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Psychophysical and signal detection analyses of hypnotic anesthesia

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PSYCHOPHYSICAL AND SIGNAL DETECTION ANALYSES OF HYPNOTIC ANESTHESIA

by

Douglas Joseph Tataryn

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As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Douglas Joseph Tataryn

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and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

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ABSTRACT

Two experiments designed to study the effects of hypnotic suggestions on tactile sensitivity are reported. Experiment 1 utilized 40 subjects selected and classified into four groups according to their scores on the Stanford Scale of Hypnotic Susceptibility: Form C (SHSS:C). The effects of suggestions for anesthesia, as measured by both traditional psychophysical methods and signal detection procedures, were linearly related to hypnotic susceptibility. Experiment 2 employed the same methodologies in an application of the real-simulator paradigm, to examine the effects of suggestions for both anesthesia and hyperesthesia. A total of 19 undergraduate students were selected for their scores on the SHSS:C and classified into two groups: insusceptible simulators, who were given instructions to simulate the behavior of a highly hypnotizable person; and highly hypnotizable reals, who underwent a standard hypnotic procedure. Significant effects of hypnotic suggestion on both sensitivity and bias were found in the anesthesia condition, but not for the hyperesthesia condition. A new bias parameter, C', was derived which indicated that much of the bias found in the initial analyses was artifactual, a function of changes in sensitivity across conditions. There were no behavioral differences between reals and simulators in any of the conditions, though analyses of post-experimental interviews suggested the two groups had very different phenomenal experiences. Finally, a manipulation of response strategies induced different levels of sensitivity. The implications of

these and other similar findings for signal detection theory are discussed in the context of implicit and explicit perception. Taken together, these results indicate that hypnotic suggestions can produce genuine decrements but not increments, in tactile sensitivity. The magnitude of these changes are partly a function of which perceptual system -- the implicit or the explicit -- is implicated in the assessment of sensitivity. Overall, these conclusions are consistent with "neodissociation" accounts of hypnotic phenomena.

CHAPTER 1

HYPNOTICALLY INDUCED ALTERATIONS IN SENSORY FUNCTIONING

Hypnosis has been defined as 'a social interaction in which one person, the subject, responds to suggestions offered by another person, the hypnotist, for experiences involving alterations in perception, memory and action' (Kihlstrom, 1987). These alterations can be quite dramatic. For example, hypnotized subjects may see things that are not in the environment, or fail to see things that are. Or, an adult person may temporarily reexperience him- or herself as a child. And at the end of the interaction, the person may fail to remember the events and experiences that transpired while he or she was hypnotized.

Although hypnosis has been of interest to psychologists of all stripes since the latter part of the 19th century, it has only relatively recently that it has begun to be investigated with the conceptual and methodological tools of the modern psychologist. In a very real sense the controlled experimental study of hypnosis began with the work of Clark Hull (1933); and laboratory work became especially common with the introduction, beginning in 1959, of standardized techniques for assessing individual differences in hypnotizability (Hilgard, 1965) -- and thus enabling investigators to predict in advance who would respond positively to hypnotic suggestions.

Hence, in the past 30 years we have seen extensive psychophysical investigations of hypnotic analgesia (Hilgard & Hilgard, 1975), in depth discussions regarding the disrupted retrieval processes of posthypnotic amnesia (Kihlstrom, 1985), and the detailed study of hypnotic age regression (Nash, 1987). Although considerable progress has been made on many fronts (for reviews see Hilgard, 1965, 1975; Kihlstrom, 1985; Spanos & Chaves, 1989), however, it is still the case that many popular hypnotic suggestions remain unexamined with respect to their effects and the mechanisms underlying them.

