Zwosta and Zenhausern were surprised by their findings and proposed that some kind of dual mechanism involving distraction of the subjects may have been at work. They did not elaborate this point, however, so their meaning is somewhat unclear.

The publication most relevant to the present research is that of Hardy and Legge (1968). They reported two experiments both of which involved subliminal stimulation in one modality concomitant with a detection task in another. In the first experiment emotional subliminal stimuli (the words "cancer", "danger", "failure", and "orgasm") were presented auditorally over white noise while the subject concentrated on detecting two visual stimuli -- the inverted mirror image of the word "bridge" and a solid rectangle of light. The effect of the subliminal emotional words was to significantly increase visual threshold level as compared to subliminal neutral words.

In the second experiment the modality roles were reversed, and a signal detection paradigm was used to determine d' and Beta in an auditory task. Four neutral words ("feature", "fencer", "plasma", "gander") and four emotional words ("failure", "cancer", "orgasm", "danger") were subliminally projected on a screen while the subject was instructed to indicate whether he detected a signal over white noise. Auditory sensitivity was found to decrease significantly with the presentation of emotional stimuli while it did not for neutral stimuli. Hardy and Legge also found that changes in performance were not due to changes in Beta.

A number of other studies may be regarded as supportive of Hardy and Legge's results. Some involve the topic of the effect of subliminal material on conscious tasks while others address the question of intrasensory facilitation. In the former category are two studies by Dixon and Haider (1961) and Henley and Dixon (1976). Dixon and Haider did not use a cross-modal design but instead compared threshold changes in subjects' eyes. They found that emotional subliminal stimuli presented to one eye evoked a rise in threshold in the other eye. In a similar study carried out in 1976 using schizophrenic patients, Henley and Dixon found that the word "breast" shown to one eye raised threshold in the other eye, but that the word "cancer" had a facilitating effect. Subliminally presented pictures depicting family situations also raised threshold in the tested eye.

Although they did not use changes in threshold to indicate the differential effects of emotional versus neutral subliminal stimuli, Erdelyi and Appelbaum (1973) have shown related disruptions in processing which they named cognitive masking. They reported that the detectibility of eight neutral elements in a display presented once at 200 milliseconds was inhibited when the display included an emotional element in the ninth (centre) position. Detectibility in this experiment was measured by the number of elements remembered in recognition and forced recall procedures. Recognition scores were significantly higher for the subjects who were shown the display with nine neutral elements and no emotional elements.

Of particular interest to the present study because it involves cross-modal effects of subliminal verbal stimuli on a neutral visual stimulus presented above threshold is the work of Henley (1975). Henley modeled her experiment after one by Smith, Spence, and Klein (1959) in which the subliminal presentation of the words "happy" and "sad" influenced the subject's description of a neutral face as happy or sad. The 1975 experiment used a neutral face also, but this time the words "happy" and "sad" were delivered through earphones below the auditory threshold. Henley found that the material from the attended auditory channel was fully analyzed and integrated with the visual stimulus. Henley also reported that reaction times for hits (when the auditory cue was "happy" and the subject's response was "happy", etc.) were significantly shorter than for the responses which did not use the auditory cue.

The expectation adopted in Hardy and Legge's (1968) study that stimulation in one sensory channel should facilitate performance in another channel is in and of itself the topic of a sizable and sophisticated body of literature. While it is not the purpose of the present research to illuminate the intricacies of cross-modal stimulation, it is nevertheless relying on changes in threshold in one modality as a function of input in another for a dependent measure. It is necessary, therefore, to at least cite some relevant evidence for this expectation beyond the work of Symons (1963). Hershenson (1962), Morrell (1967), Berstein, Clark and Edelstein (1969), and Klayman (1973) have all reported cross-modal facilitation effects, focusing on the interstimulus interval (ISI) as an important factor in the effect at supraliminal levels of stimulation. Brebner (1970) carried out an experiment using simultaneous bisensory stimulation and found that it resulted in performance superior to unimodal stimulation. And in the allied field of human factors research, Colquhoun (1975) found that for sonar monitoring tasks, displays in both auditory and visual modes are superior to unimodal displays. Thus it may be stated that there is sufficient evidence to adopt Hardy and Legge's (1968) cross-modal methodology which rests on the assertion that stimulation from one sensory channel can affect threshold level in another channel.

Such an effect upon auditory threshold level was, therefore, the dependent measure of primary interest in the present research because it could serve as a demonstration of the differential influence of neutral and emotional material visually embedded and presented subliminally. While Hardy and Legge (1968) found that emotional stimuli resulted in lower auditory sensitivity than neutral stimuli, the direction of change was not a necessary part of this study's hypothesis. Because of inconsistencies in the literature (Dixon, 1971), it was felt that a significant difference in sensitivity levels would be sufficient evidence of registration of the embedded material. The use of signal detection, furthermore, affords investigation of response bias as well as sensitivity, an approach warranting further evaluation in subliminal research.

## Method

Subjects. Nineteen males and twenty-two females whose first or second language was English participated in the experiment. All of the subjects were recruited on the Loyola campus of Concordia University from undergraduate psychology courses or a subject volunteer list and were paid a nominal fee of $3.25 for their participation.

Apparatus. The selection of the visual stimuli for subliminal presentation was accomplished by two stages of testing conducted on the Sir George Williams campus of Concordia University in order to prevent information about the experiment spreading to the projected subject pool at Loyola.

The first stage involved the selection of four-letter words with demonstratable emotionality or neutrality for the college-aged population. Ten male and ten female volunteers were presented 12 emotional and 24 neutral words printed separately on white 4" x 6" cards for 5 seconds each. Reactions to the words were assessed with Galvanic Skin Responses (GSR) as recorded on a Marietta Apparatus Company GSR (Model 12-13R) with a Rustrack Recorder (Style 4232). (Refer to Appendix A1 for a more detailed description of the procedure.) Then subjects were asked to rate each word on a Rating Check List whose five-step scale ranged from neutral to highly emotional. Those words which most frequently caused a drop in skin resistance (Venables & Christie, 1973) and which also received the highest ratings for emotionality were selected as words for the emotional stimulus category. Those which caused the least frequent GSR changes <u>and</u> had the lowest ratings were selected for the neutral category. For males the emotional words selected were "cock", "rape", "suck", and "cunt"; the selected neutral words were "five", "soon", "knit", and "tone". For females the most emotionally potent words were "kill", "rape", "cunt", and "fuck"; the selected neutral words were "dial", "card", "role", and "walk". (See Appendix A2 for the GSR and Word Rating data for all 36 words.

The second stage of visual stimulus selection involved the evaluation of a method of embedding the stimulus words suggested by Metzger (1975) in which a word is disguised by placing its mirror image directly on top of the word. The result is a nonsense word made up of four nonsense letters. An example of an embedded word and its unembedded counterpart is shown in Figure 1 below.

Evaluation of this method was considered necessary to show a) that supraliminally the words were indeed hidden from a significant proportion of the college population, and b) that the hidden words were not so distorted that even with instruction no or more than one interpretation was possible.

To test these qualities 12 male and 12 female students were approached individually in the halls and cafeteria of the Hall Building and asked to participate in a brief experiment. The words selected in the first stage and embedded using the above method were printed on the same 4" x 6" cards and shown one by one for 5 seconds each. After each "design" was presented, subjects were asked to briefly describe what they had

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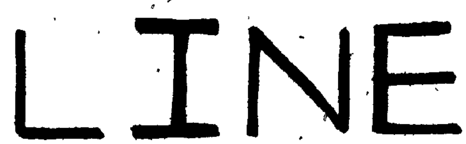



Unembedded Form

Figure 1: The word "line" in its embedded and unembedded forms

just seen. Very typical responses included "hieroglyphics" and "Greek-like" letters. After all 8 cards had been shown and described, subjects were instructed on how to locate the hidden words in the designs they had previously viewed. It was found that none of the 12 males or 12 females either spontaneously identified the embedded words or failed to find them once instructed.

For the actual experiment the words selected for each sex were printed black on white on the 4" x 6" tachistoscopic cards used previously. The designs were centered in the middle of the cards and measured 6 centimeters long and 1½ centimeters high. To ensure that the amount of light reflected from the 16 different designs for each sex was not significantly different, an EG & G Multiprobe (Model 550-2) with an EG & G Optikon photometer (Model 550-1) was used to measure light intensity in a tachistoscope channel with a presentation time of 1 second. Measurements ranged from $.84 \times 10^{-3}$ LUX to $1.10 \times 10^{-3}$ LUX. These very small differences were felt to attest to the highly similar physical parameters of the visual stimuli across the experimental conditions.

The stimulus cards were presented in a Ralph Gerbrands Company (Model T 3B-1) three-channel tachistoscope. Auditory stimuli were presented by a Maico Dual Channel Audiometer (Model MA 24B). The timing sequence of each trial including both visual and auditory events was automatically controlled by a Ralph Gerbrands six-channel Millisecond Timer (Model 300-6T).

Procedure. Subjects were run individually in one session which lasted around one hour. Those with eye glasses were asked to wear them for the experiment. The session was divided into four sections before each of which the subject received verbal instructions from the experimenter. (For the detailed instructions to the subjects for each section, refer to Appendices B1, B2, B3, and B4.)

In the initial stage of the experiment the subject received a brief description of the nature of the equipment used and was told that the study involved the evaluation of cross-modal stimulation on threshold levels and that more thorough information about the study would be given to the subjects after the research was completed.

The task of the first section was to determine the presentation time for the subliminal visual stimuli. The visual stimulus for this procedure was a design of four nonsense symbols similar in size and density to the words used in the main experimental trials. The series of events which the subjects were instructed to observe and report upon consisted of the following sequence. The beginning of each trial was marked by the appearance of a black fixation point in the centre of the illuminated field. The visual stimulus was timed to appear two seconds after the warning point. The disappearance of the point three seconds later signalled the end of the trial and the time for the subject's report of "no change", "flash", or "lines".

The duration time of the stimulus presentation for each subject was determined by starting at 1 millisecond, increasing it by 1 millisecond steps up to the point at which the subject reported "lines", and then locating the duration at which the subject reported only "flash". For each subject, therefore, the probability of detection of the visual stimuli approximated zero. This stringent standard for guaranteeing that the subliminal stimuli were indeed always subliminal was felt to offer better experimental control than that used by Hardy and Legge (1968) who set the probability of detection at 0.3. The average subliminal stimulus presentation time for males was 5.3 msec with a standard deviation of 2.6. For females the mean presentation time was 4.8 msec with a standard deviation of 1.6. (A t test for independent groups on the difference between mean presentation time for males and females was not significant ( $t = .733$, $p > .05$) ). No subject required more than 20 nor less than 13 trials.

At the same time that the subject was attending to the visual task he was also receiving 55 decibels of uninterrupted white noise presented binaurally through earphones connected to the audiometer. This was done to equate the conditions under which the visual stimuli were to be presented during the experimental trials.

The second part of the experiment concerned the setting of an auditory threshold with a probability of detection of 0.5 for each subject for a 1000 cycles-per-second tone superimposed over 55 decibels of white noise presented binaurally through earphones.

The auditory threshold was determined by using the staircase method (Dember & Warm, 1979). A series of 12 neutral English words were subliminally presented at the rate of one per trial at the duration determined in the previous trials of the experiment. The auditory signal occured 1.7 seconds after the subliminal visual stimulus, an interstimulus interval (ISI) suggested by pilot work and near Hardy and Legge's ISI of 1.5 seconds, the rationale being that time was required for the effect of the visual stimulus to take place. The subject was instructed to respond either "yes" or "no" to indicate whether or not he had heard the signal. The order of events in each trial is given in a diagram in Figure 2. The timing used in this section was used in the remainder of the experiment. Intertrial duration, when the subject's response was recorded and the next trial set up, was about 10 seconds.

For males the mean auditory threshold level, which was computed for each subject at the completion of 30 trials, was 25.8 decibels with a standard deviation of 2.2. For females it was 25.4 decibels with a standard deviation of 1.2. No significant statistical difference existed between the two groups ($\underline{t} = 1.29$, $p > .05$).

The third section of trials in the experiment was designed to give subjects practice with an alteration in the categories of response and with the signal detection paradigm in general. The use of four categories of response ( a "3" for absolute confidence, a "2" for some confidence, and a "1" for a 'hunch' that the signal was delivered, and a "0" for absolute

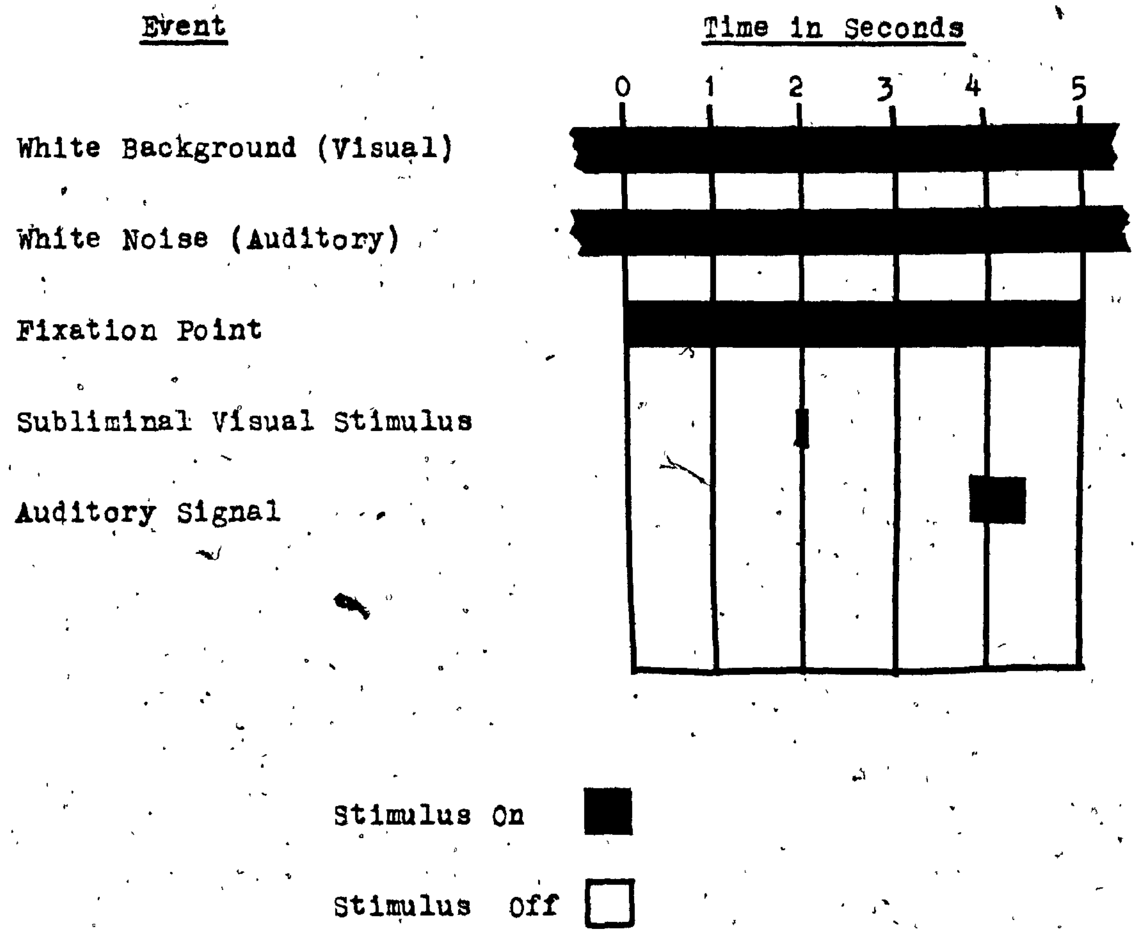



Figure 2: Diagram of the sequence of events in a trial with auditory signal

confidence that it was not delivered) rather than two (yes/no) categories was found in pilot investigations to be advisable in the light of some subjects' reticence to respond "yes" when less than 100% certain. It is also a technique well-established in signal detection research (Green & Swets, 1966). The visual subliminal stimuli were the same 12 neutral words used in the auditory threshold determination trials, each shown three times in a randomized order. The order of presentation for auditory signal occurence was also randomized; the probability of there being a signal present was set at 0.5, i.e. 18 of the 36 trials were without an auditory signal.

