Implications of Subliminal Classical Conditioning for Defeating the Use of Countermeasures in the Detection of Deception: Subliminal Evaluation of Classically Conditioned Stimuli

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Abstract

Traditionally, classical conditioning paradigms have focused on reflexive responses to stimuli that are readily identified. In this research, the probability and magnitude of electrodermal responses elicited by stimuli below awareness levels (subliminal) were investigated. Thirty male college students were randomly assigned to either a supraliminal or subliminal treatment group (15 per group). During conditioning employing a partial reinforcement schedule, one of three geometric shapes presented at awareness level (supraliminal) was paired with a 1 to 4 milliampere electrical shock of 250 milliseconds duration. After conditioning had occurred, subjects' electrodermal responses to sub- and supraliminally presented stimuli (the geometric shapes) were measured. Backward masking was used to reduce the probability of accurate stimulus recognition during the subliminal treatment condition. Data analysis showed that subjects in both conditions responded more frequently to target stimuli (CS+) than to stimuli which had not been previously paired with shock (CS-). While subliminally presented stimulus recognition accuracy did not differ significantly from chance level, the frequency and magnitude of subliminal treatment group responses to both the CS+ and CS- were greater than those of the supraliminal group. These results suggest that subliminally presented visual stimuli can elicit differential autonomic nervous system responding to CS+ and CS-. The higher rate of responding and larger response magnitudes observed in the subliminal group may, however, have been due to generalized CS+ expectancy in a situation where the stimuli could not be accurately identified.

Attempts to define the unconscious and to explain unconscious processes have varied from those originally proposed by Freud, to more recent efforts to describe these processes in cognitive terms. At the root of the problem is the lack of a clear definition of "unconscious." The term "subliminal perception" has been used to describe the effects of unconsciously perceived stimuli on conscious thought. The perceptual threshold is defined in traditional psychophysics as the stimulus level necessary for the subject to reliably report the presence of the stimulus 50 percent of the time. It is believed that stimuli which are presented below a subject's perceptual threshold are encoded and stored differently from those stimuli presented above that threshold. Conscious access to such differently stored material is not readily available. However, it can be demonstrated that this material can serve a "priming effect" in memory or recognition testing. Cognitive

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[1] Editor's Note: Dr. Cestaro, who later worked as a research scientists at the DoD Polygraph Institute, was with the Department of Psychology, State University of New York at Stoney Brook, when he completed this research in 1993. The complete report, including Director Comments and all appendices, is freely available at www.dtic.mil.

psychologists have since labeled this priming effect "implicit memory." Since this phenomenon has been addressed by psychodynamic researchers as well as those using cognitive techniques, both will be reviewed in this study.

Freud interpreted "unconscious memory" as the end product of an underlying dynamic process taking place below awareness but manifesting itself as conscious behavior or ideation. The driving forces motivating behavior were claimed to be a person's unconscious wishes and fantasies. However, Freud failed to back up his claims with data collected in controlled studies. Recent studies in the psychodynamic arena have attempted to use empirical methods to support Freud's ideas. The subliminal psychodynamic activation (SPA) method has been used to provide researchers with data to support the notion that unconscious processes can influence conscious behavior (Silverman, 1976, 1983). Using systematic controlled laboratory procedures, researchers have attempted to show that unconscious stimuli have an effect on pathology in both clinical and non-clinical populations; they have achieved varying degrees of success.

In Silverman's studies, subliminally activating stimuli consisted of 4-millisecond tachistoscopic exposures of verbal or pictorial stimuli "with content designed to stimulate the unconscious wishes, anxieties, and fantasies that psychoanalysis views as central motivators of behavior" (Silverman, 1983, p.70). In all cases, the control stimuli consisted of neutral material. In the experimental condition, post-stimulus increases in depressive thinking, pathological thinking, and nonverbal behavior were demonstrated in clinical patient populations involved in these studies. These results were not obtained when the stimuli were presented supraliminally.

These findings have been criticized by various researchers (Balay & Shevrin 1988, 1989, Fudin, 1986) and supported by others (Weinberger, 1986, 1989). Balay and Shevrin (1988) criticize methodological weaknesses in all of Silverman's studies, and take to task the assumptions that subliminal stimuli can activate unconscious conflict, and that these findings are consistent with psychoanalytic theory regarding the nature of this conflict. Methodologically, they question Silverman's lack of the use of a fixation point in the blank field and inattention to the visual angle subtended by the stimulus. It should be determined what portion of the stimulus registers subliminally on what portion of the retina. The fovea, the region of central vision consisting entirely of cone receptors, is the most highly discriminating portion of the eye, and subtends a visual angle of less than 3 degrees. It is possible that the stimuli which registered only in the region of central vision were responsible for the subliminal effect, and any negative findings may be due to stimulus perception in the peripheral vision system. Therefore, to expose the stimuli foveally, the subject's focus of attention prior to and during stimulus exposure must be controlled. According to Fudin (1986), the stimuli used by Silverman would subtend a visual angle of approximately 4 degrees by 5 degrees. Balay and Shevrin (1988) also note the lack of structural and psychological similarity in the control and experimental stimuli, and the statistical problems created by using change scores. Fudin (1986) also questions the structure dissimilarities in Silverman's studies. He questions why Silverman asserts that the stimulus PEOPLE ARE WALKING (the control stimulus) is similar in structure to MOMMY AND I ARE ONE (the experimental stimulus). The stimuli used by Condon and Allen (1980) consisting of a control card containing a sentence using the random letters DGAHY LIJ G CLR SKU and a card with the subliminal message MOMMY AND I ARE ONE, are more structurally consistent than those used by Silverman. Porterfield and Golding (1985) state the problem of neutrality of the message could be controlled by using a random arrangement of the letters in MOMMY AND I ARE ONE in the control stimulus (e.g., DMNOA NIM Y ERO EMA). According to Balay and Shevrin (1988), Silverman walked boldly into the lion's den of two controversial areas: subliminal perception research and the empirical validity of psychoanalysis, neither of which is accessible to direct observation and both of which deal with concepts that are for many people counterintuitive.

Adding to the controversy over the validity of the psychodynamic activation hypothesis, Spence (1964) reported that the word cheese, presented subliminally (1/50 second duration), increased subjects' subjective hunger. Spence presented 10 cheese and 10 blank slides in random order, instructing his subjects to respond to each slide by writing something or nothing. Subjects were to rate their hunger prior to presentation of the stimuli, and again immediately following the subliminal word list presentation. Hunger ratings were higher after presentation of the subliminal word list. His findings were disputed by Jennings and George (1970) on the grounds that Spence did not use a control group, and did not control for the possibility that differential data between pre- and post-stimulation sessions may have been attributable to suggestions of hunger given to the subjects by a supraliminal word list which they had seen, and by the hunger-rating scales they had to fill out during the experimental session. Spence was also criticized for not using a forced-choice method, in that subjects could avoid making difficult discriminations by using the "nothing" response. George and Jennings (1972) attempted to replicate Spence's findings, with the addition of a multiple-choice format to force subjects to make a discrimination, and found no differences between the subliminal and supraliminal groups.