One of these underexamined phenomena is hypnotic anesthesia, in which the subject receives suggestions for a loss or diminution in tactile sensitivity -- an effect somewhat analogous to the pain reduction observed in hypnotic analgesia. Suggestions for anesthesia play a role in the 'circle-touch' test proposed by Janet (1907) for distinguishing organic from functional anesthesia, and by Orne (1959) for distinguishing truly hypnotized individuals from simulators. In this procedure, subjects receive a suggestion for tactile anesthesia in a specific area of the skin, clearly delineated by a circle (drawn, for example, on the palm of the hand), and then are touched randomly inside and outside the circle. Subjects are asked to respond 'Yes' when they are touched outside the circle, where they can feel the stimulation, and to respond 'no' when they are touched inside the circle, where they cannot feel it. Janet (1907) and Orne (Orne, 1959) claimed that patients with functionally tactile anesthesia, and hypnotized subjects responding to anesthesia suggestions, respond appropriately -- clearly indicating, by their discriminative behavior, that at some level the touches applied to the anesthetized area are registered by the sensory-perceptual system. Orne takes such responding to be indicative of 'trance logic', by which he means that hypnotized subject's ability and willingness to mix contradictory mental representations of the real and imagined state of affairs. Two published investigations have been unable to confirm Orne's assertions about trance logic in the circle-touch test (Eiblmayr, 1987; McConkey, Bryant, Bibb, Kihlstrom, & Tataryn, 1990).

As another example, Wallace and Garrett (1973) and Wallace and Fisher (1982, 1984) have reported that suggestions for hypnotic anesthesia reduce or eliminate the perceptual-kinesthetic adaptation normally acquired by subjects asked to point at a target while gazing through a prism. The effect of wearing a prism is to displace the visual environment in a direction perpendicular to the axis of the prism. Initially, controled limb movements, such as pointing 'straight ahead' with an arm, are quite inaccurate, due to the prism-induced discordance between the visual and kinesthetic modalities. With practice perceptual adaptation occurs and the effects are greatly diminished or eliminated. After removal of the prism-glasses, a rebound effect often occurs, producing errors in the opposite direction of the initial discrepancy. This is known as a displacement aftereffect. Wallace and Garrett, (1973, 1975), and Wallace and Fisher (1979) have shown that hypnotic suggestions of anesthesia directed at the adapting limb eliminates the adaptation and displacement aftereffects, apparently via disrupting normal proprioceptive feedback mechanisms.

However, Spanos and his colleagues have reported several failures to replicate Wallace's effect (e.g., Spanos, Dubreuil, Saad, and

Gorassini, 1983; Spanos, Gorassini and Petrusic, 1981). In their studies, hypnotic anesthesia had no effect on perceptual adaptation. Close examination of the research, by each of the two laboratories, suggested that subtle methodological differences, such as the presence or absence of a visual target (Spanos et al 1981; Wallace and Fisher, 1982) and whether the prism goggles were removed between condition (Spanos et al, 1983) or left on throughout the experiment (Wallace and Fisher, 1984), might be responsible for the discrepancies.

In these two debates, the fundamental issue concerns the degree to which hypnotic suggestions for tactile anesthesia reduce sensitivity to touch, and the manner in which that reduction is accomplished. The use of the circle-touch test to discriminate between organic and functional anesthesias assumes that the tactile stimulus is registered by the sensory/perceptual system; the claim that anesthesia abolishes perceptual adaptation rests on the assumption that it is not. In all this research, however, no investigator has ever carried out a psychophysical study of the effects of anesthesia suggestions themselves. The purpose of the present research was to conduct just such an investigation, as a first step toward resolving the other empirical disputes.