The final section of the experiment consisted of 96 trials run in blocks of 24 trials with an average rest period of 3 minutes between blocks. The instructions and procedure were exactly the same as for the 36 previous practice trials. The four blocks of trials represented the four conditions of visual subliminal stimulation: unembedded neutral (UN), embedded neutral (EN), unembedded emotional (UE), and embedded emotional (EE). The same neutral and emotional words for each sex in the unembedded conditions were used in the embedded conditions. Each block consisted of 16 trials with 4 appearances of each word, half with auditory signal and half without. The remaining 8 trials of the block of 24 contained no words, only blank tachistoscopic cards; half of these were presented with auditory signal, half without.

The order of visual subliminal stimuli (words and blanks) and auditory stimuli (signal present, signal absent) was randomized over the 24 trials for each block. The 24 possible orders of presentation for the blocks of trials (UN, EN, UE, and EE) were randomly assigned to subjects, a different order for each male and each female to control for any order effects.

The number of trials per experimental condition per subject was small compared to the usual signal detection experiment which typically involves a very small number of subjects who are given hundreds of trials per condition (Green & Swets, 1966). Two considerations argued for running the experiment as described. First, it was considered important to test a large number of subjects in order to ascertain if in general embedded subliminal visual stimulation could have differential effects on auditory sensitivity. Data from a small number of subjects could not be easily generalized to the population. Secondly, it was felt that many repeated trials of the emotional content might have a neutralizing effect, i.e. accomodation to the words might serve to dilute any initial shock value.

After the completion of the four blocks of trials, each subject was then tested on all of the eight embedded words to which he had been subliminally exposed. These "designs" were presented tachistoscopically one at a time for a duration of 5 seconds. After each exposure the subject was asked to describe what he had just seen. Six subjects who were able to identify at least one hidden word were excluded from the final sample of subjects.

At the end of the session subjects were asked not to divulge any details about the experiment to other students. Post experimental interviews found that no subject was aware of the subliminal nature of the study.

## Results

The dependent measures of sensitivity and response bias which result from a signal detection experiment were not calculated in this instance by the usual values d' and Beta. These measures rely on the assumption that the signal and noise distributions are Gaussian in nature. Two reasons argued against the use of d' and Beta in the present study: a) the cross-modal nature of the experiment with its complex arrangment of noise and signal patterns; and b) the small number of trials given per condition per subject. This latter situation frequently occurs when signal detection is applied to such fields as pain research (Lloyd & Appel, 1976; McCreery & Bloedel, 1978), gustatory research (Fergenson, Moss, Dzendolet, Sawyer, & Moore, 1975), and psychosocial questions (Quanty, Keats, & Harkins, 1975) where large numbers of trials are contraindicated. In such situations it has become accepted practice to use nonparametric measures of sensitivity and bias such as those proposed by Pollack and Norman (1964) and Hodos (1970). These measures are based on the unit square which plots the proportion of false alarms along the abscissa and the proportion of hits along the ordinate. As described by Grier (1971) who offered calculational formulas for the two measures, the sensitivity measure A' varies from 0 to +1.00, with 0 representing least sensitivity and +1.00 representing greatest sensitivity. The response bias value B'' varies from -1.00 to +1.00 with the former value representing extreme liberality in guessing and latter value representing extreme conservatism.

Because the two groups of subjects, males and females, were found to require different lists of words as neutral and emotional stimuli, the data description and analyses were carried out separately for the two sexes with the exception of one analysis which will be discussed later.

In preparing the subjects' responses for statistical analysis, responses of "3", "2", and "1" were collapsed into one "yes" category and "0" responses were placed in the "no" category. Data from the four different words in each category of subliminal visual stimulation (UN, EN, UE, EE) were pooled and used to calculate hit rates and false alarm rates for each category. Thus the hit rates and false alarm rates given for each subject for each condition are calculated from 8 trials with auditory signal and 8 trials without signal. (The data for males and females are given in Appendices C1 and D1 respectively, and the corresponding conversions to A' and B'' in C2, C3 and D2, D3.)

Data from the 19 male subjects will be discussed first. The results of the auditory detection trials for all four conditions of subliminal visual stimulation are provided in Figure 3 by means of the standard signal detection unit square which plots the proportion of false alarms with the proportion of hits averaged over all of the subjects. The close clustering of the four points indicates that there is little difference in performance on the auditory detection task as

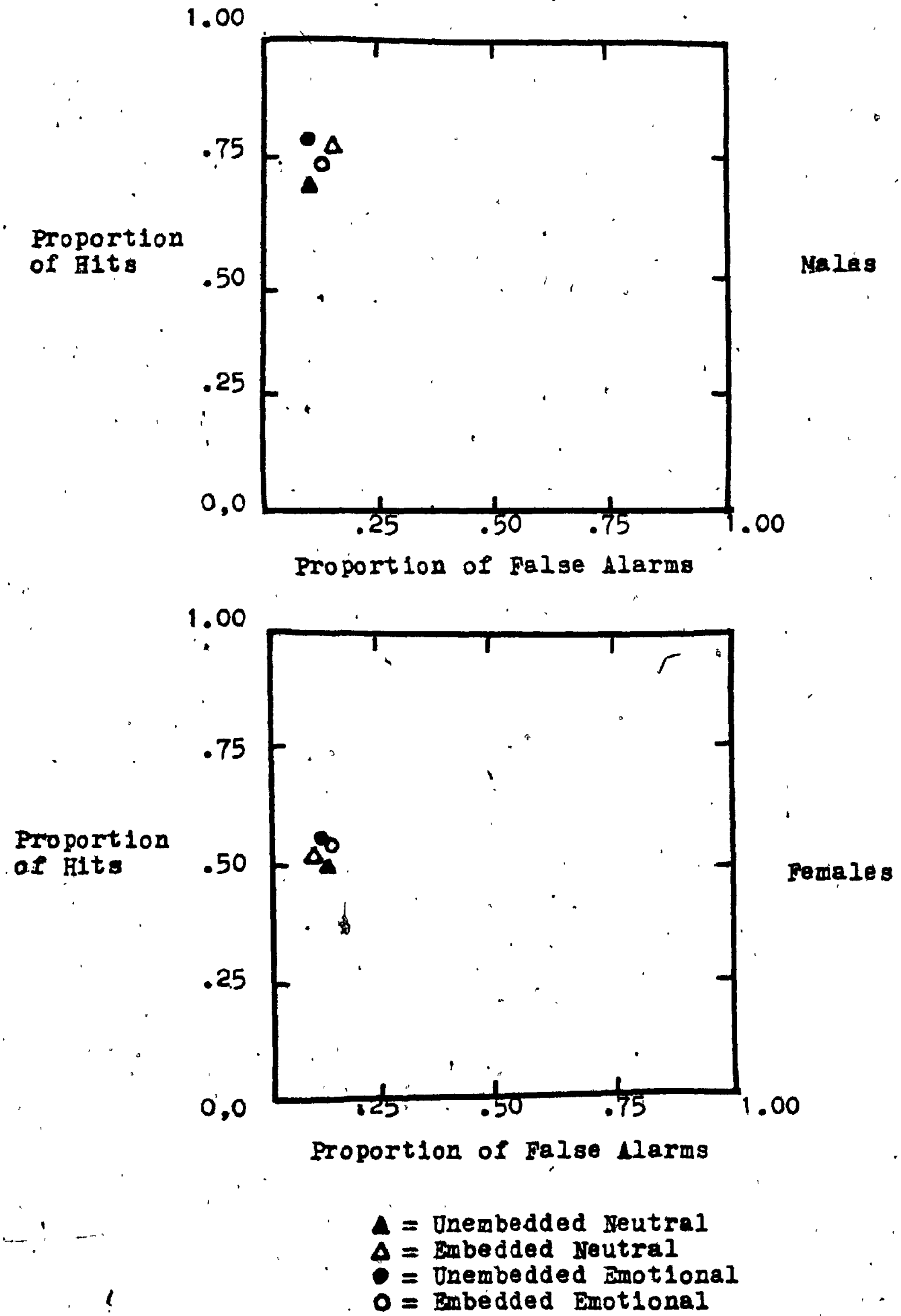



Figure 3: Isosensitivity functions for male and female subjects as a function of the four conditions of subliminal visual stimulation

function of the four conditions of subliminal stimulation.

Statistical tests were conducted on these data by means of two 2 x 2 analyses of variance for repeated measures, one for the sensitivity measure A' and one for the response bias measure B''. As suggested by Kirk (1968) for variables whose values range from 0 to 1.00, A' values were transformed into their arcsin equivalents, and B'' values were linearly transformed by adding +2.0 in order to eliminate minus signs. Figure 4 graphically depicts the mean transformed A' and B'' scores for males on the UN, EN, UE, and EE conditions. As can be seen from the proximity of the data points and the length of the error bars (calculated from the standard error of the mean), there are only marginal differences in auditory performance as a function of the subliminal visual stimuli. Summary tables for the analyses of variance on the A' and B'' measures are provided in Table 1. For both measures neither the emotionality factor (emotional versus neutral) nor the embeddedness factor (embedded versus unembedded) nor an interaction of the two factors resulted in any significant differences in auditory performance for the male subjects.

Identical treatment of the data was carried out for the 22 female subjects. Figure 3 provides the isosensitivity functions for the proportions of hits and false alarms averaged over all subjects as a function of the four conditions of subliminal visual stimulation. As in males, the close proximity of the data points indicates little difference in performance between the four experimental conditions. Figure 5

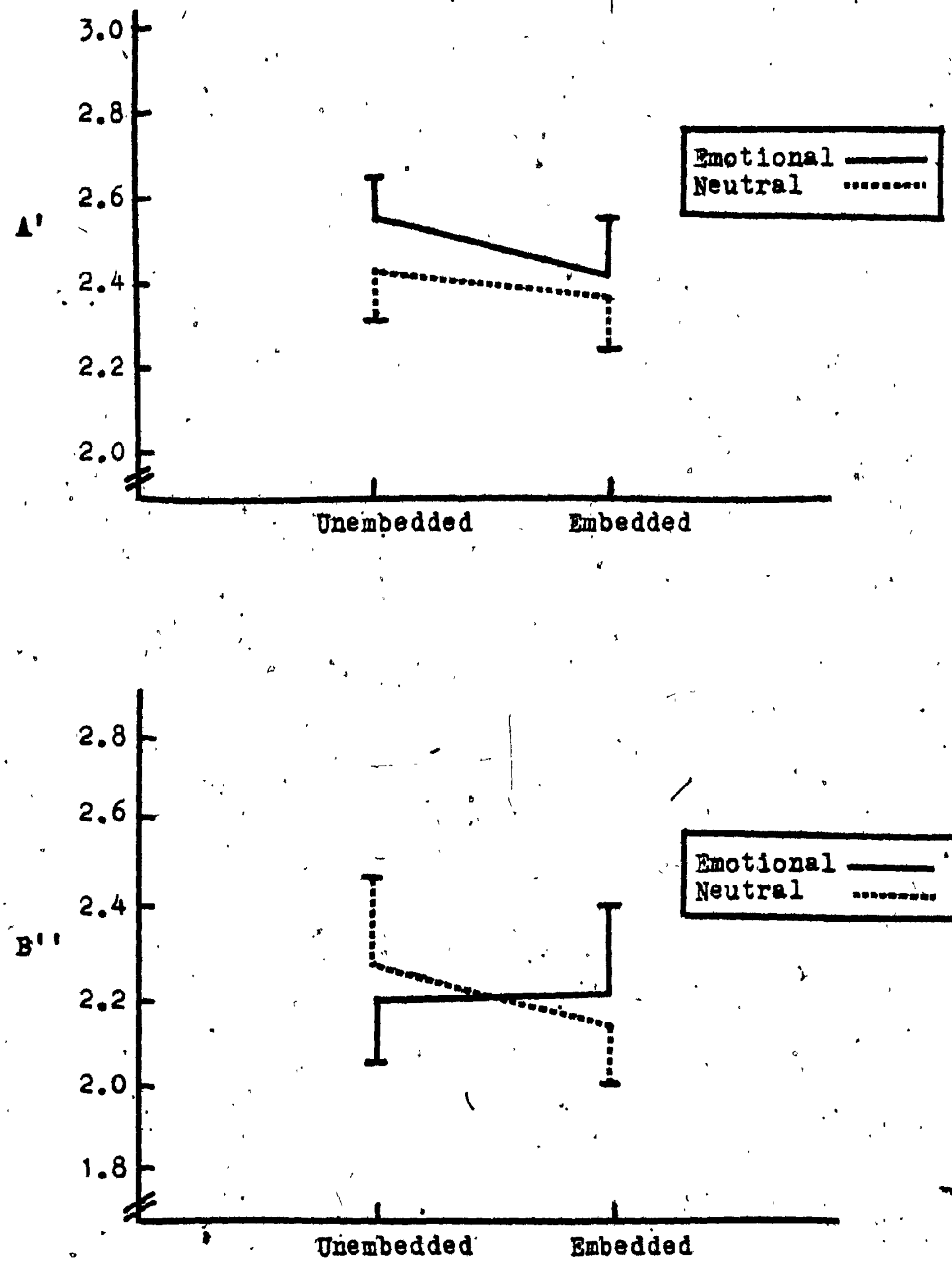



Figure 4: Mean transformed A' and B'' values as a function of emotionality and embeddedness of subliminal visual stimuli in males. Each error bar equals one half of the standard error of the mean.

Table 1

Analyses of Variance: A' and B'' for Males

| Source | df | SS | MS | F | p |
|---|---|---|---|---|---|
| A' | | | | | |
| Emotionality (A) | 1 | .141 | .141 | 1.94 | .18 |
| Error A | 18 | 1.309 | .073 | | |
| Embeddedness (B) | 1 | .219 | .219 | 1.72 | .21 |
| Error B | 18 | 2.295 | .128 | | |
| A x B | 1 | .027 | .027 | .97 | .34 |
| Error A x B | 18 | .511 | .028 | | |
| Error within subjects | 18 | 9.467 | .526 | | |
| B'' | | | | | |
| Emotionality (A) | 1 | .013 | .013 | .19 | .67 |
| Error A | 18 | 1.271 | .071 | | |
| Embeddedness (B) | 1 | .119 | .119 | .20 | .66 |
| Error B | 18 | 10.616 | .590 | | |
| A x B | 1 | .034 | .034 | .19 | .67 |
| Error A x B | 18 | 3.364 | .187 | | |
| Error within subjects | 18 | 22.230 | 1.235 | | |

*Note.* In these and all subsequent tables the terms "Error __" and "Error __ x __" refers to the factor x subject variation.

shows graphs of the transformed auditory A' and B'' values averaged over all female subjects for the four conditions of subliminal visual stimulation. As in males, differences in performance are small and easily accounted for by the error bars. Two 2 x 2 analyses of variance were carried out on the transformed A' and B'' values. The summary tables for these analyses are given in Table 2. Neither of the main factors of emotionality and embeddedness nor an interaction of the two caused significant differences in sensitivity or response bias on the auditory detection task.