In addition, non-psychodynamic experimental research has studied unconscious learning and the perception of stimuli that are below the level of awareness, in an attempt to show that these stimuli have some cortical representation that can be brought into awareness (Eich, 1984, Marcel, 1983, Bornstein, Leone, & Galley, 1987). In a shadowing study conducted by Eich (1984), it was shown that subjects could recognize and spell previously unattended homophones (words spelled differently, having the same pronunciation, such as PEAR and PAIR), and he claimed that these results offered evidence that remembering does not have to be deliberate or intentional. In this study, subjects were to attend to an essay presented on the right channel through a pair of stereo headphones, and were told they would be tested later for comprehension of the material presented. They were also informed that during the experimental session, extraneous information of an unspecified nature would be presented on the left channel. On completion of the shadowing task, the subjects were to generate a short spoken synopsis of the shadowed material. The next task was to listen to a list of words spoken by the experimenter and state aloud whether the word was old or new (i.e., had or had not been presented on the unattended channel), and to assign a confidence rating (1 = definitely old; 2 = probably old; 3 = guessing old; 4 = guessing new; 5 probably new; 6 = definitely new) to each word spoken. Following this recognition task, subjects were to spell a series of 64 words spoken by the experimenter, of which 16 were old homophones, 16 were new homophones, 8 were old nonhomophones, and 24 were new nonhomophones. A typical old homophone presented during the experimental session was taxi-FARE, with the tested old homophone being FARE. On the recall task (spoken synopsis) subjects did poorly, and did not perform significantly better on the recognition portion of the test, consistent with the claim made by many researchers that there is little or no long-term retention of unattended events. However, the results of the spelling test revealed that the probability of spelling a homophone in line with its less common interpretation was higher if the item had been presented on the unattended channel.

Kleepsies and Wiener (1972) investigated the orienting response as an indicator of subliminal perception. According to Rosenman (1968), a saccadic eye movement ("orienting reflex") toward the display would be expected if there is any input from a briefly exposed stimulus. The dependent measures used by Kleepsies and Wiener (1972) were frequency and latency of first eye movement ("orienting reflex"), and "report" data from the subjects. Subjects were instructed to respond on the thematic content (threatening versus non-threatening) and stimulus structure (angular versus curved) of stimuli presented at subliminal and supraliminal levels. Typical stimuli were high contrast photos of a man seated with his right forearm bent up toward his head. In the threatening situation, he was holding a revolver in his right hand. In the non-threatening photo, he was holding a pipe

in his right hand. Curved structure was defined as smooth, curving lines on both the threatening and non-threatening stimuli, while angular structure was defined as straight lines and sharp angles on the threatening and non-threatening stimuli. These researchers found no differences which were a function of thematic content, at any exposure duration.

A number of studies have shown that there is a significant, measurable, positive attitude change toward stimuli to which subjects have been merely exposed for short duration. This subliminal mere exposure effect has been successfully demonstrated using plain geometric shapes (Kunst-Wilson & Zajonc,1980; Bornstein, Leone, & Galley, 1987), and subliminally presented photographs of people (Bornstein, Leone, & Galley, 1987). Bornstein, et al., (1987) also have shown that this mere exposure effect enhances subjects' attitudes toward persons in the natural environment when subjects have been subliminally exposed to photographs of those persons. In all cases, the emphasis has been on changes in observable behavior or affect that could be attributable to information which subjects were not able to verbalize.

Using electrophysiological methods, McCleary and Lazarus (1949) and Lazarus and McCleary (1951) were able to demonstrate that subjects were able to make discriminatory responses, as measured by electrodermal responses (EDRs), to stimuli presented at speeds too rapid for conscious recognition. These researchers presented five-letter nonsense syllables to subjects, flashed at speeds ranging from 6 ms to one second, on a screen placed seven feet from the subject. In all cases, the fastest speed produced recognition accuracy results which did not differ significantly from chance. However, those words which had been previously paired supraliminally (1 second duration) with shock on a partial reinforcement schedule produced a measurable change in EDR from levels associated with non-shock paired words. For this response, Lazarus and McCleary (1951) coined the term "subception." These results were supported by O'Grady (1977), but he noted that there were problems associated with some of the measures used. In O'Grady's experiment, emotional stimuli and neutral stimuli were the independent variables used to elicit a response in skin resistance. O'Grady found that mean deflections of skin response were higher for subliminally presented emotional stimuli than for subliminally presented neutral stimuli.

Emotional stimuli consisted of sexually charged photographs, and the neutral stimuli were photographs considered to have no emotional value, such as a hat, a dog, and a bridge. O'Grady also states that according to Chun and Sarbin (1968), Lazarus and McCleary (1951) failed to establish a distinction between preverbal and verbal skin resistance, and that the verbal skin resistance measures contaminate the subception effects. O'Grady describes the preverbal measure as the skin resistance --- after the stimulus presentation but before decision and report. The verbal skin resistance is said to be a function of the subject's cognitive decision and subsequent verbalization. Just how this temporal distinction is made is unclear. Chun and Sarbin (1968) believe that verbal skin resistance measures appear more similar to the resistance measures reported by Lazarus and McCleary (1951).

More recently, Masling, Bornstein, Poynton, Reed, and Katkin (1991) have been able to support Silverman's (1976) findings using electrophysiological methods. Using an arousing experimental message (NO ONE LOVES ME) and a neutral control message (NO ONE LIFTS IT), subjects exposed to the short duration (4 ms) arousing message showed a significant increase in EDR when compared to controls. These results support Silverman's hypothesis that drive-related stimuli presented below awareness thresholds produce significant effects on behavior.

In addition to research using visual stimuli, some studies have been conducted using subliminal (masked by 40 dB white noise) auditory verbal stimuli. One such study by Borgeat and Goulet (1983), showed a significant effect of "activation subliminal suggestions" on physiological measures of heart rate, EMG, and EDR during and following a stressing task. During the experimental task, subjects were exposed to auditory 25-dB activating and deactivating

suggestions masked by a 40-dB white noise signal. For the deactivating subliminal auditory messages, suggestions of heaviness and warmth on the various parts of the body, and suggestions of subjective calm, relaxation, and sleepiness were employed. The subliminal activating suggestions suggested muscle energy and activity in the same parts of the body, and urge and readiness for some action to be accomplished in the future. Similar results were obtained by Borgeat, Elie, Chalout, Chabout, and Louis (1985) using an auditory attend/non-attend paradigm on measures of EDR, EMG, and heart rate.