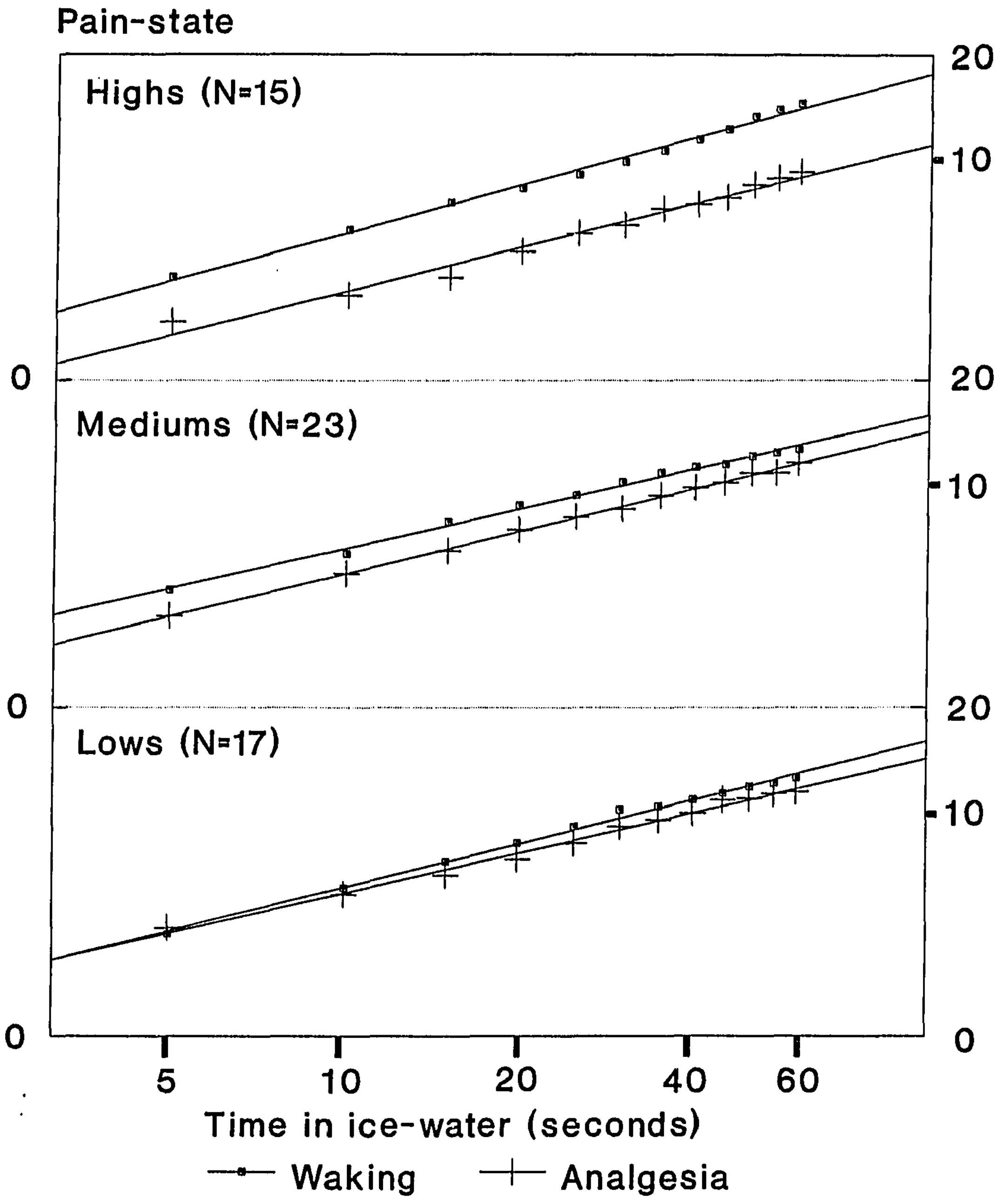
Psychophysical Studies of Hypnotic Suggestion

Such a psychophysical study is not wholly unprecedented, however. Investigations of this sort have been carried out in a number of domains, and these form the background for the studies reported here.

Analgesia. In a classic study of the relationship between the effects of suggestions for analgesia and hypnotic susceptibility, Hilgard (1967) initiated what has become the paradigmatic definition of a hypnotic phenomenon -- establishing the relationship between the magnitude of an effect and hypnotic susceptibility. Using the method of magnitude estimation, he collected pain reports from subjects whose arms had been submersed in circulating ice water (the cold pressor test). Perceived pain was measured every 5 seconds after submersion, by self-report, in which '0' indicated no pain, and '10' indicated pain so severe that the subject wished to remove his or her hand from the water. Pilot research established a linear relationship between self-reported pain and the length of time in the water when both variables are plotted on logarithmic scales. The study employed three groups of subjects, classified as high, (N=15), medium (N=23), and low (N=17) in hypnotizability, and tested in two conditions (hypnotic analgesia and control). Plotting pain ratings as a function of time on log-log paper, Hilgard found that all three groups had identical linear slopes. That is, pain increased with time in ice water, and at the same rate for all three groups of subjects. The groups also had identical intercept values in the control condition, in the absence of hypnosis and the analgesia suggestion. In the hypnotic analgesia condition, however, there were significant group differences in the intercept values representing the levels of reported pain.