Of secondary interest in the experiment was the group of 8 trials within each of the four main blocks of trials (UN, EN, UE, EE) in which no word was presented subliminally, i.e. a blank white card was shown instead. Four of these trials were presented with the auditory signal and four were presented without. These trials were inserted into the blocks with a two-fold purpose: a) to afford a base rate comparison of no visual content versus visual content, and b) to afford the opportunity of looking for any effects of the four kinds of words carrying over to subsequent trials, i.e. a context effect on the blank trials.

The design used to assess the base rate question was a repeated measures 4 x 2 analysis of variance of the auditory hit rates and false alarm rates on blank trials within the four experimental conditions for each subject. (See Appendix E1 for the males' hit rates and false alarm rates on the blank trials and Appendices E2 and E3 for their conversions

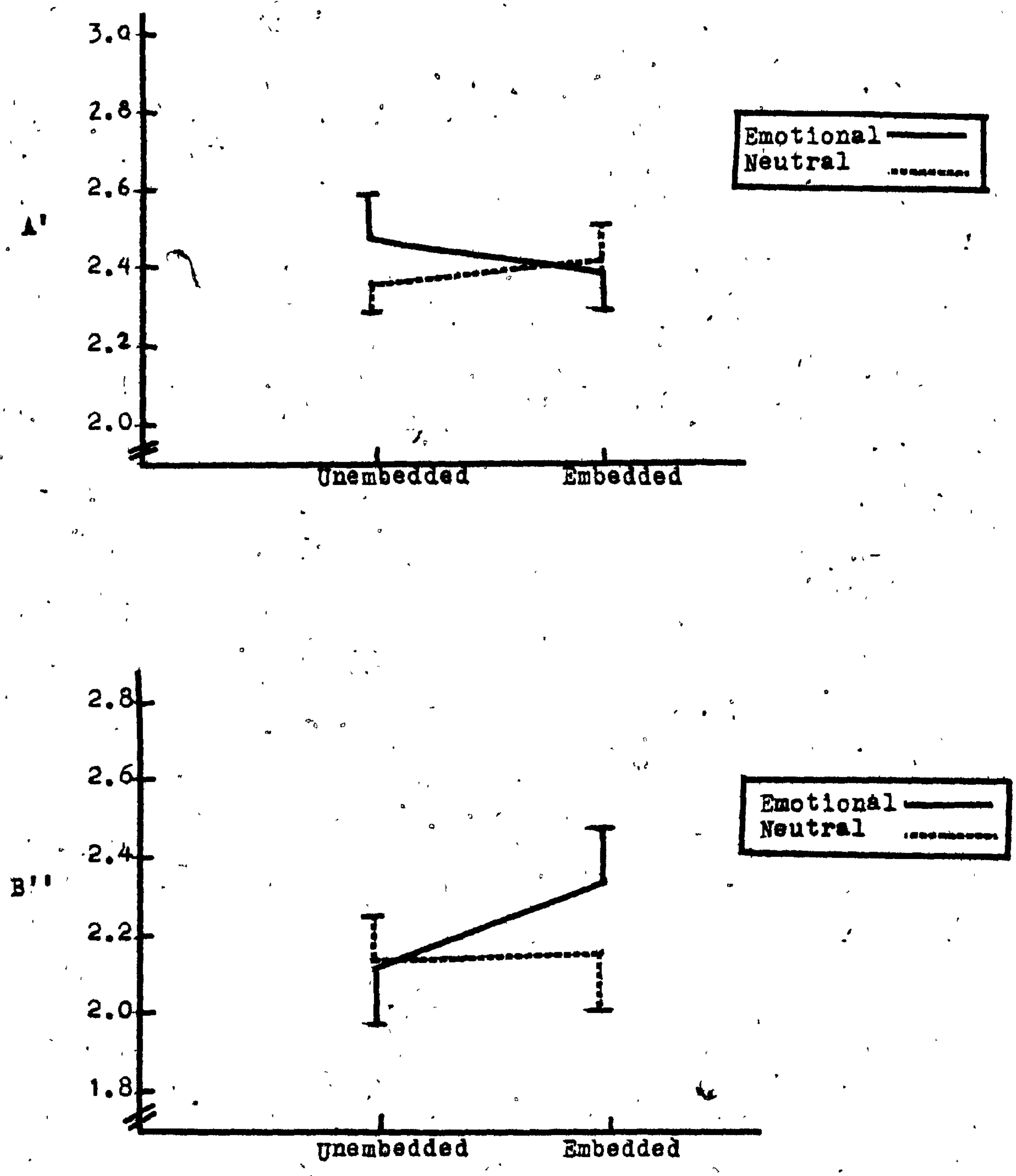



Figure 5: Mean transformed A' and B'' values as a function of emotionality and embeddedness of subliminal visual stimuli in females. Each error bar equals one half of the standard error of the mean.

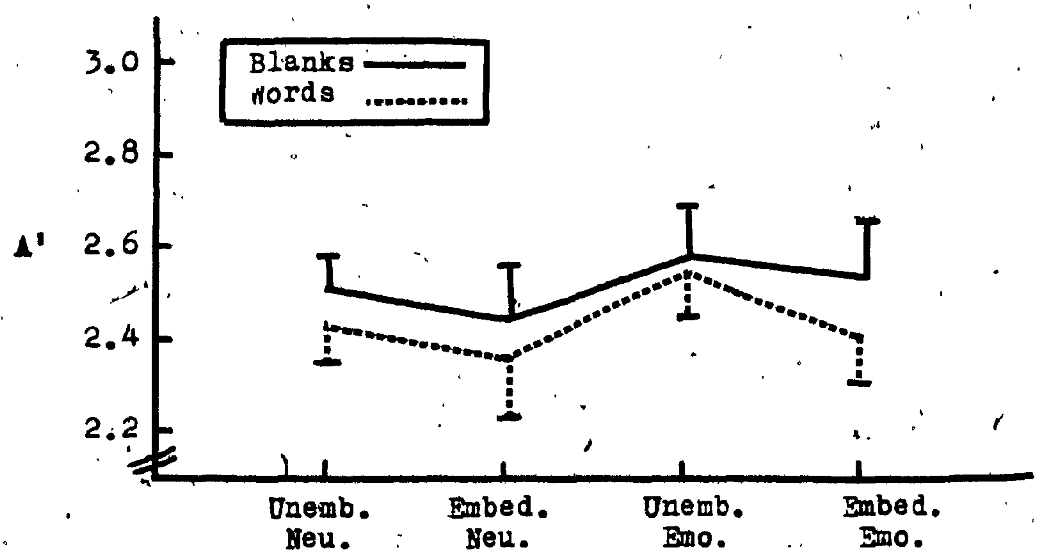
Table 2

Analysis of Variance : A' and B'' for Females

| Source | df. | SS | MS | F | p |
|---|---|---|---|---|---|
| A' | | | | | |
| Emotionality (A) | 1 | .056 | .056 | .56 | .46 |
| Error A | 21 | 2.109 | .100 | | |
| Embeddedness (B) | 1 | .003 | .003 | .002 | .99 |
| Error B | 21 | 3.727 | .177 | | |
| A x B | 1 | .090 | .090 | .86 | .36 |
| Error A x B | 21 | 2.192 | .104 | | |
| Error within subjects | 21 | 7.972 | .380 | | |
| B'' | | | | | |
| Emotionality (A) | 1 | .142 | .142 | .83 | .37 |
| Error A | 21 | 3.582 | .171 | | |
| Embeddedness (B) | 1 | .319 | .319 | .80 | .38 |
| Error B | 21 | 8.410 | .400 | | |
| A x B | 1 | .241 | .241 | .70 | .41 |
| Error A x B | 21 | 7.260 | .346 | | |
| Error within subjects | 21 | 20.650 | .983 | | |

into A' and B'' values respectively. The averages of the transformed A' and B'' values are presented in graphic form in Figure 6. Again there appears to be little difference in auditory sensitivity between the four categories of subliminal stimulation. However, the B'' values show greater variability between the worded and blank trials, particularly in the embedded categories. On the blank trials there is a rise in the subjects' conservatism in responding. The analyses of variance performed on the transformed A' and B'' values are given in Table 4. No significant differences in the A' values were found for either main factor or for an interaction of the factors. The B'' analysis also yielded no acceptable level of significance, but the Type factor (blank versus worded trials) approached significance with $p = .06$.

An identical analysis of the base rate comparison was carried out for the female subjects. Auditory hit rates and false alarm rates for each subject on the blank trials are shown within the four blocks of subliminal visual stimulation in Appendix F1; conversions into A' and B'' values are given in Appendices F2 and F3 respectively. Mean transformed A' and B'' values for females are graphed in Figure 7. The upper graph on the page reveals some difference between the blank and worded trials on the two neutral categories for auditory sensitivity. More variability is evident across the categories of subliminal visual stimulation in the B'' values with the greatest increase in conservatism for blank trials in the unembedded emotional block. Two 4 x 2 repeated measures



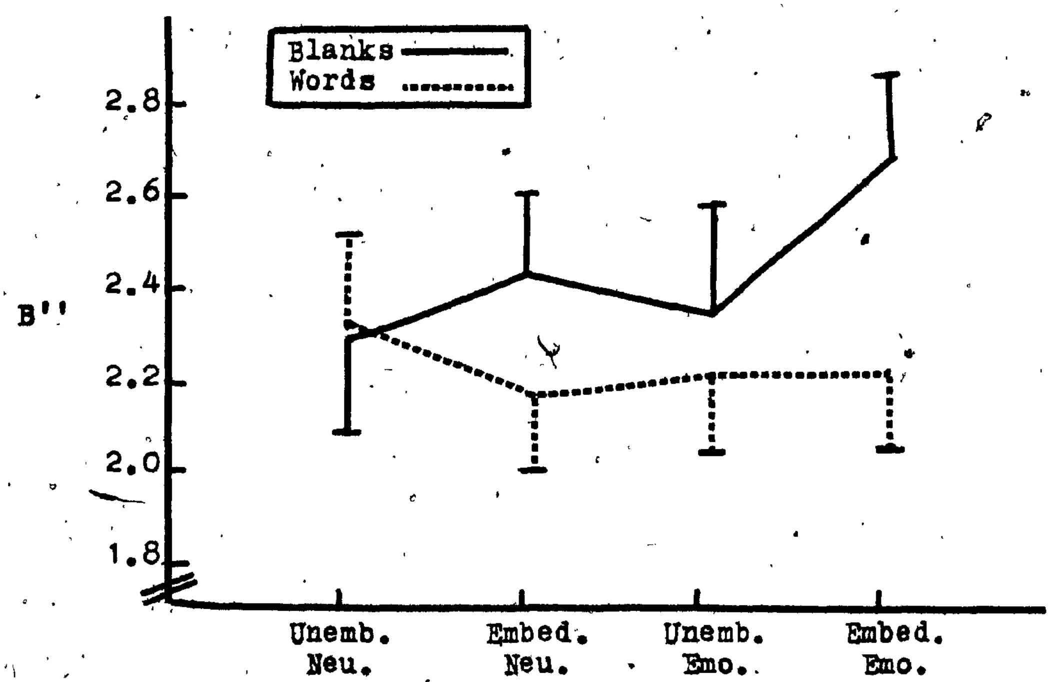




Figure 6: Mean transformed A' and B'' values for males as a function of trials with blanks vs trials with words, both within blocks of the four conditions of subliminal visual stimulation. Each error bar equals one half of the standard error of the mean.

Table 3

Analyses of Variance: Comparisons of Auditory A' and B'' Values for Male Subjects as a Function of Blocks of Trials (UN, EN, EU, EE) and Type of Trial (Words or Blanks)

| | Source | df | SS | MS | F | p |
|---|---|---|---|---|---|---|
| A' | | | | | | |
| | Blocks (B) | 3 | .518 | .173 | 1.15 | .34 |
| | Error B | 54 | 8.117 | .150 | | |
| | Type (T) | 1 | .207 | .207 | 1.25 | .28 |
| | Error T | 18 | 2.979 | .166 | | |
| | B x T | 3 | .059 | .020 | .20 | .89 |
| | Error B x T | 54 | 5.195 | .096 | | |
| | Error within subjects | 18 | 15.351 | .853 | | |
| B'' | Blocks (B) | 3 | .638 | .213 | .59 | .63 |
| | Error B | 54 | 19.644 | .365 | | |
| | Type (T) | 1 | 1.655 | 1.655 | 4.01 | .06 |
| | Error T | 18 | 7.435 | .413 | | |
| | B X T | 3 | 1.187 | .396 | 1.32 | .28 |
| | Error B X T | 54 | 16.199 | .300 | | |
| | Error within subjects | 18 | 32.507 | 1.806 | | |

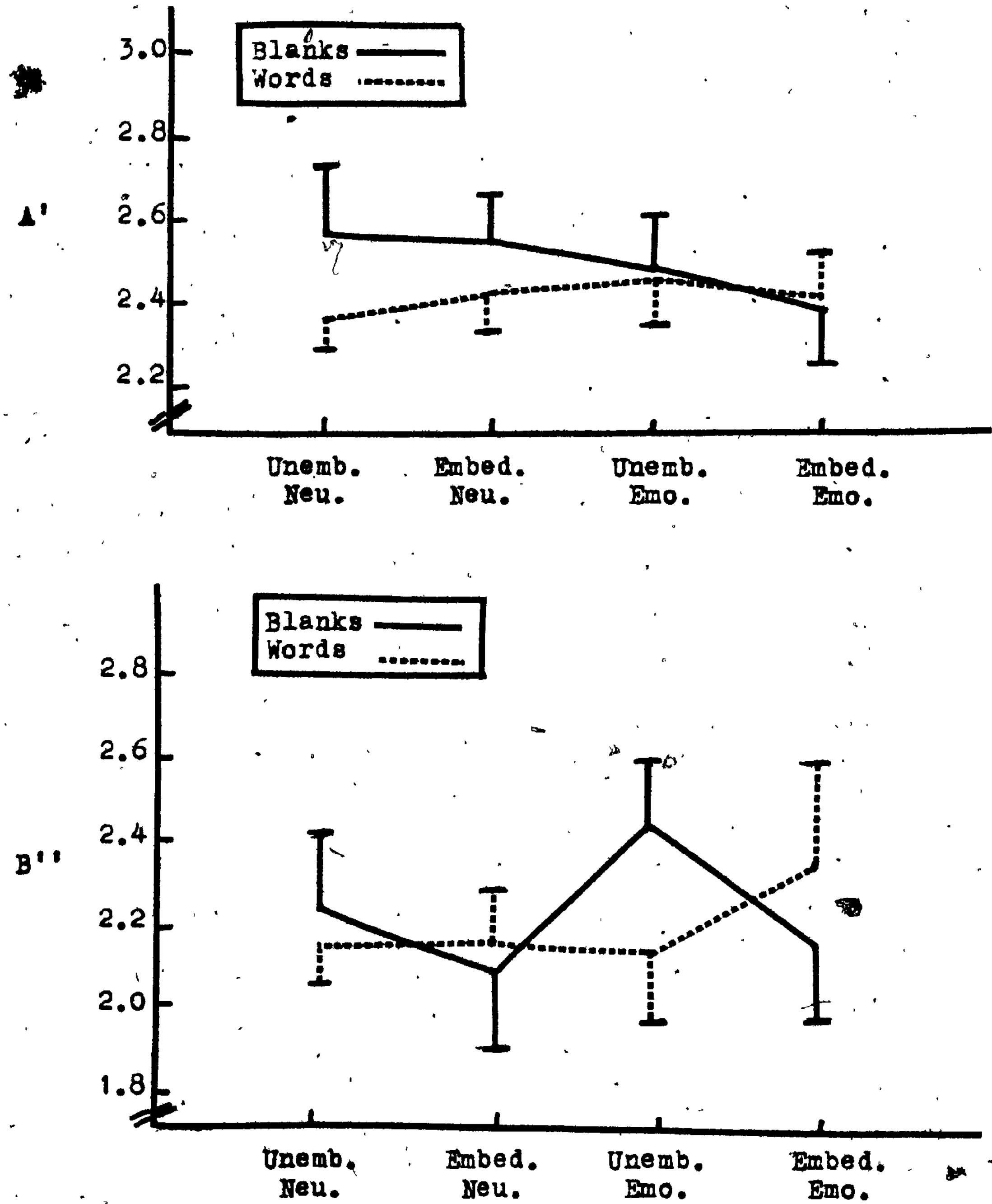



Figure 7: Mean transformed A' and B'' values for females as a function of trials with blanks vs trials with words, both within blocks of the four conditions of subliminal visual stimulation. Each error bar equals one half of the standard error of the mean.

analyses of variance were performed, and the results are summarized in Table 4. No significant differences were found to exist for either main factor or an interaction of the factors in the auditory sensitivity or response bias measures.