A novel approach to subliminal activation was taken by Kaser (1986). In his research, he studied the effects of a subliminal message on subjects' production of images and dreams. The subliminal stimulus consisted of an audio-taped sung message speeded up until it could not be consciously understood by subjects. This message was mixed with a normal music recording and played to subjects in the experimental group.

The control group heard the normal music without the subliminal message. Both groups produced a pretest drawing before the tapes were played, an imagery drawing immediately after hearing the tapes, and a dream drawing of any dream they might have had on the night following the stimulus session. Drawings were rated on a scale of 1 to 3 for their manifest and latent content, with manifest content defined as being "any part depicting a literal interpretation of the objects, ideas and/or situations referred to in the message fragment." Latent content was defined as being "any part depicting a symbolic representation of the objects, ideas and/or situations referred to in the message fragment." A significant difference was found between the dream drawings and imagery drawings of the control and experimental groups. The effect of the subliminal message delivered to the experimental group showed the effect of the subliminal message when examined by two art therapists who were blind as to what type of drawing they were rating. No such effect was found on the control group.

The intent of the present research was to evaluate the effect of supraliminal classical conditioning on autonomic nervous system responses measured during supraliminal and sub-threshold presentations of the conditioned stimulus. An aversive stimulus (shock) was used as the unconditioned stimulus (US) paired with a previously neutral stimulus (a plain geometric shape) used as the conditioned stimulus (CS+). The dependent measures were the magnitudes of the electrodermal response (EDR) above baseline, and the proportions of responses (probabilities) to the CS+ and CS- after conditioning.

Method

Subjects

Thirty six undergraduate males served as subjects. Fifteen subjects were used in each of two experimental conditions. Subjects were recruited from an undergraduate subject pool and were given credit for participation. Additionally, each subject was paid ten dollars upon completing the experiment. Six subjects were dropped from the analysis because of equipment malfunctions.

Apparatus

Visual stimuli consisted of three plain, two-dimensional geometric shapes; a circle, a square, and a triangle (see Appendix A). The stimuli were printed black on white on 35 mm slides placed in a Kodak Carousel slide projector and projected onto a .75 meter by 1 meter screen placed opposite the subject in an acoustically damped chamber, with the stimulus subtending a visual angle of approximately 8 degrees. A red solid-state laser, placed adjacent to the slide projectors, was used to project a 6 mm diameter spot on the center of the screen to function as a visual fixation point and warning light signaling the upcoming stimulus presentation. A video monitor with a 63.5 cm diagonal viewing area was placed 1.25 meters in front of the subject, directly below the projection screen, to provide instructions during the session. Tachistoscopic shutters were placed directly in front of each of the two slide projector lenses to control the stimulus duration.

One slide projector was used to present the CS. The second slide projector was used to present the masking stimulus during subliminal trials, consisting of mixed,

discontinuous horizontal and vertical grating lines with a frequency of 1 cycle/degree (see Appendix B). To reduce the effects of over-stimulation of the rods in the retina and to control for long-duration visual after-images, both projectors were equipped with red filters. Each of the three shapes was presented in pseudo-random order during all trials. Electrodermal activity was detected by Beckman Ag-AgCl electrodes with a surface area of .8 cm^2 placed on the hypothenar eminence of the subject's nondominant palm, using cream composed of .O5M NaCl in Parke-Davis unibase (Fowles, Christie, Edelberg, Grings, Lykken & Venables, 1981). Skin conductance was detected by a constant voltage skin conductance coupler designed by Lykken and Venables (1971), and amplified and recorded by a Grass Model 7 Polygraph. An electrode assembly consisting of two concentric rings fabricated from stainless steel, mounted in a nylon holder, was used to administer shock (Turskey, Watson, & O'Connell, 1965). Each of the two ring electrodes had a machined depression to hold a sponge saturated with a saline solution and coated with conductive electrode jelly. The electrode assembly was placed on the ventral surface of each subject's nondominant forearm approximately equidistant from the wrist and elbow and secured with Velcro straps attached to the electrode assembly.

The subjects were instructed to make responses to the stimuli using the dominant hand. A PC compatible 386 computer with a Data Translation DT2821 digital/analog I/O board was used to advance the target slide projector carousel, control the laser projector, open and close the two tachistoscopic shutters, control the application of voltage to the shock electrodes, control presentations on the video monitor, apply the CS+ and CS- polygraph timing marks, and for recording subjects' button responses. During the conditioning trials shock was administered, under the control of the computer program, on 8 of the 15 presentations of the shape selected as the CS+ (partial reinforcement schedule). One analog channel was used to place a single timing mark of 1 cm amplitude on the polygraph paper contiguous with the presentation of each CS- and a double timing mark of 2 cm amplitude contiguous with the presentation of each CS+. These marks served as points to begin electrodermal response measurements. The timing marks occurred at every stimulus onset. The timing marks were calibrated for half-scale deflection (approx. 2 cm) for the CS+ and quarter-scale deflection (approx. 1 cm) for the CS- of approximately 150 ms duration. Subject responses were made on a three-button box placed within easy reach of the subject's dominant hand. The remaining analog channel was used to place timing marks of 150 ms duration and 2 cm amplitude on the polygraph paper contiguous with the subjects' response on the button box. This served as a measure of response time, and also was used to account for any possible EDR artifacts attributable to motor responses. Electrodermal responses were recorded on continuous polygraph paper, on a channel lying between the timing mark channels. Button choices were displayed on the video monitor, located below the projection screen, as representations of each of the three shapes. The arrangement of the shape choices was randomly assigned in each trial to reduce the effects of response bias on the part of the subject. Below each shape, the numbers 1, 2, and 3 were displayed, corresponding to the arrangement of the response buttons on the button box. Beck Depression Inventory and Spielberger State/Trait Anxiety Index questionnaires were used to collect psychological data from each subject.

Procedure

Prior to participating in the experiment, each subject filled out a Beck Depression Inventory, a Spielberger State/Trait Anxiety Index, a Medical History Questionnaire, and was given a short oral and written briefing describing the purpose of the experiment (see forms in Appendix C).[2]

[2] Due to space considerations, Appendix C was not included in this publication. Interested readers can download the complete report at www.dtic.mil.

Before trials began, one carousel slide projector was loaded with slides consisting of the three geometric shapes, arranged in pseudo-random order. Two separate arrangements of stimuli were used; set one for the habituation, test, and extinction trials, and set two for the acquisition trials. There were 15 of each of the three shapes, arranged such that each of the three shapes was presented in a pseudo-random order for the entire 45 trial set. Subjects in each group were placed in an acoustically damped chamber, seated in a comfortable leather chair, facing the stimulus projection screen and the video monitor on the opposite side of the chamber. The shock electrodes and EDR electrodes were placed on the subject at this time. The response box was placed within reach of the subject's dominant hand.