Figure 1 shows the basic results of this study. There were no differences between hypnotic analgesia and control conditions for the low-hypnotizable subjects; analgesia suggestions produced a small overall decrease in perceived pain for the mediums, and a large overall decrease for the highs. The overall correlation between hypnotic susceptibility and pain reduction experienced by each subject was .46. To summarize, this study, using the psychophysical technique of magnitude estimation, showed a clear relationship between hypnotizability and reductions in reported pain, when subjects are given suggestions for analgesia.

Figure 1: Hilgard's 1967 study of hypnotically induced analgesia



Deafness.

In 1979, Crawford, Macdonald, and Hilgard extended Hilgard's basic paradigm to examine the relationship between hypnotic susceptibility and responsiveness to hypnotically-induced deafness. Besides serving to test the generalizability of this relationship to another perceptual system, the study of deafness has several advantages over the study of pain. First, sound has associated with it a physical-world metric (i.e., decibels), while pain has no real-world physical counterpart. Thus, in order to do a psychophysical study of pain, assumptions must be made, such as assuming that elapsed time in ice water is at least monotonically related to increasing pain. A second disadvantage of pain stimuli is that they are, by operational definition (i.e., time in ice water), ordered according to stimulus magnitude, which may influence magnitude estimations. The stimuli for an auditory deafness experiment do not have this limitation and can be randomly presented.

The Crawford, Macdonald, and Hilgard (1979) study used 70 university students stratified into 4 groups: Lows (N=14), Low Mediums (N=13), High Mediums (N=14), and Highs (N=29), and seven levels of tone intensity (17 - 70 decibels). As with the analgesia study, overall decrements in hearing were related to hypnotic susceptibility (overall correlation = .59). Figure 2 reproduces the original graph of the log of the magnitude estimates against the seven decibel[1] intensities. Clearly there is a linear relationship across all groups and conditions,