Given the lack of any significant results from the above analyses, it was decided that further examination of the data might be a useful step toward illuminating possible reasons for these findings. One such examination proved particularly useful.

It was observed that on the 36 practice trials administered after the visual and auditory determination tasks and before the four blocks of experimental trials there was a considerable range in subject reaction to the signal detection paradigm. The staircase method was used to locate a 50% probability level of detection, but performance on the practice trials did not reflect this prediction. As can be seen in Appendix G for males and Appendix H for females, hit rates ranged from .444 to 1.000 and .556 to 1.000 respectively. Given the assumption that the subliminal visual stimuli might only be able to affect auditory performance when the task was more ambiguous (Engen, 1971), it was decided to select those subjects who performed least well on the practice trials for separate analysis. Selection was not carried out on the basis of hit rates, however. A' scores were used instead as the criterion since these also take into account the subject's willingness to guess (Grier, 1971).

Appendix G for males and Appendix H for females list the

Table 4

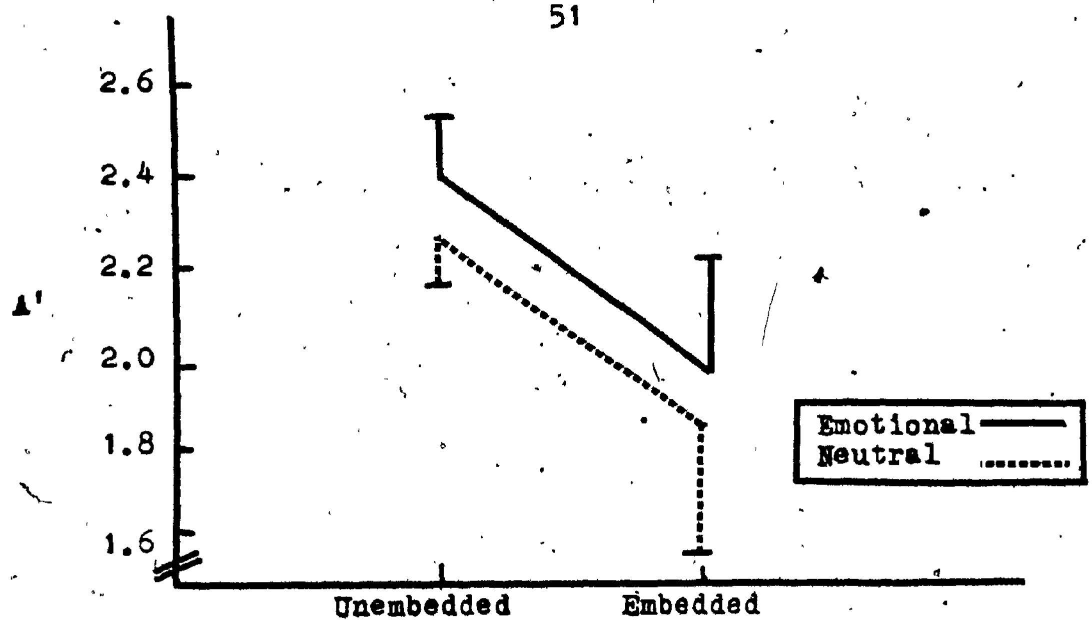
Analyses of Variance: Comparisons of Auditory A' and B'' Values for Female Subjects as a Function of Blocks of Trials (UN, EN, EU, EE) and Type of Trial (Words or Blanks)

| | Source | df | SS | MS | F | p |
|---|---|---|---|---|---|---|
| A' | | | | | | |
| | Blocks (B) | 3 | .214 | .071 | .36 | .78 |
| | Error B | 63 | 12.407 | .197 | | |
| | Type (T) | 1 | .286 | .286 | 1.55 | .23 |
| | Error T | 21 | 3.879 | .185 | | |
| | B x T | 3 | .364 | .121 | 1.178 | .33 |
| | Error B x T | 63 | 6.491 | .103 | | |
| | Error within subjects | 21 | 15.037 | .716 | | |
| B'' | | | | | | |
| | Blocks (B) | 3 | .496 | .165 | .37 | .78 |
| | Error B | 63 | 28.399 | .451 | | |
| | Type (T) | 1 | .031 | .031 | .05 | .82 |
| | Error T | 21 | 12.372 | .589 | | |
| | B x T | 3 | 1.535 | .512 | 1.11 | .35 |
| | Error B x T | 63 | 29.166 | .463 | | |
| | Error within subjects | 21 | 28.102 | 1.338 | | |

ranks of these A' values for each subject. Data from the six males who fell in the lowest third of their ranks and from the seven females who fell in the lowest third of their ranks were selected for statistical analyses identical to the main body of subjects described above. The A' and B'' values computed on the four conditions of subliminal visual stimulation for this subgroup of subjects are available for males in Appendix I and for females in Appendix J.

Graphic displays of the male subgroup's mean transformed A' and B'' values for the two levels of emotionality and embeddedness are shown in Figure 8. A steep drop in auditory sensitivity is seen for both the emotional and neutral stimuli with the unembedded category revealing higher A's than the embedded category. The greater sensitivity found in the emotional categories is remarkable in its consistency but not in its size. In the B'' values there is a similar decline in scores from the unembedded category to the embedded category, meaning that the subjects appeared to become more liberal in their guessing. Differences on the emotional/neutral comparison are not as consistent, however, with the appearance of a slight interaction effect.

Two 2 x 2 analyses of variance were carried out on the data from the male subjects; the summary tables are available in Table 5. The A' analysis revealed a nearly significant main effect ($p$ = .07) for the embeddedness factor but not for the emotionality factor or an interaction of the two. The B'' analysis showed a parallel but weaker trend ($p$ = .10)



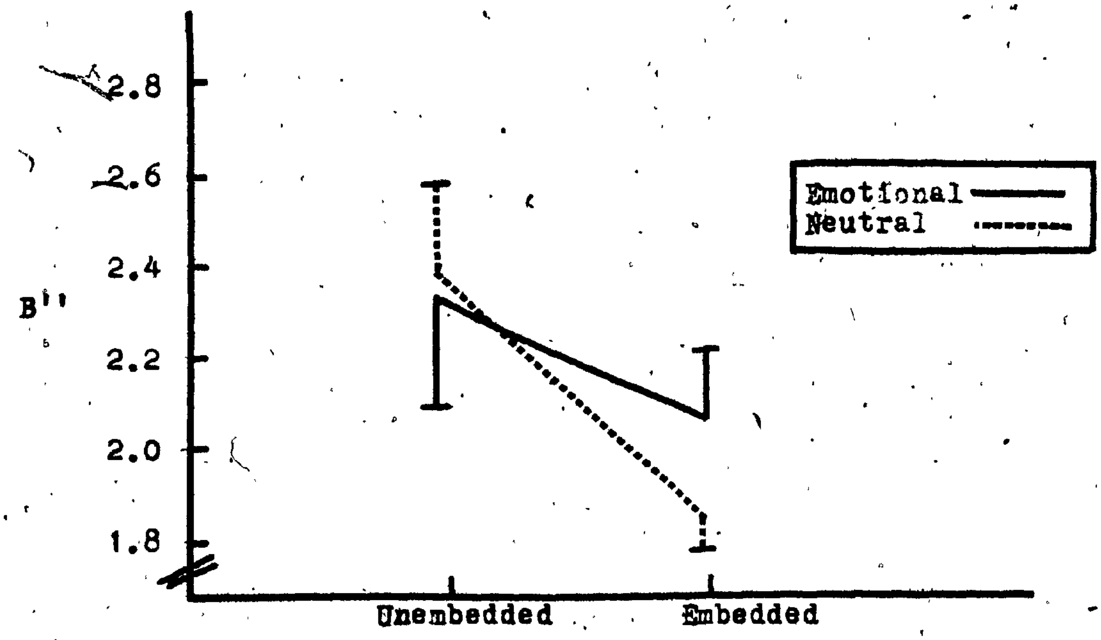




Figure 8: Mean transformed A' and B'' values as a function of emotionality and embeddedness of subliminal visual stimuli in the six males with the lowest sensitivity on the practice trials. Each error bar equals one half of the standard error of the mean.

Table 5

Analyses of Variance: Comparisons of A' and B'' as a Function of Emotionality and Embeddedness of Subliminal Visual Stimulation in the Six Males with the Lowest Sensitivity on the Practice Trials

| Source | df | SS | MS | F | p |
|---|---|---|---|---|---|
| A' | | | | | |
| Emotionality (A) | 1 | .097 | .097 | 2.55 | .17 |
| Error A | 5 | .191 | .038 | | |
| Embeddedness (B) | 1 | 1.078 | 1.078 | 5.32 | .07 |
| Error B | 5 | 1.013 | .203 | | |
| A x B | 1 | 00 | 00 | 00 | .99 |
| Error A x B | 5 | .222 | .444 | | |
| Error within subjects | 5 | 2.799 | .560 | | |
| B'' | | | | | |
| Emotionality (A) | 1 | .099 | .099 | .91 | .38 |
| Error A | 5 | .544 | .109 | | |
| Embeddedness | 1 | 1.045 | 1.045 | 4.12 | .10 |
| Error B | 5 | 1.268 | .254 | | |
| A x B | 1 | .006 | .006 | .07 | .81 |
| Error A x B | 5 | .463 | .093 | | |
| Error within subjects | 5 | 1.116 | .223 | | |

in the main effect for the same factor with no other significant effects.

Identical analyses were carried out on the data from the seven female subjects with the lowest sensitivity on the practice trials. The graphs in Figure 9 show the mean transformed auditory A' and B'' values for the four experimental conditions. In the A' scores there appears to be consistently higher sensitivity on the neutral words over the emotional words. Embeddedness has no effect on the neutral words, however, but does seem to cause a drop in sensitivity in the emotional embedded category. The data on B'' measures reveal a slight trend towards more conservative responses on both the neutral and emotional embedded categories.

Two 2 x 2 analyses of variance were carried out for the female subjects' A' and B'' transformed scores; the summary tables are available in Table 6. Again there is a trend in the A' main effect ($p = .08$), not in the embeddedness factor as in the male subjects' analysis, but this time in the emotionality factor. The analysis of variance of the B'' values revealed no significant effect.

The preceding statistical analyses showing nearly significant effects in embeddedness in males and emotionality in females prompted a further examination of sex differences in the subgroups' reactions to the subliminal visual stimulation. Because different emotional and neutral words were used for male and female subjects, it may be argued that any analysis of sex differences is confounded. However, it may also be

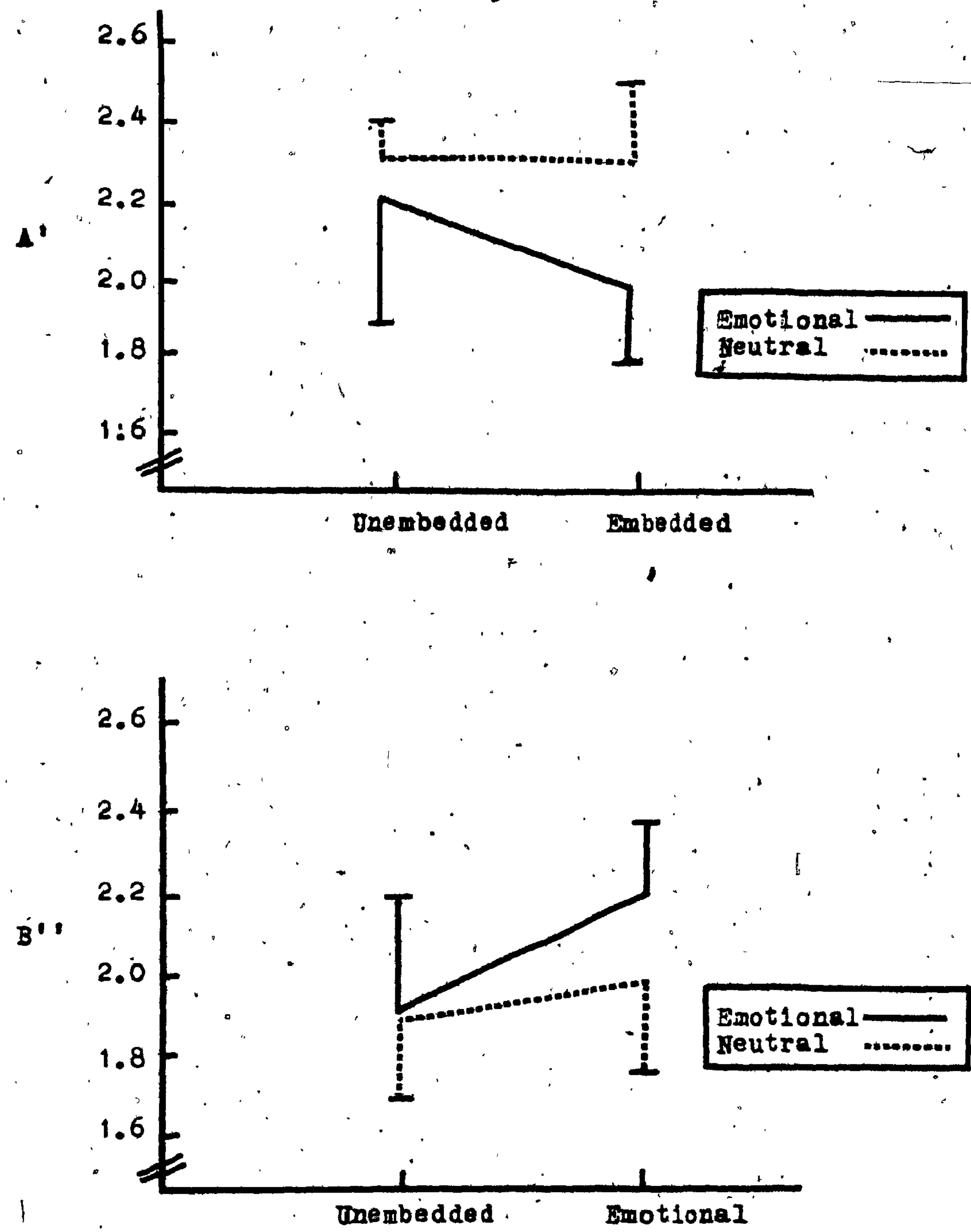



Figure 9: Mean transformed A' and B'' values as a function of emotionality and embeddedness in the seven females with the lowest sensitivity on the practice trials. Each error bar equals one half of the standard error of the mean.