Prior to the experimental trials, each subject was exposed to a 11 stimulus-adjustment procedure to determine the two levels of shock judged to be at (1) pain level, and (2) tolerance level for that subject. Results of a short pilot study had shown that a shock level of 1 ma was probably sufficiently aversive for reliable conditioning. Subjects not meeting this minimum criterion were dropped from the experiment but given full credit for their participation. The subject self-administered shock by pressing one of the buttons on the button box. The subject administered shock as many times as he needed to determine each level. After the pain level was determined by the subject, the subject signaled so by pressing another button on the button box, which advanced the computer program to the tolerance level adjustment procedure and signaled the experimenter to adjust the electrical stimulator accordingly. EDRs were recorded during the adjustment and rating procedure to establish the occurrence of a response to the stimulation.

Completion of the two rating levels advanced the program to the baseline EDR procedure. The baseline EDR was run for 5 minutes to establish a stable baseline measure of electrodermal activity and allow the experimenter time to calibrate the EDR channel for each subject. No subject responses were required during this procedure.

Following the above adjustment and baseline procedures, all thirty subjects participated in the habituation/recognition condition prior to the acquisition trials. Fifteen presentations of each of the three stimuli (45 trials total) were made, with stimulus durations of 8 ms. Pilot studies had shown that the 8 ms stimulus duration was sufficient for reliable recognition of the simple geometric shapes used in this study. No visual masking was used during these trials. The subject's task was to attempt to identify each of the shapes by pressing the appropriate button on the response box. This period also served as a practice session to familiarize the subject with the procedures. A 70% correct response rate was used as the criterion for reliable recognition, although the pilot studies had shown that 100% accuracy could be obtained with reasonable consistency. It was expected that recognition rates would be high in the supraliminal conditions and also in the habituation condition in the absence of any masking stimulus (see Merritt & Balogh, 1989, p. 577). To ensure appropriate motivation to respond accurately, subjects were informed, prior to the experiment, that monetary payment would be made to them, with the amount contingent on the number of correct responses made in all trials. At the end of the experiment, all subjects received the same amount of compensation.

Prior to the experiment, all subjects were told that this study would be investigating the relationship between short presentations of visual stimuli and autonomic nervous system activity. Each subject was informed that occasionally during the experiment he would experience a sensation on his forearm similar to the one experienced during the "stimulus-adjustment" procedure conducted prior to the experimental session. At the end of the experiment, subjects were informed of the actual purpose of the experiment.

During the experimental trials, each subject was instructed to fixate on the red warning light which was projected on the center of the stimulus screen either 1.5, 2.0, or 2.5 seconds before the presentation of each target stimulus. These presentation delay times were randomized for each subject within each set of trials to avoid temporal effects.

The subjects were informed that the stimulus would be presented sometime after the red light was illuminated. The red warning light was extinguished three seconds after masking stimulus offset in the subliminal condition, and three seconds after target stimulus offset in the supraliminal conditions, signaling the subject to make a response. The subject was instructed to press the button on the response box corresponding to the shape of the figure perceived during the stimulus presentation following the warning light. In all cases, the subject was forced to make a choice since there was no button associated with uncertainty.

During the habituation/recognition condition no shock was administered. EDRs were recorded and time-marked at each presentation of a stimulus. Target stimulus duration was 100 ms in the supraliminal conditions, and 8 ms in the subliminal conditions, for each stimulus figure, with a minimum ITI of 138 to allow for return to baseline. ITIs could extend beyond 138 if the subject was slow in making a decision and responding. In the subliminal test trials, the masking stimulus was presented for a period corresponding to a 5 to 1 mask/target ratio (40 ms). In all conditions, the subject was instructed to press the button on the button box corresponding to the perceived stimulus shape. The supraliminal acquisition session, consisting of 15 presentations of each stimulus (45 trials), was run immediately after the habituation/recognition condition.

The CS+ stimulus was randomly assigned to each subject by the software. Again, the subject was instructed to press the button on the button box corresponding to the figure perceived on the projection screen. Within the acquisition trials the CS+ onset was followed two seconds later by a 250 ms duration shock delivered to the subject through the shock electrodes (trace conditioning). The US (shock) was administered in only 8 of the 15 presentations of the CS+ (partial reinforcement schedule). These eight presentations were randomly distributed within the acquisition trials. Although the conditioned stimulus was a compound stimulus consisting of the laser dot and the CS+, the laser dot was presented within all trials, under all conditions, and did not add any additional information that would enable differentiation between a CS+ or CS- on the upcoming presentation.

The next set of 45 test trials without shock was administered to measure EDR during presentations of the three stimuli to assess the effects of any acquisition of the CS+. A final set of 45 trials without shock, in which the three stimuli were presented at supraliminal durations, established extinction to the CS+.

Results

Recognition Accuracy

To test the effectiveness of the backward masking of the short duration (8 ms) visual stimuli, subjects were tested for correct identification (recognition) of the stimuli during the habituation and test trials.

The subjects in the supraliminal group correctly identified nearly all the visual stimuli (93% to 100%). Furthermore, recognition of the short duration unmasked presentations during the habituation trials was nearly perfect for all subjects in both groups (96% to 100%).

In the masked test trials, the subliminal group demonstrated chance or near chance recognition, ranging from 33% to 62% correct responses. Z-tests for the significance of these proportions of correct responses vs. expected responses (chance) showed probabilities ranging from .28 to 1. No subjects in this group obtained recognition probabilities which were significantly different from chance levels (i.e., 33%), indicating that the masking was effective in preventing recognition of the short duration target stimuli. Data were analyzed three ways to test the effectiveness of the conditioning procedure, using a strict conditioning criterion, a relaxed conditioning criterion, and no criterion.

Strict Conditioning Criterion

All 36 subjects showed skin conductance responses to the shock stimulus during stimulus adjustment trials and acquisition trials. Responses were defined as increases in skin conductance of at least 0.1 microsiemens with onset latencies of 1-3

seconds after CS presentation. However, six subjects were dropped from the study because of equipment failure during the experimental sessions, and 22 were excluded from this data analysis because they failed to meet the strict conditioning criterion of three phasic responses to the CS+ during test/extinction trials.

The eight remaining subjects were distributed equally within the two test conditions.

Response Probabilities

Response probabilities were calculated as proportions (number of valid responses elicited by each stimulus type [CS+ or CS-] divided by the total number of possible responses for each stimulus type). There were 15 CS+ stimuli and 30 CS- stimuli within each 45 trial set. If a subject had three CS+ responses and three CS- responses, the probabilities would be .20 and .10 respectively. If there was more than one response to a CS, only the first response was counted. Of the 30 subjects tested, only eight met the conditioning criteria (four in the subliminal condition and four in the supraliminal condition). The mean response probabilities for CS+ and CS- for subjects in both the supraliminal and subliminal groups are shown graphically in Figure 1. Analysis of variance of response probabilities indicated a significant main effect of stimulus type ($F = 11.117$, $df = 1,6$, $p = .016$).