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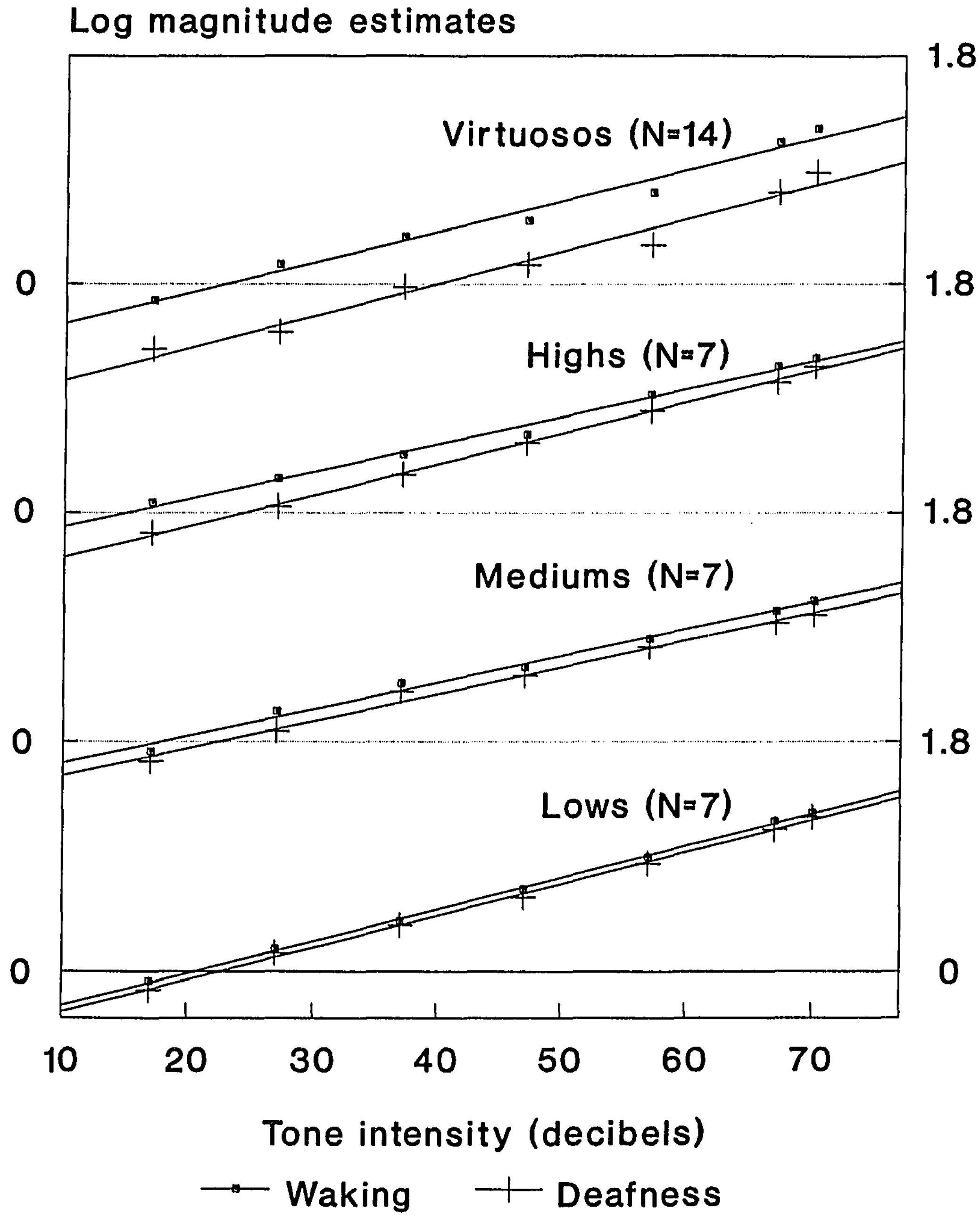
[1] Decibels are a logarithmic unit of measurement, defined as 10 times the logarithm (base 10) of the ratio of the electrical to the acoustical powers of the stimulus.

with the intercepts and slopes close to identical across groups in the normal-hearing condition. Suggestions for hypnotic deafness caused a change in intercept but not slope (i.e., equal decrements in hearing across the range of stimuli) in the hypnotic-deafness condition, the magnitude of which was related to group membership. Thus, this study of hypnotic deafness has confirmed the same (log-log) relationship between hypnotic susceptibility and perceptual alterations found in the hypnotic analgesia studies.

Figure 2: Crawford, Macdonald, and Hilgard's 1979 study of hypnotically induced deafness



Although the effects documented in the magnitude-estimation studies of analgesia and deafness are clear, they are not unambiguous. As Jones and Spanos (1982) noted, experiments employing classical psychophysical techniques are not able to discriminate between genuine changes in sensitivity on the one hand, and alterations in response criterion for another. For example, in the magnitude-estimation studies, an apparent effect of analgesia or deafness suggestions can be produced simply by subtracting a constant from the felt intensity: reporting a value of 2 on a 0-10 scale, for example, when the actual intensity is 4, and a value of 6 when the actual intensity is 8. Alternatively, in studies employing threshold-determination procedures, apparent analgesia or deafness can be produced simply by denying sensation on trials where sensation actually occurs: reporting that the stimulus is not felt, or heard, when in fact it was. It was take account of just this sort of problem, in nonhypnotic studies of classical psychophysics, that signal detection theory (SDT; Green and Swets, 1966) and its associated procedures was developed. Signal detection theory explicitly recognized that an observer's response is a function of both underlying sensitivity, the actual ability to discriminate a stimulus, and the response criterion the observer used to decide that a stimulus had occurred. The details of this theory will be discussed in the next chapter. For the present discussion it is sufficient to simply understand that SDT provides both a framework and methodology by which to separate the influence of response criterion from measures of underlying sensitivity.