Table 6

Analyses of Variance: Comparisons of A' and B'' as a Function of Emotionality and Embeddedness of Subliminal Visual Stimulation in the Seven Females with the Lowest Sensitivity on the Practice Trials

| Source | df | SS | MS | F | p |
|---|---|---|---|---|---|
| A' | | | | | |
| Emotionality (A) | 1 | .316 | .316 | 4.29 | .08 |
| Error A | 6 | .441 | .074 | | |
| Embeddedness (B) | 1 | .089 | .089 | .17 | .70 |
| Error B | 6 | 3.182 | .530 | | |
| A x B | 1 | .100 | .100 | .47 | .52 |
| Error A x B | 6 | 1.291 | .215 | | |
| Error within subjects | 6 | 3.177 | .530 | | |
| B'' | | | | | |
| Emotionality (A) | 1 | .049 | .049 | .50 | .51 |
| Error A | 6 | .586 | .098 | | |
| Embeddedness (B) | 1 | .239 | .239 | .66 | .45 |
| Error B | 6 | 2.186 | .364 | | |
| A x B | 1 | .041 | .041 | .26 | .63 |
| Error A x B | 6 | .952 | .159 | | |
| Error within subjects | 6 | 4.133 | .689 | | |

argued that the words selected may be different but equivalent for each sex since such factors as word length, size, and amount of light reflection were equated. Moreover, the selection procedure involving GSR and word ratings helped to assure the emotional equivalence of the words for each sex. It was felt, therefore, that these arguments were strong enough to allow comparisons of sex differences within the same design.

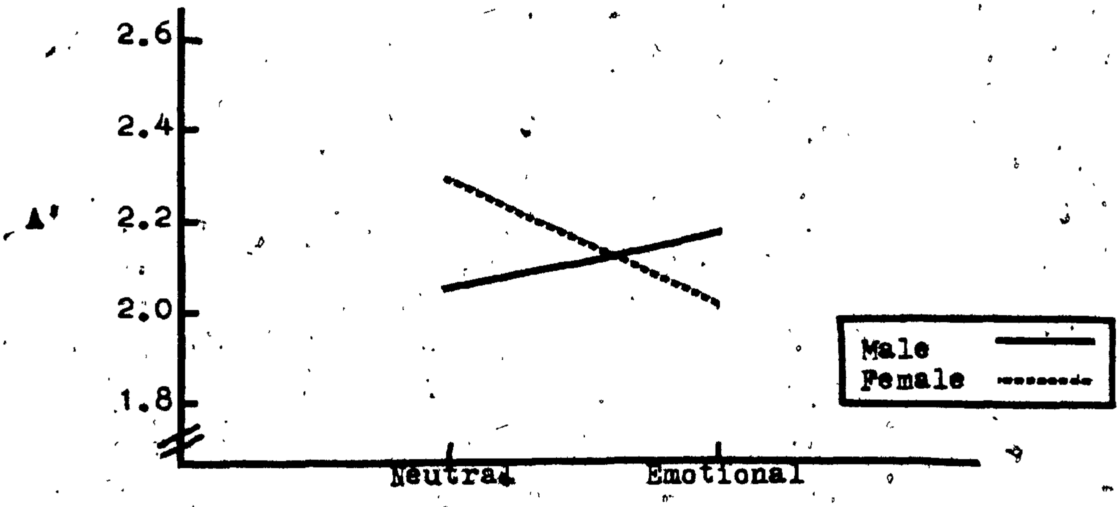
A 2 x 2 x 2 (sex x emotionality x embeddedness ) analysis of variance was carried out for each auditory detection measure. Since these analyses in effect combined the data previously displayed in Figures 8 and 9, they will not be graphically recombined. The two summary tables are shown in Table 7. A clearly significant ($p = .03$) interaction was found for sex and emotionality in the A' analysis. With the embeddedness factor collapsed, it can be seen in Figure 10 how for males auditory sensitivity is greater for the emotional stimuli than for the neutral stimuli, while for females the opposite takes place -- greater sensitivity occurs in the neutral category. The B'' measure yielded a suggestive interaction between the sex and embeddedness factors, though it fell short of significance ($p = .08$). This interaction is also graphed in Figure 10. With the data collapsed across emotionality, it becomes evident that males become increasingly liberal with the embedded words while females become increasingly conservative.

No significant or suggestive differences (all $p$'s $> .10$) were found in the 4 x 2 analyses of variance carried out to

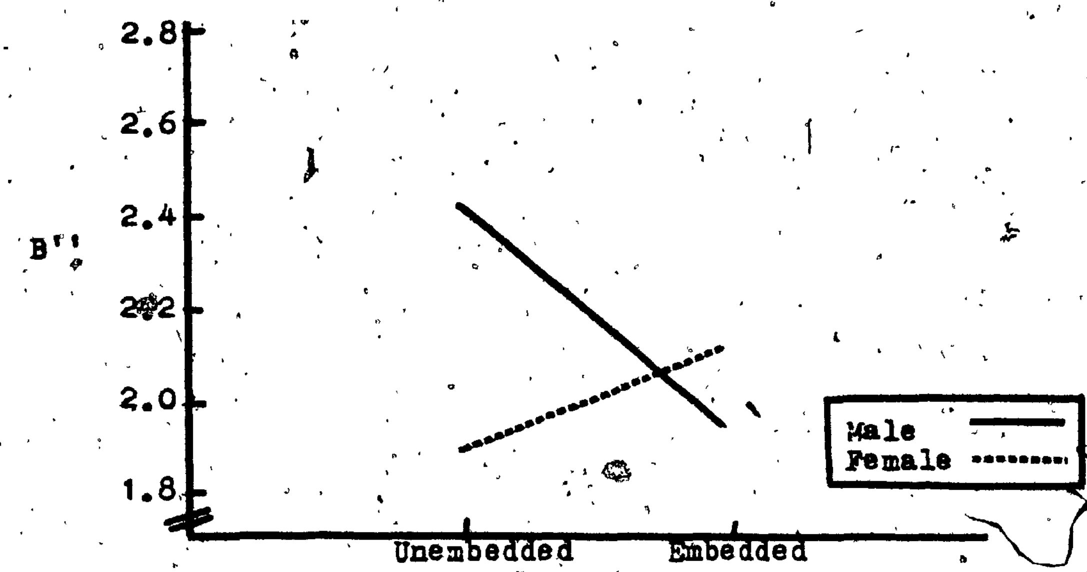
Table 7

Analyses of Variance: Comparisons of A' and B'' on Three Factors -- Sex, Emotionality, and Embeddedness, in Subjects with the Lowest Sensitivity on the Practice Trials

| Source | df | SS | MS | F | p |
|---|---|---|---|---|---|
| A' | | | | | |
| Sex (A) | 1 | .031 | .031 | .06 | .81 |
| Error A | 11 | 5.976 | .543 | | |
| Emotionality (B) | 1 | .040 | .040 | .70 | .42 |
| A x B | 1 | .373 | .373 | 6.49 | .03* |
| Error B | 11 | .632 | .057 | | |
| Embeddedness (C) | 1 | .855 | .855 | 2.24 | .16 |
| A x C | 1 | .312 | .312 | .82 | .38 |
| Error C | 11 | 4.195 | .381 | | |
| B x C | 1 | .055 | .055 | .40 | .54 |
| A x B x C | 1 | .046 | .046 | .33 | .58 |
| Error B x C | 11 | 1.513 | .138 | | |
| B'' | | | | | |
| Sex (A) | 1 | .281 | .281 | .59 | .46 |
| Error A | 11 | 5.249 | .477 | | |
| Emotionality (b) | 1 | .142 | .142 | 1.38 | .27 |
| A x B | 1 | .007 | .007 | .06 | .81 |
| Error B | 11 | 1.131 | .103 | | |
| Embeddedness (C) | 1 | .113 | .113 | .36 | .56 |
| A x C | 1 | 1.172 | 1.172 | 3.73 | .08 |
| Error C | 11 | 3.454 | .314 | | |
| B x C | 1 | .041 | .041 | .32 | .59 |
| A x B x C | 1 | .006 | .006 | .05 | .83 |
| Error B x C | 11 | 1.415 | .129 | | |




Significant interaction ($p$ = .03) of sex by emotionality collapsed across embeddedness for auditory A'




Interaction ($p$ = .08) of sex by embeddedness collapsed across emotionality for auditory B''

Figure 10: Graphic depictions of two interaction effects concerning sex differences

compare auditory detection performance on the blank trials versus the worded trials in either of the subgroups. The data for males are graphed in Figure 11 and the results of the analyses of variance for A' and B'' are presented in Table 8. The data for females are graphed in Figure 12, and the summary tables are presented in Table 9. These separate analyses carried out on the subgroups of subjects who showed least auditory sensitivity on the practice trials concluded examination of the data.

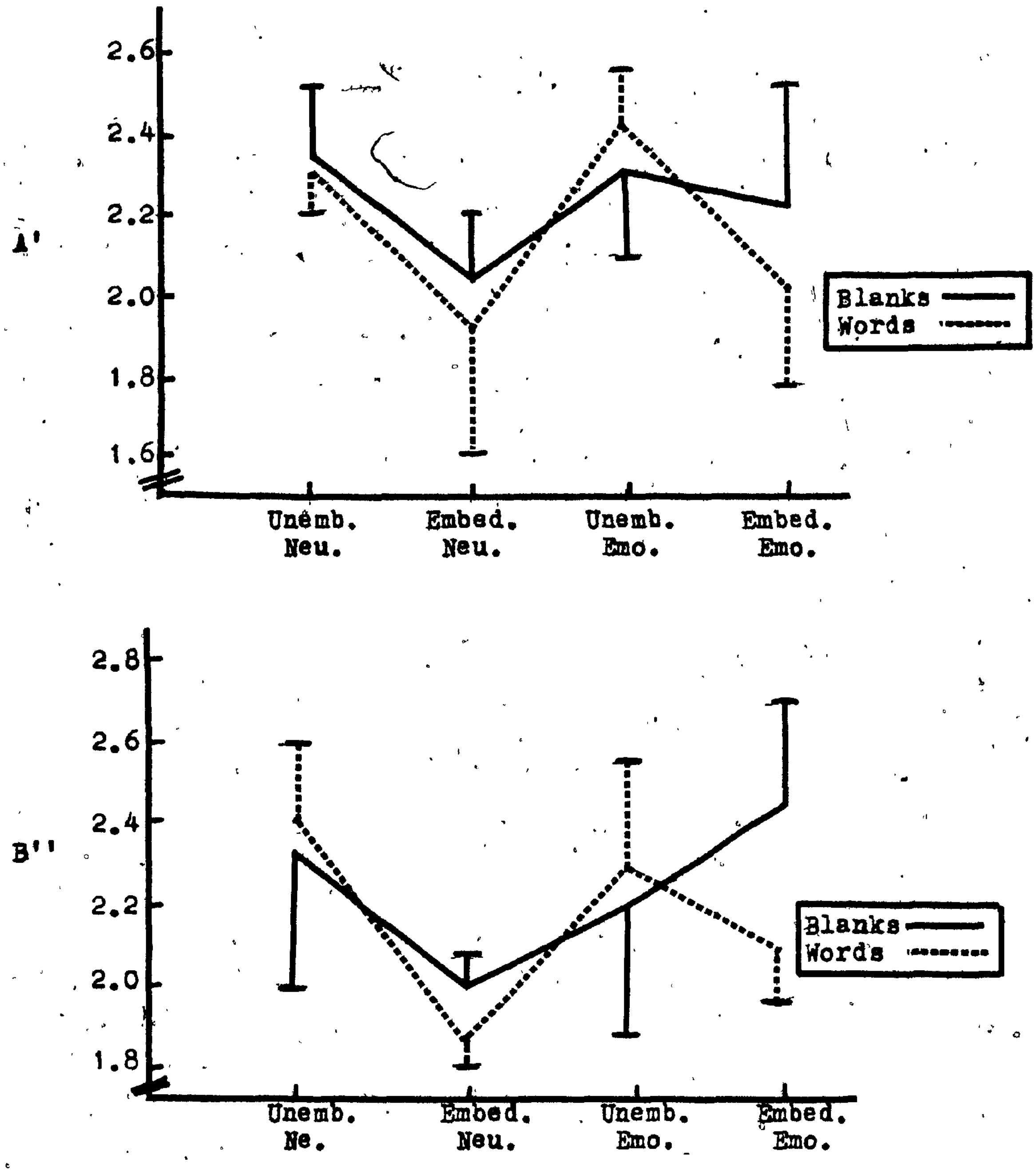



**Figure 11:** Mean transformed A' and B'' values as a function of trials with blanks vs trials with words, both within blocks of the four conditions of subliminal visual stimulation, for the males with the lowest sensitivity on the practice trials. Each error bar equals one half of the standard error of the mean.