Response Magnitudes

Mean SCR magnitude in microsiemens for each subject was obtained by dividing the sum of the individual response magnitudes for each of the two stimulus types by the number of valid responses per stimulus type for that subject within each trial set. The individual mean response magnitudes are shown in Table 1, and the group means are depicted in Figure 2. Mean magnitudes were greater for subjects in the subliminal condition for both CS+ and CS-. In addition, for subjects in the subliminal group, response magnitude was greater to CS- than CS+, whereas in the supraliminal group, response magnitude was equal to CS+ and CS-. Analysis of variance (ANOVA) of the data contained in Figure 2 revealed a non-significant main effect of groups ($F = 5.046$, $df = 1,6$, $p = .066$), a main effect of stimulus type ($F = 6.331$, $df = 1,6$, $p = .046$), and a group x stimulus type interaction ($F = 5.9471$ $df = 1,61$ $p = .051$).

Questionnaires

Subjects' scores on the Beck Depression Inventory (BDI) and Spielberger State Trait Anxiety Index (STAI) also were analyzed. Scores are shown in Table 2, in which it may be seen that lower scores were obtained by subjects in the subliminal group. A between-groups t- test showed significant differences in BDI scores between subjects in the subliminal group and those in the supraliminal group ($t = -4.078$, $df = 6$, $p < .01$). Subjects who had valid electrodermal responses to the subliminal CS+ had significantly lower scores on the BDI than those subjects who had valid responses to the supraliminal CS+. Although the same directional trend was noticed in the STAI scores, analysis of these data did not show significant differences between the two groups.

Relaxed Conditioning Criterion

Relaxing the selection criterion to use those subjects who had at least one phasic electrodermal response to the CS+ increased the sample size to 20 subjects, 10 per condition. Response probabilities and magnitudes were calculated as they were for the previous subject set.

Figure 1. Response probabilities of skin conductance responses to CS+ and CS- within the two groups with N = 8.

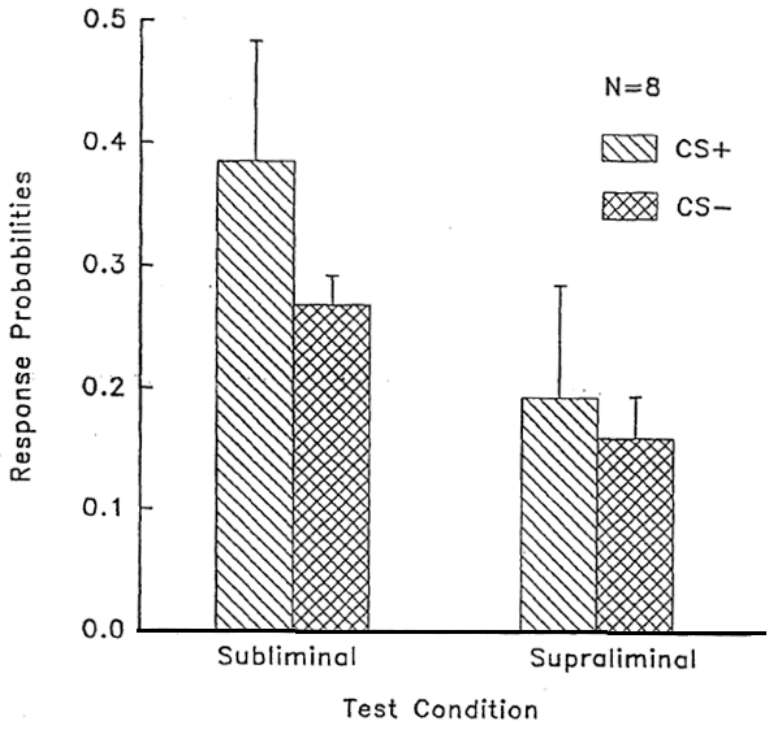


Table 1. Individual Skin Conductance Response Magnitudes in Microsiemens for Both Groups With N = 8

	Group			
	Subliminal		Supraliminal	
	CS+	CS-	CS+	CS-
	1.20	1.80	.63	.56
	.75	1.05	.20	.20
	1.05	2.00	.43	.43
	.43	.50	.63	.73
MEAN	.858	1.338	.473	.480

Figure 2. Changes in skin conductance magnitude as a function of condition with N = 8.

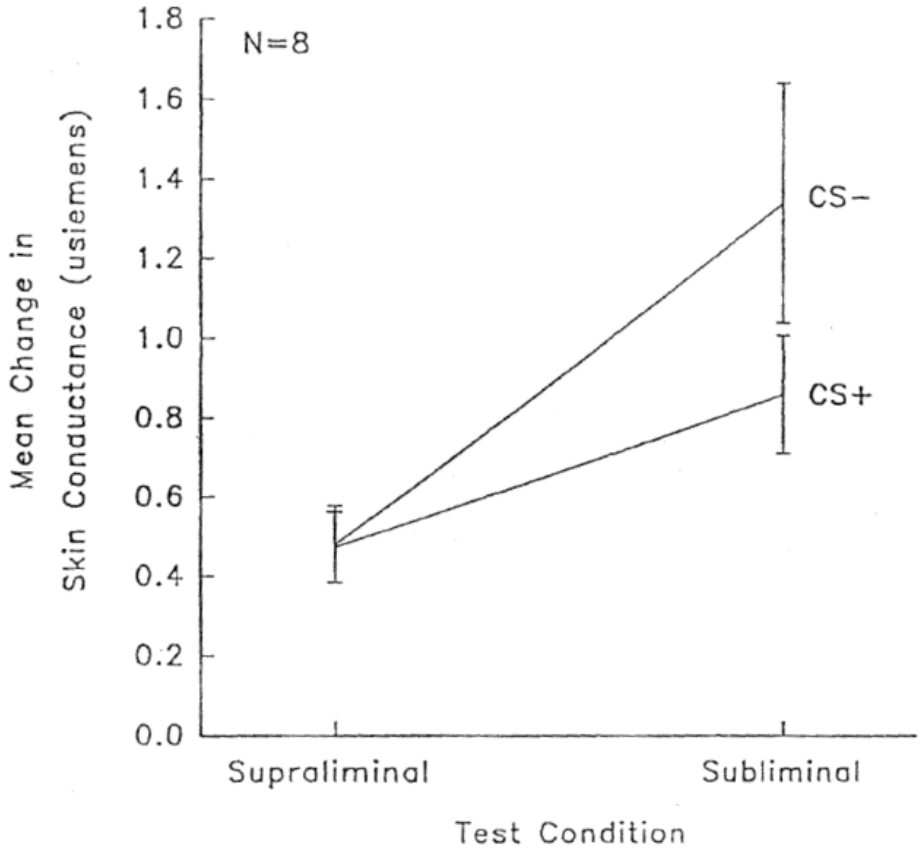


Table 2. Scores Obtained on the Beck Depression Inventory and the Spielberger Trait Anxiety Index

	Beck		Spielberger	
	Supra	Sub	Supra	Sub
	9	4	35	30
	7	1	43	36
	8	0	35	21
	5	1	33	35
MEANS	7.25	1.50	36.5	30.5

Response Probabilities

The mean response probabilities for CS+ and CS- for subjects in both groups are depicted in Figure 3. A two-way analysis of variance (ANOVA) revealed a significant main effect of stimulus type, CS+ or CS- ($F = 11.72$, $df = 1,18$, $p = .003$), indicating that all subjects responded more frequently to CS+ than to CS-.