Jones and Spanos (1982) employed signal-detection methods to study the effects of suggestions for hypnotic deafness; in addition, they added a condition in which subjects received suggestions for increased auditory sensitivity as well. Their experiment employed 150 acoustical trials delivered via headphones. One half of the trials contained simply background noise, and the other half, randomly interspersed with these, contained a pure tone as well as the background noise. The design employed 48 high- and 48 low-hypnotizable subjects. Each group was further subdivided into one of two induction conditions (presence or absence of hypnotic induction) and further according to one of three instructions groups (increase sensitivity, decrease sensitivity, no instructions). They found no significant effect of suggestion on perceptual sensitivity, in either direction. The only consistent trend was that highs increased sensitivity, relative to baseline (non-instruction) when given <u>either</u> set of instructions to change sensitivity (i.e., both the increase and decrease instructions). There was a significant three-way interaction for bias, most easily interpreted in the following way: For the hypnotic induction condition only, highs became more liberal in their response criteria while the lows became more conservative[2]. Jones and Spanos also reported that across all conditions, subjects classified as lows were consistently more sensitive to acoustical stimuli than the Highs.

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[2]In the text, Jones and Spanos report a larger interaction than the one in the table of results, and hence the actual size of the interaction is not known.

In an unpublished manuscript, Jones and Spanos (1987) conceptually replicated their 1982 study using a visual masking paradigm. One hundred and forty-four subjects were sub-divided into the same groups as the Jones and Spanos (1982) experiment, yielding a total of 12 subjects per cell. Interestingly, this study also finds the same trend as the last: highs increase sensitivity relative to no instructions, given either instructions for increasing and decreasing sensitivity. Jones and Spanos attempt to explain this trend, now found in two studies, by stating that highs process the task inefficiently until explicitly asked focus on it by a set of instructions. They support this argument with two lines of rationale.

First, they cite a signal detection study by Watson and Clopton (1969), which found that people could increase sensitivity above asymptotic behavior, if sufficiently motivated[3] to do so. What they do not mention however, is Watson and Clopton's own conclusions on the phenomena:

> In summary, these small, motivation-induced increments in per cent of correct judgments show that listeners are capable of momentary enhancement of detection performance lasting at least nine sec, but also that the average increments are not large enough to be an important consideration... (p. 286).

Another aspect of Watson and Clopton's study not mentioned, is that each increase in sensitivity was consistently followed by a

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[3]Of the four experimental operationalizations of "increased motivation": motivational instructions; monetary reward; aversive electric shock following failures; and feedback of performance at blocked intervals, only the latter one increased sensitivity.

decrease in sensitivity below baseline performance. Hence the effects of motivational influences on sensitivity averaged over the entire testing session, produced no net increment in sensitivity. These facts, as well as the existence of the effect in all of Watson and Clopton's subjects, and not just a small percentage (as would be expected if the effect was related to high hypnotizability as Jones and Spanos claim), precludes the motivational hypothesis from being an explanation for the low relatively low sensitivity of the highly susceptibility subjects.

A second rationale offered by Jones and Spanos is that since highs are inefficiently processing stimuli, the variance of their sensitivity index should be larger than lows. They support this hypothesis with a series of F-tests in which most combinations of variance ratios (e.g., high against lows, and within the high group, no instruction vs instructions), are significantly different from each other[4]. There is, however, a far more parsimonious explanation for the differences in obtained variances between the Highs and the Lows across conditions. It is simply that for conditions in which near perfect responding occurs, the variances must be smaller. Since the Highs in general are less sensitive than Lows, and the Lows are responding with close to perfect accuracy, the Highs will in general have more variance associated with their scores in any given condition. To illustrate this, the 1982 paper is examined. All of the means for the Highs and Lows are within one

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[4] The results of their tests are actually statistically inappropriate, yielding a high Type I error rate. There are a variety of more appropriate methods for testing the hypothesis of homogeneity of variance, such as the F-max test (Cohen and Cohen, 1975).