Table 8

Analyses of Variance: Comparisons of Auditory A' and B'' Values for Male Subjects with the Lowest Sensitivity on the Practice Trials as a Function of Blocks of Trials (UN, EN, UE, EE) and Type of Trials (Words or Blanks)

| Source | df | SS | MS | F | p |
|---|---|---|---|---|---|
| A' | | | | | |
| Blocks (B) | 3 | 1.399 | .466 | 1.75 | .20 |
| Error B | 15 | 3.998 | .267 | | |
| Type (T) | 1 | .057 | .057 | .14 | .72 |
| Error T | 5 | 1.997 | .399 | | |
| B x T | 3 | .204 | .068 | .42 | .74 |
| Error B x T | 15 | 2.432 | .162 | | |
| Error within subjects | 5 | 2.780 | .556 | | |
| B'' | | | | | |
| Blocks (B) | 3 | 1.343 | .448 | 1.42 | .28 |
| Error B | 15 | 4.726 | .315 | | |
| Type (T) | 1 | .073 | .073 | .68 | .45 |
| Error T | 5 | .539 | .108 | | |
| B x T | 3 | .452 | .151 | .59 | .63 |
| Error B x T | 15 | 3.830 | .255 | | |
| Error within subjects | 5 | 2.286 | .457 | | |

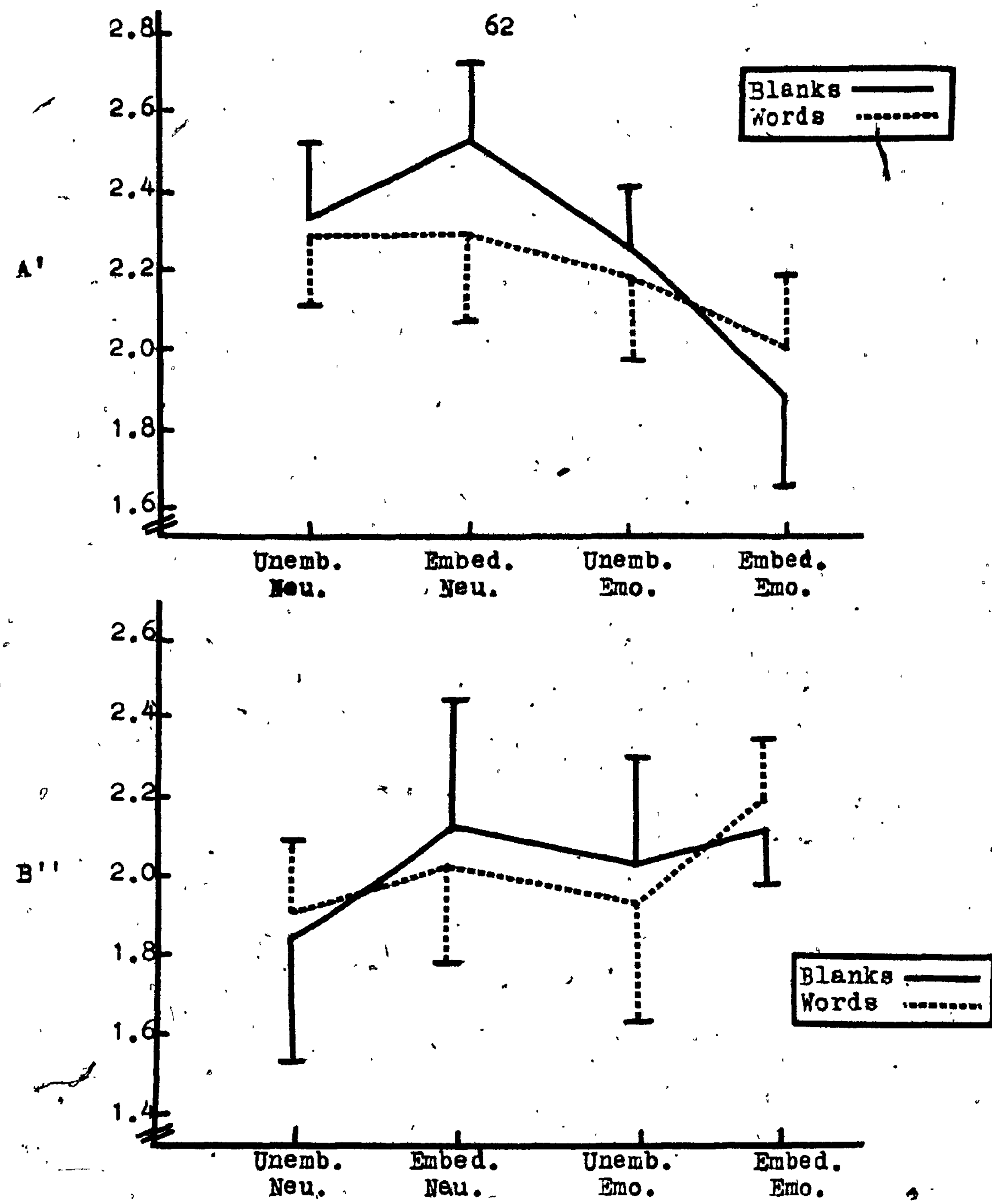



Figure 12: Mean transformed A' and B'' values as a function of trials with blanks vs trials with words, both within blocks of the four conditions of subliminal visual stimulation, for the females with the lowest sensitivity on the practice trials. Each error bar equals one half of the standard error of the mean.

Table 9

Analyses of Variance: Comparisons of Auditory A' and B'' Values for Female Subjects with the Lowest Sensitivity on the Practice Trials as a Function of Blocks of Trials (UN, EN, UE, EE) and Type of Trials (Words or Blanks)

| Source | df | SS | MS | F | p |
|---|---|---|---|---|---|
| A' | | | | | |
| Blocks (B) | 3 | 2.022 | .674 | 2.24 | .12 |
| Error B | 18 | 5.423 | .301 | | |
| Type (T) | 1 | .081 | .081 | .25 | .63 |
| Error T | 6 | 1.952 | .325 | | |
| B x T | 3 | .210 | .070 | .61 | .62 |
| Error B x T | 18 | 2.061 | .115 | | |
| Error within subjects | 6 | 3.117 | .519 | | |
| B'' | | | | | |
| Blocks (B) | 3 | .558 | .186 | .49 | .69 |
| Error B | 18 | 6.792 | .377 | | |
| Types (T) | 1 | .002 | .002 | .01 | .95 |
| Error T | 6 | 2.119 | .353 | | |
| B x T | 3 | .010 | .033 | .07 | .98 |
| Error B x T | 18 | 9.180 | .510 | | |
| Error within subjects | 6 | 4.595 | .766 | | |

## Discussion

The present experiment as planned and carried out with 41 subjects failed to replicate the findings of Hardy and Legge (1968), although its methodology was closely modeled after their study. No significant changes in auditory sensitivity were found as a function of neutral and emotional visual subliminal stimulation. Although the lack of significant changes in response bias does coincide with Hardy and Legge's results, without any changes in sensitivity this finding is not of significant interest. In addition, the hypothesized effect of embedded visual subliminal material of neutral and emotional content was not found and therefore did not lend support to the idea of qualitative differences in subliminal perception as proposed by Eagle et al. (1966). Furthermore, the base rate comparison of blank versus worded visual trials indicates that nothing about the visual content was affecting the auditory channel, i.e., there was no difference between "something" and "nothing".

The analysis of the data from the two subgroups of subjects showed, however, that this was not entirely the case. For those subjects who operated in more ambiguous circumstances, i.e., whose A' scores on the practice trials ranked in the lowest third of their group, there were some definite trends towards significant changes in both sensitivity and bias. The fact that some degree of ambiguity was required in the detection task should not be of any particular surprise, especially in the light of the long tradition of social psychological research using unstructured perceptual tasks in order to evaluate bias, set, group pressure, etc. (Sherif & Sherif, 1956).

It does raise the question, however, of why such differences in the performance of subjects in the practice trials, which marked the transition from the staircase method to the signal detection methodology, were found to exist in this experiment. Hardy and Legge did not report such difficulties with their sample of seven male and seven female subjects. While some of this variation may be due to individual differences in reaction to the demand characteristics of the experiment as a whole, it is also important to note that the staircase method which is used to find the intensity level of the signal is itself open to variation in response bias among the subjects. In the present experiment, the subjects were instructed to respond yes or no as to whether they heard the signal or not. It becomes obvious, then, that those who were stringent about answering positively only when certain they heard the signal would establish for themselves a less ambiguous signal level than those who were more likely to guess. The four categories of response (3,2,1,0) in the signal detection trials, which were used to bring about more conformity in response criterion among the subjects, came only in the third section of the experiment after signal intensity had been established.

The above observation also applies to Hardy and Legge's methodology, so it cannot entirely explain the problem encountered in the present experiment. Variations in instructions may also have contributed to differences in the two studies. In pilot work for this experiment it was observed that subjects were quite sensitive to variations in instructions, some of which resulted in subjects making no hits while others resulted in perfect performances. The final form of the instructions did result in more variable performance among subjects but did not necessarily place enough subjects in the proper range for ambiguity. What the most effective range might be, moreover, is in and of itself an interesting question for future research into cross-modal subliminal research using signal detection.

The statistical analyses of the data from the two subgroups of subjects yielded some suggestive results. Although they were not uniform enough to make definitive conclusions, they cannot be dismissed altogether. One interesting finding emerged out of the 2 x 2 x 2 analysis of variance which compared male and female subgroups and yielded a significant result ($p = .03$) in the interaction of sex and emotionality on the A' measure. For male subjects auditory A' values with emotional words were higher than with neutral words, whereas for female subjects auditory sensitivity with neutral words was greater than with emotional words. In contrast, Hardy and Legge found that emotional words decreased auditory sensitivity for both males and females.

This discrepancy in findings may have resulted from the words used as stimuli in the two studies. Hardy and Legge used "cancer", "danger", "failure", and "orgasm" as their emotional words. With the possible exception of the last item, all of these words have connotations similar for both sexes. Thus it could be argued that no sex differences were found for this reason. Such a comparison in this study is not possible, however, because different words were chosen for each sex in an effort to use the most powerful emotional stimuli. Given the care in preparing the stimulus cards, it can at least be argued that structural differences in the words were not responsible for differential effects in males and females.

Dixon (1971) in his review of the perceptual defense literature discusses sex differences which he obtained in a 1958 study where males had raised visual thresholds for emotional words while females had lowered thresholds for emotional words. The one exception to this finding was that for the word "whore" this relationship was reversed. Dixon's point is that the direction of the threshold change is dependent upon many factors such as sex, meaning, the emotional intensity of the stimuli, and individual characteristics. What is really important for him is that some threshold change regardless of direction can be demonstrated as a result of subliminal stimulation. Such significant threshold changes were found in the data from the subject subgroups in the interaction of the emotionality factor with the sex variable which, however, was not the primary interest of the present experiment.

The analyses which did not combine the two subgroups but dealt with them separately did show some interesting trends in the data. The A' analysis of variance for the male subgroup showed a nearly significant main effect ($p$ = .07) for embeddedness with both emotional and neutral categories displaying a drop in auditory sensitivity. This main effect for embeddedness, which was not found in the female subgroup, would reinforce the previous point concerning sex differences in that such differences have consistently been reported in studies using embedded stimuli above threshold. Bush and Coward (1974), for example, found that female subjects proposed more incorrect solutions and needed more time to find the embedded material. Parlee and Rajagopal (1974) found that these differences held up in Indian culture as well as in North American culture.

Additional support for these sex differences comes from observations made during the pilot testing for the present experiment. The method of embedding the words in this study was the second method pretested; the first, which did not double the centre lines at which the mirror images meet, was spontaneously disembedded by one-third of the males approached while no females were able to decode the designs. In addition, in the post-test after the experiment proper, four males and only two females were eliminated from the data because they spontaneously identified at least one of the hidden words.

While these sex differences in identifying embedded visual material shown above threshold appear relevant to this study's data from the subgroups, the analyses do not constitute a valid test of the proposition. As it stands, the data shows a steep drop in auditory sensitivity with both the emotional and neutral words. This may only indicate that the embedded designs per se caused an emotional reaction because of subjects' inability to decipher them. Only significant differences between the embedded neutral and embedded emotional conditions would show that the hidden content of the designs is actually being registered. The data of the present study does not indicate that this was the case.

The A' analysis of variance for the female subgroup showed a nearly significant main effect ($p = .08$) for the emotionality factor. Auditory sensitivity with the subliminally presented neutral words was consistently greater than with the emotional words, a trend consistent with Hardy and Legge's findings. In addition, the greatest differences between experimental conditions were in the unembedded neutral/embedded emotional and embedded neutral/embedded emotional comparisons. It is this last comparison which is particularly vital to this study's aim of looking for qualitative differences in subliminal perception. Once again, the data is not strong enough to permit definitive conclusions, only suggestions.

The above discussion has involved comparisons of A' values over various experimental conditions. But it will be recalled that signal detection offers two dependent measures, sensitivity and response bias. And it is the second measure, calculated by B'' in the present research, that Dixon (1971) finds of particular importance for the subliminal perception hypothesis. Dixon argues that significant change in sensitivity unaccompanied by significant change in response bias offers excellent proof of physiological effects unaffected by the subject's control over his response criterion. The studies by Dorfman (1967) and Broadbent and Gregory (1967) bore out Dixon's prediction. Hardy and Legge (1968) and Zwosta and Zenhausern (1969) also found no significant changes in Beta in their cross-modal experiments. The data from the present experiment casts some doubt on this contention, since in three instances changes in response bias approached statistically significant levels: a) in the 4 x 2 analysis of variance for all 19 male subjects, a significance level of .06 was reached in the blank versus worded trials comparison; b) in the 2 x 2 analysis for the male subgroup, a significance level of .10 was found for the embeddedness factor; c) in the 2 x 2 x 2 analysis for the male and female subgroups, a significance level of .08 was found in the sex x embeddedness interaction.

A consistent pattern in these findings is difficult to ascertain primarily because they do not, except in the second case, parallel significant changes in A'. Also, the nearly significant changes in B'' are found in male subjects and not in female subjects. (The interaction effect in the 2 x 2 x 2 analysis is due to the fact that the males' B''s changed much more than the females'.) One hypothesis about the observed changes in B'' is related to the participants' subjective awareness of their performance. This hypothesis arises from the parallel drop in A' and B'' values for the subgroup of males in the 2 x 2 analysis indicating that as sensitivity decreased the number of false alarms increased. The reason why such a parallel change occured in only this one instance is open to conjecture, but consideration of this observation leads to a more fundamental point about the use of signal detection in this type of subliminal research.

The subjective experience for participants in this particular experiment was one in which they were to listen for a signal which would be presented at a constant level on one half of the trials. Having become accustomed to the situation in the practice trials, expectations of their performance in the next four blocks of trials remained the same. However, for those subjects who experienced increased difficulty in some of the blocks of trials ( and several subjects verbalized their suspicions of unannounced changes in the intensity level of the auditory signal) one solution to the situation was to become more lenient in their criteria of what was signal plus noise and what was noise alone in order to keep their performance consistent.

The position of these subjects whose performance may be altered by the addition of "internal noise" resulting from stimulation of which they are unaware is a unique one in the signal detection literature. Indeed the closest parallel to the situation is to be found in studies which vary signal intensity in order to examine changes in response criterion. This question, however, has not been as systematically researched as has the influence of payoff matrices and a priori signal probabilities. Curry, Nagel, and Gai (1977) have addressed this lack in the literature and have reviewed what few studies exist. They distinguish between experiments where different signal strengths are blocked and where they are randomly interspersed, arguing that the former design allows subjects to adjust their strategies for the various blocks while the latter design does not. While the blocked studies may on the surface seem to offer a closer parallel to the present experiment, it must be remembered that no such changes were announced to its subjects -- their instructions remained the same even though they may have experienced a change in the situation.

This possibility of influencing signal strength by increasing noise and thereby changing response criterion brings into question, therefore, Dixon's (1971) assertion that changes in sensitivity without changes in bias offer excellent support for the subliminal perception hypothesis. It may be correct for the typical perceptual defense experiment where it is important to show that recognition thresholds are not influenced by the subject's willingness to report taboo items before feeling certain. But in this type of experiment where the subject's performance may be altered by conditions of which he is unaware, it may well be that changes in response bias can result. Significant changes in response criterion do not, therefore, <u>automatically</u> negate a study's value to the subliminal perception hypothesis.

An explanation of why Hardy and Legge did not find any significant differences in Beta may rest with the statistical treatment of their data. Given that each subject received only 64 experimental trials in all, their use of parametric measures of performance such as d' and Beta was probably inappropriate. In addition, the authors acknowledged a shortage of false alarms with which to calculate Beta and were forced to calculate an estimate of the probability of a false alarm, a procedure with dubious merit.

One more question arising from the present data needs to be addressed: the base rate comparison of blank versus worded trials. In the data from all of the males and females it was found that there was no significant difference in A' values between the two types of trials over the four blocks of visual subliminal stimulation. This seemed to argue that nothing about the visual stimuli was affecting auditory sensitivity. In the subgroups' data it was also evident that there were no significant differences resulting from the blank versus the worded trials comparison. In this case, however, the same conclusion -- that nothing about the visual material was being registered -- cannot be credited because nearly significant effects in A' were found for embeddedness for males and emotionality for females. This lack of significant differences between the blank and worded trials, then, prompts further consideration.