Response Magnitudes

The group means for the larger subject set are shown in Figure 4. Consistent with the findings for the smaller group, mean magnitudes were greater for subjects in the subliminal condition for both CS+ and CS-.

For subjects in the subliminal group, response magnitude was greater to CS- than CS+, whereas in the supraliminal group, response magnitude was greater to CS+ than CS-. Analysis of variance of the data contained in Figure 4 revealed a main effect of groups ($F = 4.292$, $df = 1,18$, $p = .053$), and a non-significant group x stimulus type interaction ($F = 2.33$, $df = 1,18$, $p = .144$).

Figure 3. Response probabilities of skin conductance responses to CS+ and CS- within the two groups with N = 20.

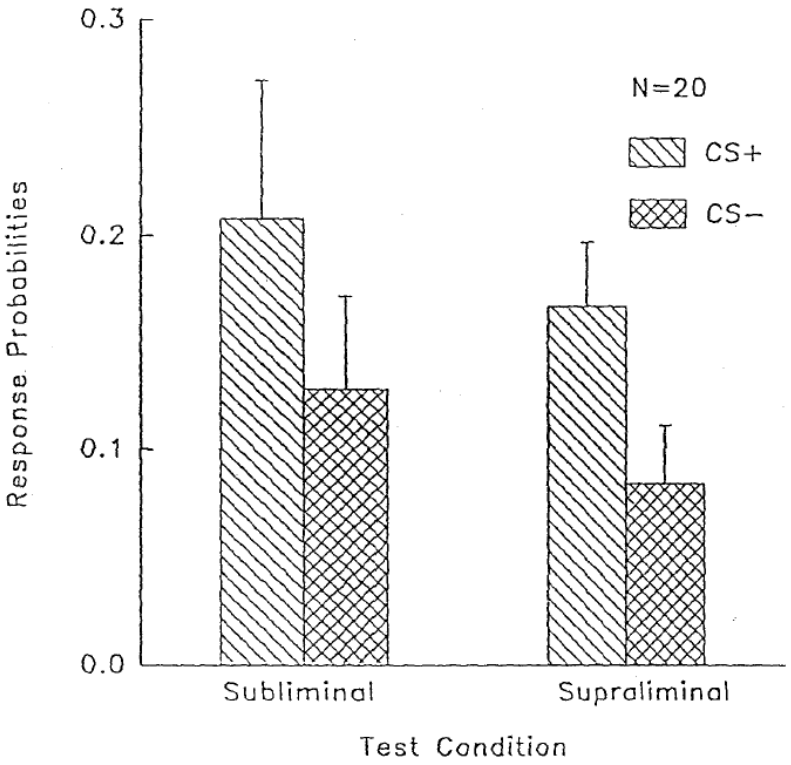
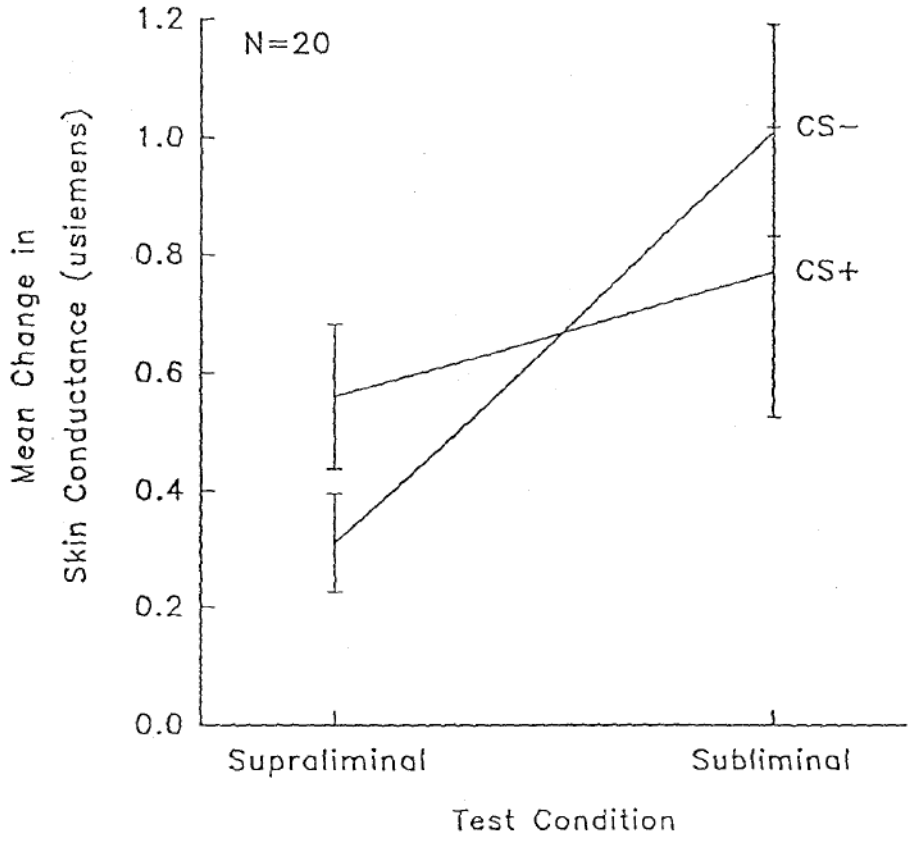


Figure 4. Changes in skin conductance magnitude as a function of condition with N = 20.



Questionnaires

Subjects' scores on the Beck Depression Inventory (BDI) and Spielberger State Trait Anxiety Index (STAI) did not differ significantly between the two groups. Since subjects were not assigned to groups by BDI or STAI scores, no relationship between groups and scores on these measures was expected. However, as with the smaller group, the subliminal group had lower mean scores on all three measures. BDI scores were 4.9 vs. 7.5, Spielberger State scores were 33.9 vs. 37.5, and trait scores were 35.1 vs. 36.0 respectively for the subliminal and supraliminal groups.

No Conditioning Criterion

The final analyses included all subjects who participated in the experiment. The remaining ten subjects added to these analyses had no responses to either the CS+ or CS-, with the exception of one subject who had a single CS- response.