standard deviation of a perfect sensitivity score (1.0), and the lows are considerably closer to perfect responding than the Highs. Accordingly, their is almost no variance associated with the mean sensitivity of the Lows, and for the Highs there is a perfect negative correlation between the mean sensitivity and the magnitude of the variances. Hence all of the differences in the observed variances that Spanos and Jones contend support the idea that highs are inefficient processors of information, are in actually a simple function of ceiling effects attenuating the observed variances. Indeed, when the Lows are given a harder discrimination task in experiment two of Jones and Spanos (1982) their range of variances (standard deviation ranged from .07 to .19) is almost identical to the range of variances of the Highs in experiment one (standard deviation ranged from .07 to .25). Hence while Lows may be more sensitive that Highs on a given task, in this case at least, the differences in variances of the mean sensitivity is an outcome of this, not a collateral supporting fact of the 'inefficiency' of the cognitive processes of the Highs.

Enhancement of visual acuity. Although Jones and Spanos (1982) failed to find evidence for increased sensitivity following hypnotic suggestion, such evidence has been obtained by other investigators. In the first of these studies, Graham and Leibowitz (1972) reported three experiments that examined the effects of suggestion on the visual acuity of myopes. In the first experiment, they employed nine highly hypnotizable subjects who had a subjective refractive error which did not vary more than 0.5 diopter from the static (objective) refractive error and less than 1.5 diopter of astigmatism. A special chart was employed consisting of 19 rows of 10 Landolt 'C's, in which the break in the Cs ranged from .5 to 9.8 minutes of arc and was oriented in one of eight possible positions; vertical and at 45 degree intervals from vertical. Visual threshold was defined as the first row that the subject obtained less than 50% accuracy in guessing the orientation of the 'C'[5].

After threshold determination, the subject was hypnotized and given instructions to become completely relaxed, refreshed and alert, to concentrate on the muscles around and behind the eyes and to 'notice them becoming as relaxed and weightless as the rest of the muscles in the body' (p. 172). It was also explained that the degree of relaxation obtained would affect the muscles controlling the eye lens, thus permitting clearer vision. Acuity was assessed again. After the hypnotic testing, but while still hypnotized, the subjects were given post-hypnotic suggestions and instructions to practice relaxing their eye muscles and that their increased acuity would transfer over to the waking state. The subjects were tested with this procedure three times over a period of three weeks. There were significant improvements both within and across sessions, for both the hypnotized and normal states, with the degree of improvement being a function of the severity of the initial myopia (see Figure 3). A subsequent re-examination at the