One explanation is suggested by the striking similarity in the way in which the blank trials parallel changes in both A' and B'' in the worded trials over the four experimental conditions. It may be that the worded trials were influencing performance on the blank trials. (If the converse were true one would not expect any differences across the four conditions of emotionality and embeddedness.) In her cross-modal study of the effects of subliminal auditory suggestion on the description of a visually presented neutral face, Henley (1975) reported finding just such carry-over effects when descriptions of the face presented without concomitant auditory stimulation were affected by the auditory cue from the preceding trial. Henley suggested that these findings may have given evidence for a Poetzl-like effect.

Such a conclusion is not so easily reached with a signal detection paradigm, however. As MacDonald (1974) observed, intertrial dependencies of all kinds exist, meaning that performance on each trial is influenced by preceding trials. Similarly, Atkinson (1963) argued in his variable sensitivity theory of signal detection that the decision process is one which can change from trial to trial as a function of the information gained from preceding trials. Some of the factors which have been found to influence the carry-over from one trial to the next are the intertrial interval (MacDonald, 1974), use of feedback (Tanner, Haller, & Atkinson, 1967), and the subject's tendency to match his responses in accordance with the stated signal probability (Craig, 1976). The latter factor may have been particularly potent in the present experiment given the short blocks of 24 trials which may have contributed to the subjects' awareness of "how they were doing" and adjusting their responses according to their expectations. Thus the argument for a carry-over effect as found in Henley's study cannot be readily applied to a signal detection paradigm.

The preceding discussion of intertrial dependencies suggests some concluding remarks about the use of signal detection in subliminal perception research. As pointed out in the above discussion, concerns about the effects of signal detection methodology have overshadowed evaluation of the results in terms of the hypothesized effects of subliminal cross-modal stimulation. Perhaps this concern about methodology is to be expected when results are generally less than significant but not so weak as to be dismissed entirely. It is a frequent reaction to look for areas where more tightly controlled procedures or alterations in methodology might have produced stronger results. Certainly the latter strategy was used in this study's analysis of the subject subgroups' data. It is felt, however, that the experimental control, especially in the crucial physical parameters of the subliminal visual stimulation, represents an improvement over previous experiments. The concern over methodology is , rather, a concern about the power of the many variables from subject reaction to instructions to intertrial dependencies which have been found to operate in the typical signal detection experiment.

In addition, it must be acknowledged that the use of signal detection in applied areas such as this is undoubtedly an arduous task. One reason for this is that its cumbersome methodology demands many trials in order to establish consistent subject performance in various experimental conditions. As a consequence the purely psychophysical experiments use a very small number of subjects while applied researchers must struggle with the need for larger numbers in order to generalize their findings. In this dilemma the temptation is strong, then, to reduce the number of trials. The applied signal detection literature is, as a result, littered with studies which inappropriately use parametric measures and fail to attain a suitable balance between hits and false alarms -- Hardy and Legge are not alone in their struggles.

Another consequence of concern to the present research in particular is that the signal detection literature has not dealt much with the problem of changing signal strengths and the resulting effects on sensitivity and bias, although as Curry et al. (1977) point out, this situation is much closer to everyday experience than changes in payoff schedules and the like. It is difficult, therefore, to interpret changes in bias outside of what common sense might dictate for experiments such as the present one.

All of these statements do not necessarily preclude the use of signal detection in subliminal perception research.

As Dixon (1971) has pointed out, significant changes in threshold, whether they be raised or lowered, provide an important means of demonstrating the registration of subliminal content. The use of signal detection offers a sound way of analyzing changes in sensitivity corrected for the subject's propensity for guessing. The meaning of changes in response bias measures like Beta and B'' is not so clear at the present time.

Suggestions for further research in this area would still include the use of signal detection but in a more traditional application with fewer subjects, a closer examination of the signal intensity established for the detection task, many more trials for each experimental condition, and the elimination of blocking in favor of a mixed schedule of presentation with more blank trials interspersed between worded trials. With these alterations in methodology, the suggestive findings from the present research may be sufficiently strengthened to demonstrate the subliminal perception of embedded material not consciously available above threshold.

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## Appendix B1

Instructions for Visual Threshold Determination

"In the first part of the experiment I want you to report to me on your perception of visual events taking place in the tachistoscope. The beginning of a trial is marked by the appearance of a fixation point in the centre of a plain white field. One trial is 5 seconds long; the fixation point's disappearance marks the end of a trial. If, while the fixation point is on, you are aware of no change in the field, respond "no change". If, while the fixation point is on you perceive a brief flash of light, respond "flash". If, while the point is on you become aware of lines or dashes in the field, I want you to respond "lines". The time to respond is when the point goes off. While we do these 15 to 20 trials, I want you to wear these earphones through which you will hear constant white noise. Be sure to fixate on the point while it is present."

## Appendix B2

**Instructions for Auditory Threshold Determination**

"In the next section of trials I want you to report to me on auditory, not visual, events. As before, you will be looking into the tachistoscope while receiving white noise through the earphones. Again the appearance of the fixation point marks the duration of a trial. This time, however, I want you to listen for this signal--(signal presented once at 50 decibels). It is a 1000 cycle-per-second signal; it will always be the same pitch, will always last ½ second, and will occur only once while the fixation point is on. It will be presented on every trial, but you will not hear it on every trial because I will be varying the intensity of the signal. In other words, on some trials it will be loud enough to hear; on others it will not. I want you to fixate on the point when it appears and use it as a visual cue to listen. Use categories of response: yes, meaning 'yes, I heard the signal'; and no, meaning 'no, I did not hear the signal'. Again your time to respond is when the point goes off. We will do 30 trials in this section."

## Appendix B3

## Instructions for Signal Detection Practice Trials

"In the next trials the sequence of events remains the same but there will be two changes in the experiment. Again you will be reporting to me on whether you hear the signal or not. But this time I will only be delivering the signal on half of the trials. The order of when it's there and when it isn't there is randomized so you will have no way of predicting ahead of time what kind of trial it will be.

In addition I want you to use a new way of responding. Rather than forcing you to use only yes or no, you may now use four categories of response. A response of '3' means that you are absolutely confident that the signal was delivered. A response of 'zero' means you are absolutely confident that the signal was not delivered. A response of '2' means you are somewhat confident of the signal having been delivered whereas a response of '1' means you have a hunch that the signal was delivered. There will be 36 trials in this section."

## Appendix B4

## Instructions for Experimental Trials

"In this last group of 96 trials the instructions will remain the same as before. The signal will occur on only half of the trials. Continue to use the 3,2,1,0 categories of response. After every 24 trials I will give you the opportunity to take a short break."

Appendix C1

Hit Rates (H.R.) and False Alarm Rates (F.A.) for Male Subjects on the Four Conditions of Subliminal Visual Stimulation

| | Unembedded Neutral H.R. / F.A. | Embedded Neutral H.R. / F.A. | Unembedded Emotional H.R. / F.A. | Embedded Emotional H.R. / F.A. |
|---|---|---|---|---|
| S1 | .125 / 0 | .500 / 0 | .500 / 0 | .625 / 0 |
| S2 | .500 / 0 | .750 / 0 | .500 / .125 | .625 / 0 |
| S3 | .500 / 0 | .750 / 0 | .875 / 0 | .250 / 0 |
| S4 | 1.000 / 0 | 1.000 / 0 | 1.000 / 0 | 1.000 / 0 |
| S5 | .500 / 0 | 1.000 / .125 | .875 / .250 | .875 / .500 |
| S6 | .625 / .375 | .750 / .625 | .795 / .500 | .875 / .625 |
| S7 | 1.000 / .125 | .750 / .125 | 1.000 / .375 | .875 / .375 |
| S8 | 1.000 / .125 | 1.000 / 0 | 1.000 / .125 | 1.000 / 0 |
| S9 | .750 / .375 | 1.000 / .250 | .875 / .250 | .875 / .250 |
| S10 | .625 / .125 | .625 / .375 | .500 / .125 | .750 / .375 |
| S11 | 1.000 / .250 | 1.000 / .375 | 1.000 / .250 | 1.000 / .250 |
| S12 | .625 / 0 | .750 / .375 | .843 / .125 | .500 / .125 |
| S13 | .750 / .125 | .500 / .125 | .375 / .250 | .625 / .125 |
| S14 | .875 / .125 | .875 / 0 | .875 / .125 | .750 / 0 |
| S15 | .750 / .375 | .875 / .375 | 1.000 / .250 | .625 / .125 |
| S16 | .625 / 0 | .750 / .250 | 1.000 / 0 | 1.000 / 0 |
| S17 | .250 / 0 | .125 / .250 | .250 / 0 | .125 / .250 |
| S18 | .875 / .125 | .875 / .250 | .875 / 0 | .625 / .250 |
| S19 | .750 / .375 | .750 / .125 | 1.000 / 0 | 1.000 / .125 |

Appendix C2

A' Values of Male Subjects on the Four Conditions of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| S1 | .781 | .875 | .875 | .906 |
| S2 | .875 | .938 | .795 | .906 |
| S3 | .875 | .938 | .875 | .813 |
| S4 | 1.000 | 1.000 | 1.000 | 1.000 |
| S5 | .875 | .938 | .887 | .795 |
| S6 | .700 | .625 | .795 | .738 |
| S7 | .969 | .887 | .906 | .843 |
| S8 | .969 | 1.000 | .969 | 1.000 |
| S9 | .775 | .938 | .887 | .887 |
| S10 | .843 | .700 | .795 | .775 |
| S11 | .938 | .906 | .938 | .938 |
| S12 | .906 | .775 | .843 | .795 |
| S13 | .750 | .345 | .738 | .700 |
| S14 | .929 | .969 | .929 | .938 |
| S15 | .833 | .887 | .969 | .906 |
| S16 | .906 | .833 | 1.000 | 1.000 |
| S17 | .813 | .208 | .813 | .208 |
| S18 | .929 | .887 | .969 | .775 |
| S19 | .775 | .887 | 1.000 | 1.000 |

Appendix C3

B'' Values of Male Subjects on the Four Conditions of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| S1 | 1.000 | 1.000 | 1.000 | 1.000 |
| S2 | 1.000 | 1.000 | .391 | 1.000 |
| S3 | 1.000 | 1.000 | 1.000 | 1.000 |
| S4 | 1.000 | 1.000 | 1.000 | 1.000 |
| S5 | 1.000 | -1.000 | -.263 | -.391 |
| S6 | 0 | -.111 | -.391 | -.364 |
| S7 | -1.000 | .263 | -1.000 | -.364 |
| S8 | -1.000 | 1.000 | -1.000 | 1.000 |
| S9 | -.111 | -1.000 | -.263 | -.263 |
| S10 | .364 | 0 | .391 | -.111 |
| S11 | -1.000 | -1.000 | -1.000 | -1.000 |
| S12 | 1.000 | -.111 | .364 | .391 |
| S13 | .364 | 0 | 0 | .391 |
| S14 | 0 | 1.000 | 0 | 1.000 |
| S15 | -.111 | -.111 | .111 | .263 |
| S16 | 1.000 | 0 | 1.000 | 1.000 |
| S17 | 1.000 | -.263 | 1.000 | -.263 |
| S18 | .125 | -.263 | 1.000 | .111 |
| S19 | -.111 | .263 | 1.000 | -1.000 |

Appendix D1

Hit Rates (H.R.) and False Alarm Rates (F.A.) for Females on the Four Conditions of Subliminal Visual Stimulation

| | Unembedded Neutral H.R. / F.A. | Embedded Neutral H.R. / F.A. | Unembedded Emotional H.R. / F.A. | Embedded Emotional H.R. / F.A. |
|---|---|---|---|---|
| S1 | .875 / .250 | 1.000 / .375 | .875 / .250 | .875 / .375 |
| S2 | .625 / .375 | .750 / .375 | 1.000 / .125 | .875 / 0 |
| S3 | 1.000 / .125 | .750 / 0 | 1.000 / 0 | 1.000 / .125 |
| S4 | .625 / .125 | .625 / .125 | .625 / .375 | .500 / .375 |
| S5 | .625 / .125 | .625 / .250 | .875 / .250 | .875 / .250 |
| S6 | .750 / 0 | .625 / 0 | .750 / 0 | .750 / 0 |
| S7 | .875 / .125 | 1.000 / 0 | 1.000 / 0 | .875 / 0 |
| S8 | .875 / .250 | .250 / .375 | 1.000 / .250 | .500 / .750 |
| S9 | .750 / .500 | .875 / .375 | .875 / .250 | .875 / .125 |
| S10 | .500 / 0 | .750 / .125 | .500 / 0 | .750 / 0 |
| S11 | .250 / 0 | .250 / 0 | .750 / .250 | .125 / 0 |
| S12 | .375 / .375 | .625 / .125 | .750 / .125 | .500 / .375 |
| S13 | .875 / .375 | 1.000 / .250 | .750 / .250 | .875 / .625 |
| S14 | 1.000 / .375 | .875 / .500 | 1.000 / .500 | .875 / .500 |
| S15 | .875 / 0 | .750 / .250 | .750 / .375 | .875 / 0 |
| S16 | .875 / .125 | 1.000 / 0 | .875 / 0 | .875 / 0 |
| S17 | .750 / .375 | .750 / .375 | .500 / .750 | .750 / .250 |
| S18 | 1.000 / .125 | 1.000 / .125 | 1.000 / .125 | 1.000 / 0 |
| S19 | .625 / .250 | .750 / 0 | .625 / .125 | .875 / 0 |
| S20 | .625 / .125 | .750 / .125 | .875 / 0 | .875 / .250 |
| S21 | .500 / .250 | .875 / .125 | 1.000 / 0 | 1.000 / .125 |
| S22 | .750 / 0 | .875 / .125 | .375 / 0 | .500 / 0 |

Appendix D2

A' Values for Female Subjects on the Four Conditions of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| S1 | .887 | .906 | .887 | .843 |
| S2 | .700 | .775 | .969 | .969 |
| S3 | .969 | .938 | 1.000 | .969 |
| S4 | .843 | .843 | .700 | .613 |
| S5 | .843 | .775 | .887 | .887 |
| S6 | .938 | .906 | .938 | .938 |
| S7 | .929 | 1.000 | 1.000 | .969 |
| S8 | .887 | .325 | .938 | .125 |
| S9 | .708 | .843 | .887 | .929 |
| S10 | .875 | .887 | .875 | .938 |
| S11 | .813 | .813 | .833 | .781 |
| S12 | .500 | .843 | .887 | .613 |
| S13 | .843 | .938 | .833 | .738 |
| S14 | .906 | .795 | .875 | .795 |
| S15 | .969 | .833 | .775 | .969 |
| S16 | .929 | 1.000 | .969 | .969 |
| S17 | .775 | .775 | .125 | .833 |
| S18 | .969 | .969 | .969 | 1.000 |
| S19 | .775 | .938 | .843 | .969 |
| S20 | .843 | .887 | .969 | .887 |
| S21 | .708 | .929 | 1.000 | .969 |
| S22 | .938 | .929 | .844 | .875 |