Response Probabilities

A two-way analysis of variance revealed a significant main effect of stimulus type, CS+ or CS- ($F = 8.72$, $df = 1, 28$, $p = .006$), indicating that the addition of the ten subjects with no CS+ or cs- responses did not have a significant effect on the results.

Response Magnitudes

A final analysis of variance of response magnitudes failed to reveal the groups effect found in the previous analyses ($F = 2.41$, $df = 1, 28$, $p = .13$).

Questionnaires

Between-groups t-tests of all three psychological measures for all 30 subjects did not reveal any significant differences between

groups. Additionally, no differences were found between the ten non-responding subjects and the twenty subjects who demonstrated acquisition of the conditioned response.

Discussion

The results of this experiment demonstrate that there were measurable phasic responses to both the supraliminal and subliminal conditioned stimuli (CS+), with larger response magnitudes and higher probabilities of responding occurring in the subliminal condition. All subjects were able to accurately identify the unmasked short duration visual stimuli, confirming that there was sufficient stimulus energy for visual perception. Presentation of the mask in the subliminal condition reduced recognition to chance or near chance levels, establishing the effectiveness of the mask. Although the differential responding to CS+ and CS- in both conditions met predictions when response probabilities were analyzed, the reversal in relative response magnitudes to CS+ and CS- between the two groups and the overall greater response magnitudes in the subliminal group were not predicted. Both phenomena are difficult to explain, given that all subjects in the subliminal group identified the short-duration, masked stimuli at levels not significantly different from chance. Additionally, the greater proportions of responses (probabilities) in the subliminal condition when compared to the supraliminal condition are not easily explained. This means that the CS+ got more responses, but magnitudes were larger for the CS- responses. However, since the stimuli were not accurately recognized by subjects in the subliminal condition, the higher rate of responding to both stimuli may be the result of a generalized expectancy of the conditioned stimulus (see Booth, Siddle, & Bond, 1989). Uncertainty of the signal value of the short flashes of light in the subliminal condition may have been responsible for the greater response probabilities shown in that condition for both the CS+ and CS-, but does not adequately explain the larger mean magnitudes of the CS- responses. This was not seen in the supraliminal condition. Group size (N = 8, N = 20) did not affect the results significantly, with the exception of the larger supraliminal group, which had a highly significant probability of responding to the CS+ ($p = .005$).

Portions of these findings were similar to those reported by McCleary and Lazarus (1949).

Although subjects were not able to report a correct conscious visual discrimination, they were still able to make discriminations between CS+ and CS- at the autonomic (unconscious) level as shown in the response ratio data represented graphically in Figures 1 and 3. None of the subjects' phasic electrodermal responses could be attributed to artifacts of the motor responses (pushing a button) required for stimulus identification.

A serious shortcoming of this study was the fact that so many subjects (22 of 30) failed to acquire a strong conditioned response. A majority of those subjects would have been dropped from the study if the conditioning criterion were not relaxed, leaving a relatively small group of subjects remaining in the final analysis. Although these results are encouraging, some changes in methodology may be necessary to support the underlying hypothesis. The large number of subjects not acquiring the stronger conditioned response, and the rapid extinction of the acquired response shown in the data may have been caused by low-level aversiveness of the unconditioned stimulus (electrical shock). Subjects were allowed to self-administer the shock and determine their own levels of perceived pain and tolerance during stimulus adjustment trials, which may account for early habituation, and subsequent weak conditioning and rapid extinction. Even though all 30 subjects progressed beyond the 1 rna level established during pilot trials, and some were able to tolerate 2 to 4 times that level, their subjective reports of pain threshold may have been premature due to anxiety and unfamiliarity with the stimulus.

Further studies should investigate more appropriate methods for determining a truly aversive US, either by establishing one relatively high stimulus level for all subjects, or by requiring a greater number of stimulus adjustment trials which in turn may prompt the subject to tolerate higher levels of

stimulation. Either of these methods may prevent early habituation during acquisition.

Any follow-on studies should investigate additional ways to elicit more robust responses.

Finally, the significantly lower BDI scores obtained by subjects in the strict criterion subliminal group may have been a chance occurrence. Since subjects in both groups demonstrated acquisition of the conditioned response, there appears to be no relationship between BDI scores and response acquisition. However, it may prove useful to design a study in which a subject population with very low and very high scores (e.g., lower third and upper third) on the Beck Depression Inventory is tested subliminally in order to examine response magnitudes and probabilities v BDI scores. This may reveal a relationship between subliminally driven autonomic reactivity and levels of depression.

Future research also may provide valuable insights into practical applications of subliminal techniques. Although there is considerable controversy over the use of polygraph equipment for lie detection (Lykken, 1978, Raskin & Hare, 1978, Ben-Shakhar & Furedy, 1990), it is possible that the use of subliminal methods may help to enhance the reliability and validity of polygraph tests.

Although the control question test {CQT) and the relevant/irrelevant technique (RIT) are considered to be two of the most widely accepted polygraph techniques in use today, (Ben-Shakhar & Furedy, 1990) most courts in this country will not admit polygraph data into evidence in criminal cases due to the poor validity of polygraph results in general. Valid results depend heavily on the expertise of the examiner, the belief in this expertise by the examinee, and the examiner's rapport with the examinee (Ben-Shakhar & Furedy, 1990). Additionally, the examinee's belief in the infallibility of the polygraph as a "lie detector" has a great deal to do with the outcome of the examination. The polygraph has yet to reveal a standard "lie response" and persons trained in countermeasures are well aware of the shortcomings of the instrument and the variability among examiners. The technique employed in this study, when used in a highly structured manner, may be more appropriate within the context of the guilty knowledge test (GKT), where information directly related to the commission of a crime could be presented at a subliminal level, along with presentations of unrelated or neutral information. Supraliminal presentations of neutral material could be interspersed as distractors. A subject who is not aware of the stimuli presented, with no expectation of when the stimuli will be presented, and who also is not aware of his unconscious (involuntary) responses would have extreme difficulty in employing timely counter-measures designed to deceive the examiner. Differential responding between neutral and relevant stimuli would indicate knowledge of concealed information known only to investigators and the guilty party. Basing these polygraph results against ground truth, gained through confession or reliable eyewitness testimony, would validate the technique. Polygraph examinations employing these methods may gain additional acceptance and support in the future.