Appendix D3

B'' Values for Female Subjects on the Four Conditions of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| S1 | -.263 | -1.000 | -.263 | -.364 |
| S2 | 0 | -.111 | -1.000 | 1.000 |
| S3 | -1.000 | 1.000 | 1.000 | -1.000 |
| S4 | .364 | .364 | 0 | .032 |
| S5 | .364 | .111 | .263 | -.263 |
| S6 | 1.000 | 1.000 | 1.000 | 1.000 |
| S7 | 0 | 1.000 | 1.000 | 1.000 |
| S8 | -.263 | -.111 | -1.000 | .143 |
| S9 | -.143 | -.364 | -.263 | 0 |
| S10 | 1.000 | .263 | 1.000 | 1.000 |
| S11 | 1.000 | 1.000 | 0 | 1.000 |
| S12 | 0 | .364 | .263 | .032 |
| S13 | .364 | -1.000 | 0 | -.364 |
| S14 | -1.000 | -.391 | -1.000 | .391 |
| S15 | 1.000 | 0 | -.111 | 1.000 |
| S16 | 0 | 1.000 | 1.000 | 1.000 |
| S17 | -.111 | -.111 | .143 | 0 |
| S18 | -1.000 | -1.000 | -1.000 | 1.000 |
| S19 | .111 | 1.000 | .364 | 1.000 |
| S20 | .364 | .263 | 1.000 | -.263 |
| S21 | .143 | 0 | 1.000 | -1.000 |
| S22 | 1.000 | 0 | 1.000 | 1.000 |

Appendix E1

Hit Rates (H.R.) and False Alarm Rates (.F.A.) for Male Subjects on the Blank Visual Trials Within Blocks of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| | H.R. / F.A. | H.R. / F.A. | H.R. / F.A. | H.R. / F.A. |
| S1 | .500 / 0 | .500 / .500 | 1.000 / 0 | .500 / 0 |
| S2 | .500 / .250 | .750 / 0 | .750 / .250 | .750 / 0 |
| S3 | .750 / 0 | .500 / 0 | .750 / .250 | .500 / 0 |
| S4 | .750 / 0 | 1.000 / 0 | 1.000 / 0 | .750 / 0 |
| S5 | 1.000 / 0 | 1.000 / 0 | .500 / 0 | .500 / 0 |
| S6 | .750 / .750 | .500 / .250 | 1.000 / .250 | .750 / .500 |
| S7 | 1.000 / .250 | .750 / .250 | 1.000 / 0 | .750 / 0 |
| S8 | 1.000 / .250 | 1.000 / 0 | 1.000 / 0 | 1.000 / 0 |
| S9 | .750 / .250 | .750 / 0 | 1.000 / .250 | .750 / 0 |
| S10 | .750 / .250 | .750 / 0 | .500 / 0 | .500 / .250 |
| S11 | 1.000 / .500 | 1.000 / .750 | 1.000 / .500 | 1.000 / .250 |
| S12 | .750 / 0 | .750 / .250 | .250 / 0 | .750 / 0 |
| S13 | .750 / .250 | .750 / .500 | .500 / .250 | 1.000 / 0 |
| S14 | .750 / 0 | .750 / .250 | .500 / 0 | 1.000 / 0 |
| S15 | .500 / 0 | .500 / .500 | .500 / .500 | .250 / .250 |
| S16 | .750 / 0 | 1.000 / 0 | 1.000 / .250 | 1.000 / 0 |
| S17 | .500 / 0 | .750 / .500 | .250 / 0 | .250 / .500 |
| S18 | .750 / .250 | .500 / .250 | 1.000 / .500 | 1.000 / 0 |
| S19 | 1.000 / 0 | 1.000 / 0 | 1.000 / 0 | 1.000 / 0 |

## Appendix E2

A' Values for Male Subjects on the Blank Visual Trials Within Blocks of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| S1 | .875 | .500 | 1.000 | .875 |
| S2 | .708 | .938 | .833 | .938 |
| S3 | .938 | .875 | .833 | .875 |
| S4 | .938 | 1.000 | 1.000 | .938 |
| S5 | 1.000 | 1.000 | .875 | .875 |
| S6 | .500 | .708 | 1.000 | .708 |
| S7 | .938 | .833 | 1.000 | .938 |
| S8 | .938 | 1.000 | 1.000 | 1.000 |
| S9 | .833 | .938 | .938 | .938 |
| S10 | .833 | .938 | .875 | .708 |
| S11 | .875 | .813 | .875 | .938 |
| S12 | .938 | .833 | .813 | .938 |
| S13 | .938 | .708 | .708 | 1.000 |
| S14 | .938 | .833 | .875 | 1.000 |
| S15 | .875 | .500 | .500 | .250 |
| S16 | .938 | 1.000 | .938 | 1.000 |
| S17 | .875 | .708 | .813 | .125 |
| S18 | .833 | .708 | .875 | 1.000 |
| S19 | 1.000 | 1.000 | 1.000 | 1.000 |

Appendix E3

B'' Values for Male Subjects on the Blank Visual Trials

Within Blocks of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| S1 | 1.000 | 0 | 1.000 | 1.000 |
| S2 | .143 | 1.000 | 0 | 1.000 |
| S3 | 1.000 | 1.000 | 0 | 1.000 |
| S4 | 1.000 | 1.000 | 1.000 | 1.000 |
| S5 | 1.000 | 1.000 | 1.000 | 1.000 |
| S6 | 0 | .143 | .143 | -.143 |
| S7 | -1.000 | 0 | 1.000 | 1.000 |
| S8 | -1.000 | 1.000 | 1.000 | 1.000 |
| S9 | 0 | 1.000 | -1.000 | 1.000 |
| S10 | 0 | 1.000 | 1.000 | .143 |
| S11 | -1.000 | -1.000 | -1.000 | -1.000 |
| S12 | 1.000 | 0 | 1.000 | 1.000 |
| S13 | -1.000 | -.143 | .143 | 1.000 |
| S14 | 1.000 | 0 | 1.000 | 1.000 |
| S15 | 1.000 | 0 | 0 | 0 |
| S16 | 1.000 | 1.000 | -1.000 | 1 .000 |
| S17 | 1.000 | -.143 | 1.000 | -.143 |
| S18 | 0 | .143 | -1.000 | 1.000 |
| S19 | 1.000 | 1.000 | 1.000 | 1.000 |

Appendix F1

Hit Rates (H.R.) and False Alarm Rates (F.A.) for Females on the Blank Visual Trials Within Blocks of Subliminal Visual Stimulation

| | Unembedded Neutral H.R. / F.A. | Embedded Neutral H.R. / F.A. | Unembedded Emotional H.R. / F.A. | Embedded Emotional H.R. / F.A. |
|---|---|---|---|---|
| S1 | .750 / .250 | 1.000 / .250 | 1.000 / 0 | 1.000 / 0 |
| S2 | 1.000 / 0 | 1.000 / .750 | 1.000 / 0 | 1.000 / .250 |
| S3 | 1.000 / 0 | 1.000 / 0 | 1.000 / 0 | 1.000 / 0 |
| S4 | .750 / .250 | 1.000 / .500 | .250 / .250 | .250 / .500 |
| S5 | .750 / 0 | 1.000 / .500 | .750 / 0 | 1.000 / .750 |
| S6 | .500 / 0 | 1.000 / 0 | .750 / 0 | .750 / 0 |
| S7 | 1.000 / 0 | 1.000 / 0 | 1.000 / 0 | 1.000 / .250 |
| S8 | .750 / .500 | .750 / .500 | 1.000 / .500 | .500 / .500 |
| S9 | 1.000 / .250 | .750 / .250 | .750 / .500 | 1.000 / .750 |
| S10 | 1.000 / 0 | .750 / 0 | .750 / 0 | .750 / 0 |
| S11 | .750 / 0 | .750 / .250 | .250 / .500 | .750 / .500 |
| S12 | 1.000 / .750 | 1.000 / 0 | .750 / .250 | .750 / .500 |
| S13 | 1.000 / .750 | 1.000 / 0 | 1.000 / .250 | .750 / .500 |
| S14 | 1.000 / .250 | .750 / 0 | .750 / 0 | .500 / .250 |
| S15 | 1.000 / .250 | 1.000 / 0 | .750 / 0 | 1.000 / 0 |
| S16 | .500 / 0 | .750 / .500 | .250 / 0 | .750 / .250 |
| S17 | .750 / 0 | 1.000 / .500 | .500 / .250 | .500 / 0 |
| S18 | 1.000 / 0 | 1.000 / .250 | 1.000 / 0 | 1.000 / .500 |
| S19 | 1.000 / .250 | .500 / .250 | 1.000 / .250 | 1.000 / 0 |
| S20 | .750 / .750 | 1.000 / .250 | 1.000 / .250 | .750 / .250 |
| S21 | .750 / .250 | .750 / .750 | .500 / 0 | 1.000 / .250 |
| S22 | .750 / 0 | .750 / 0 | .500 / 0 | .250 / 0 |

## Appendix F2

### A' Values for Female Subjects on the Blank Visual Trials Within Blocks of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| S1 | .833 | .938 | 1.000 | 1.000 |
| S2 | 1.000 | .813 | 1.000 | 1.000 |
| S3 | 1.000 | 1.000 | 1.000 | 1.000 |
| S4 | .833 | .875 | .500 | .125 |
| S5 | .938 | .875 | .938 | .813 |
| S6 | .875 | 1.000 | .938 | .938 |
| S7 | 1.000 | 1.000 | 1.000 | .938 |
| S8 | .708 | .708 | .875 | .500 |
| S9 | .938 | .833 | .708 | .813 |
| S10 | 1.000 | .938 | .938 | .938 |
| S11 | .938 | .833 | .125 | .708 |
| S12 | .813 | 1.000 | .833 | .708 |
| S13 | .813 | 1.000 | .938 | .708 |
| S14 | .938 | .938 | .938 | .708 |
| S15 | .938 | 1.000 | .938 | 1.000 |
| S16 | .875 | .708 | .813 | .833 |
| S17 | .938 | .875 | .708 | .875 |
| S18 | 1.000 | .938 | 1.000 | .875 |
| S19 | .938 | .708 | .938 | 1.000 |
| S20 | .500 | .938 | .938 | .833 |
| S21 | .833 | .500 | .875 | .938 |
| S22 | .938 | .938 | .875 | .813 |

Appendix F3

B'' Values for Female Subjects on the Blank Visual Trials Within Blocks of Subliminal Visual Stimulation

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| S1 | 0 | -1.000 | 1.000 | 1.000 |
| S2 | 1.000 | -1.000 | 1.000 | .143 |
| S3 | 1.000 | 1.000 | 1.000 | 1.000 |
| S4 | 0 | -1.000 | 0 | -.143 |
| S5 | 1.000 | -1.000 | 1.000 | -1.000 |
| S6 | 1.000 | 1.000 | 1.000 | 1.000 |
| S7 | 1.000 | 1.000 | 1.000 | -1.000 |
| S8 | -.143 | -.143 | -1.000 | 0 |
| S9 | -1.000 | 0 | -.143 | -1.000 |
| S10 | 1.000 | 1.000 | 1.000 | 1.000 |
| S11 | 1.000 | 0 | -.143 | -.143 |
| S12 | -1.000 | 1.000 | 0 | -.143 |
| S13 | -1.000 | 1.000 | -1.000 | -.143 |
| S14 | -1.000 | 1.000 | 1.000 | .143 |
| S15 | -1.000 | 1.000 | 1.000 | 1.000 |
| S16 | 1.000 | -.143 | 1.000 | 0 |
| S17 | 1.000 | -1.000 | .143 | 1.000 |
| S18 | 1.000 | -1.000 | 1.000 | -1.000 |
| S19 | -1.000 | .143 | -1.000 | 1.000 |
| S20 | 0 | -1.000 | -1.000 | 0 |
| S21 | 0 | 0 | 1.000 | -1.000 |
| S22 | 1.000 | 1.000 | 1.000 | 1.000 |

Appendix G

Performance Measures of Males on the Practice Trials

With A' Values Ranked

| | Hit Rate | False Alarm Rate | A' | A' Ranks |
|---|---|---|---|---|
| S1 | .722 | .222 | .834 | 8.5 |
| S2 | .722 | .111 | .883 | 14.0 |
| S3 | .667 | .111 | .865 | 12.0 |
| S4 | .944 | 0 | .986 | 17.5 |
| S5 | .889 | .167 | .920 | 15.5 |
| S6 * | .778 | .778 | .500 | 1.5 |
| S7 | .778 | .167 | .880 | 13.0 |
| S8 | .889 | .167 | .920 | 15.5 |
| S9 | .889 | .389 | .845 | 10.0 |
| S10 | .778 | .278 | .834 | 8.5 |
| S11 | .833 | .444 | .792 | 6.0 |
| S12 * | .444 | .167 | .793 | 7.0 |
| S13 * | .667 | .444 | .684 | 4.0 |
| S14 | .944 | 0 | .986 | 17.5 |
| S15 * | .611 | .500 | .601 | 3.0 |
| S16 | 1.000 | 0 | 1.000 | 19.0 |
| S17 * | .389 | .389 | .500 | 1.5 |
| S18 * | .778 | .500 | .728 | 5.0 |
| S19 | .778 | .222 | .857 | 11.0 |

*These subjects were used in the subgroup analyses.

## Appendix H

### Performance Measures of Females on the Practice Trials With A' Values Ranked

| | Hit Rate | False Alarm Rate | A' | A' Ranks |
|---|---|---|---|---|
| S1 | 1.000 | .333 | .917 | 13.5 |
| S2 | .889 | .167 | .920 | 15.0 |
| S3 | .722 | 0 | .931 | 18.0 |
| S4 * | .556 | .333 | .684 | 2.0 |
| S5 | .889 | .222 | .902 | 12.0 |
| S6 | .778 | 0 | .945 | 19.0 |
| S7 | .944 | .056 | .970 | 22.0 |
| S8 * | .778 | .333 | .810 | 5.5 |
| S9 | .833 | .222 | .880 | 9.5 |
| S10 | .833 | .111 | .920 | 15.0 |
| S11 | .833 | .111 | .920 | 15.0 |
| S12 * | .667 | .500 | .646 | 1.0 |
| S13 * | .889 | .556 | .781 | 4.0 |
| S14 * | .778 | .333 | .810 | 5.5 |
| S15 | .833 | 0 | .958 | 21.0 |
| S16 * | .778 | .222 | .857 | 7.0 |
| S17 * | .667 | .389 | .718 | 3.0 |
| S18 | .889 | .056 | .955 | 20.0 |
| S19 | .667 | .111 | .865 | 8.0 |
| S20 | .833 | .222 | .880 | 9.5 |
| S21 | .889 | .278 | .883 | 11.0 |
| S22 | .667 | 0 | .917 | 13.5 |

* These subjects were used in the subgroup analyses.

## Appendix I

A' and B'' Values on the Four Conditions of Subliminal Visual Stimulation for the Male Subjects with the Lowest Sensitivity on the Practice Trials

| | Unembedded Neutral | Embedded Neutral | Unembedded Emotional | Embedded Emotional |
|---|---|---|---|---|
| | | A' | | |
| S6 | .700 | .625 | .795 | .738 |
| S12 | .906 | .775 | .843 | .795 |
| S13 | .708 | .354 | .738 | .700 |
| S15 | .833 | .887 | .969 | .906 |
| S17 | .813 | .208 | .813 | .208 |
| S18 | .929 | .887 | .969 | .775 |
| | | B'' | | |
| S6 | 0 | -.111 | -.391 | -.364 |
| S12 | 1.000 | -.111 | .364 | .391 |
| S13 | .364 | 0 | 0 | .391 |
| S15 | -.111 | -.111 | .111 | .263 |
| S17 | 1.000 | -.263 | 1.000 | -.263 |
| S18 | .125 | -.263 | 1.000 | .111 |