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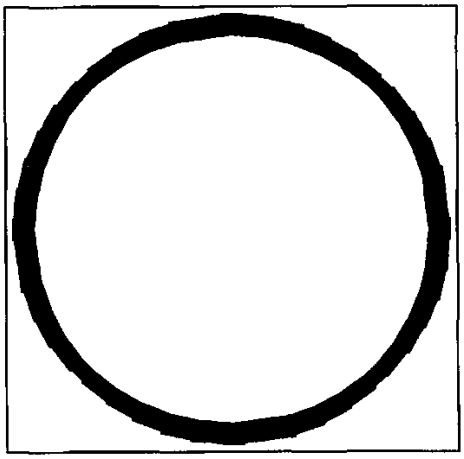
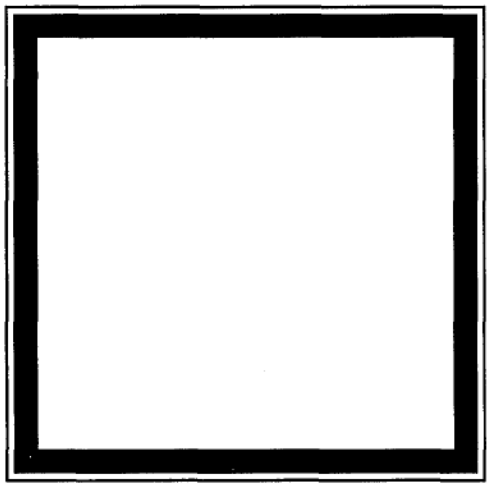
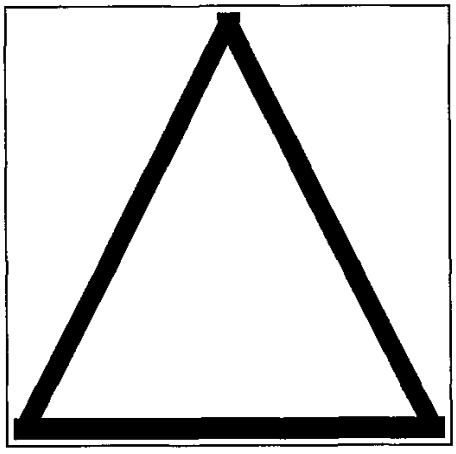
Appendix A

Plain Geometric Shapes Used as Visual Stimuli

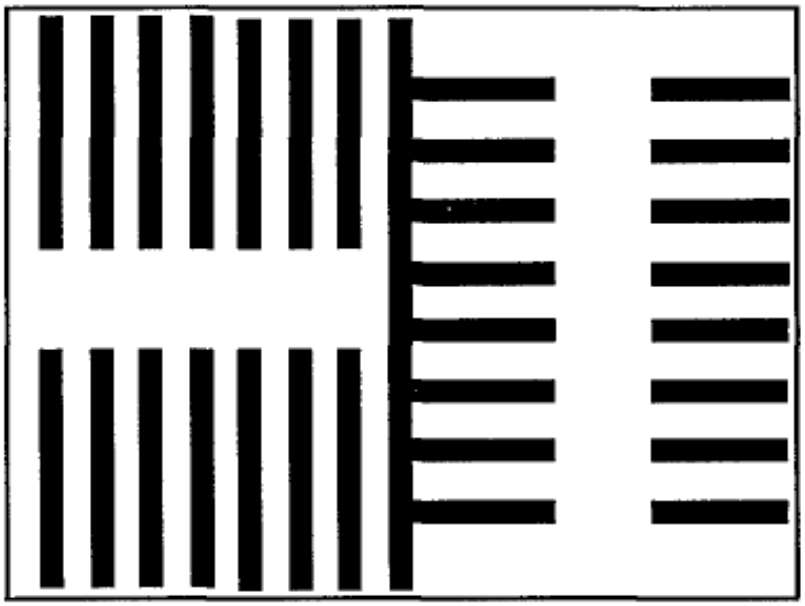






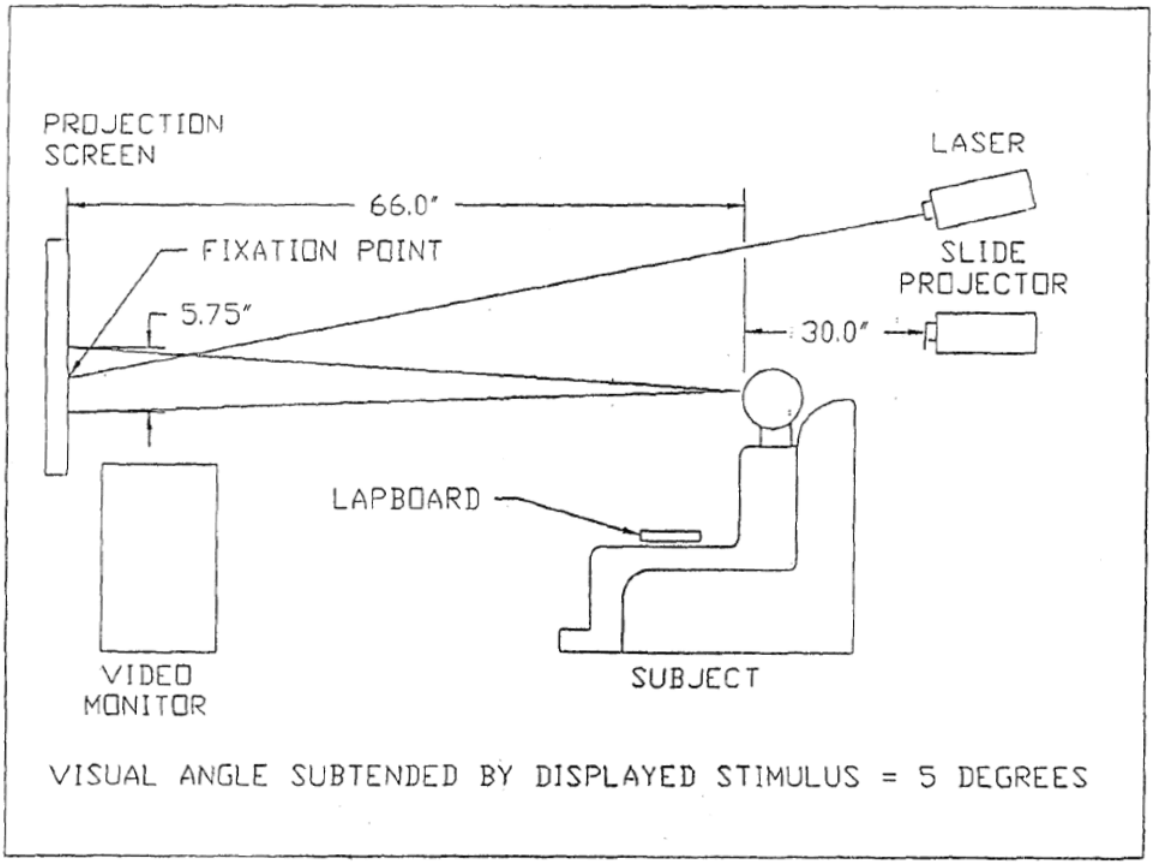
Appendix B

Vertical/Horizontal Visual Grating Pattern Used as a Mask for the Target Stimuli in the Subliminal Condition



Appendix D

Equipment Placement for Stimulus Presentation



Appendix E

Experiment Flow Chart