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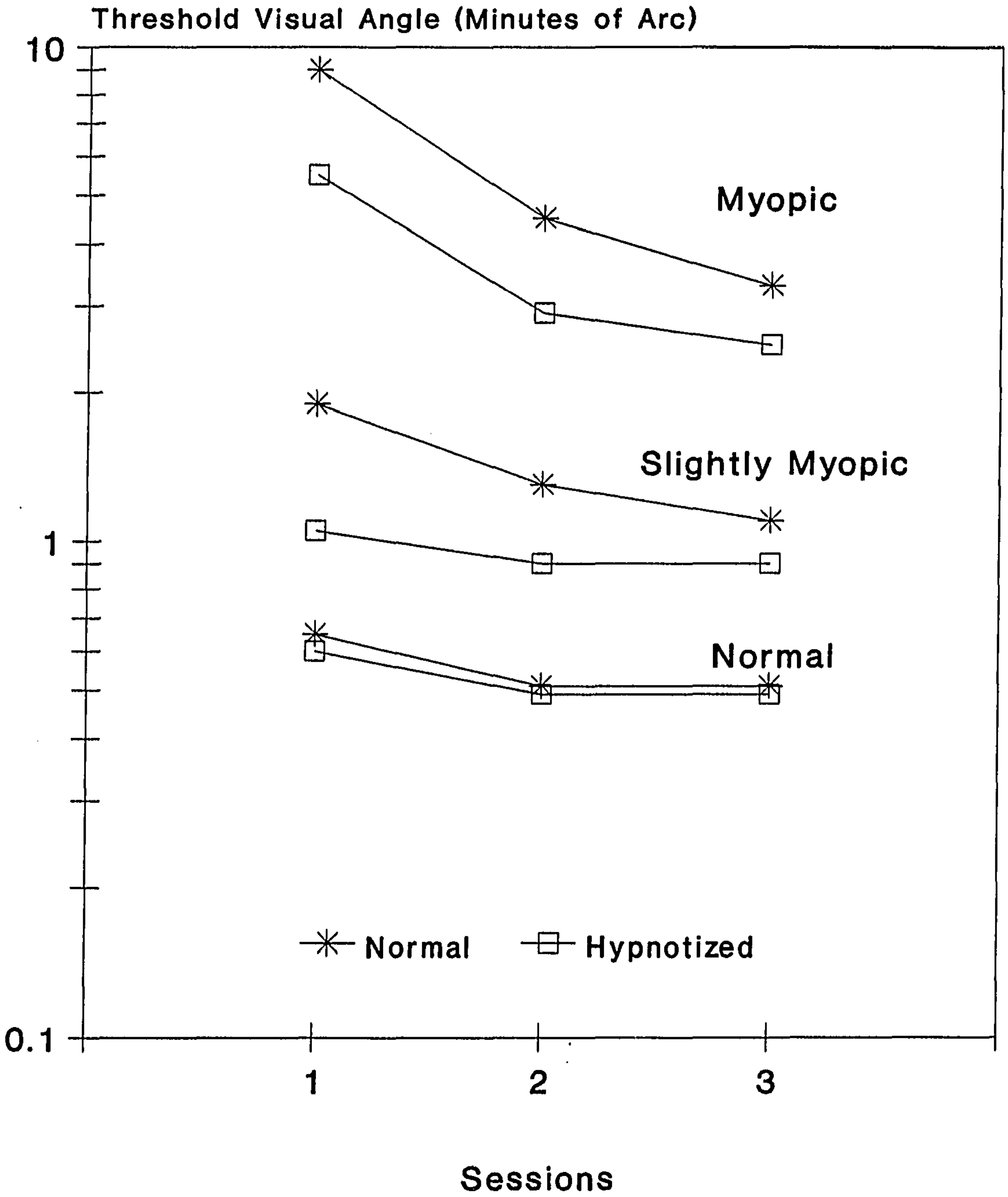
[5]Estimates of sensitivity via forced choice procedures are known to be negligibly influenced by response criteria (Green and Swets, 1966).

optometrist's office confirmed the transfer of the improvement to the non-hypnotized state. While some acuity improvement was seen in the control subjects which were run to estimate the possible effects of chart memorization (five subjects tested three times on consecutive days), and motivational influences (four subjects told that other subjects in the experiment had been able to increase their visual acuity), these increases were not of the same magnitude as the improvements seen in the experimental subjects.

Figure 3: Graham and Liebowitz's 1972 study of the[28] hypnotic enhancement of visual acuity



A second experiment attempted to replicate the first experiment using relaxation suggestions instead of hypnosis, and two groups of subjects, classified as high or low in hypnotizability. Only highly susceptible subjects showed significant improvements in visual acuity, and the improvements were of approximately the same magnitude as those seen in the hypnosis conditions of the first experiment; however, the effects of suggestions delivered during relaxation conditions increased visual acuity only in the laboratory, and not in the optometrist's office. A third experiment, using a laser scintillation technique, showed that the improvements in visual acuity were not due to physiological or structural changes in the subjects eyes (i.e., there was no objective change in the ability of the eye to accommodate) but probably occurred through the more efficient processing of visual information.

In 1982, Sheehan, Smith and Forrest pointed out a serious methodological flaw with the first experiment of Graham and Leibowitz's (1972) study: the control subjects were not matched for hypnotic susceptibility, a factor that experiment two had determined to be important. Hence, the two control groups were not equivalent to the experimental group on a critical factor, rendering the conclusions of experiment one questionable.

To address this concern, Sheehan et al (1982), matched eight pairs of subjects for both suggestibility (BSS scores ranging from 3 to 6) and degree of myopia (greater than 1.5 diopters), and randomly placed one of each pair into either the experimental or control group. The better of the two eyes was covered with a patch. The measurement of baseline visual acuity involved a two stage process, threshold assessment and a signal detection assessment. Eighty randomly ordered Landolt Cs consisting of eight occurrences of ten different size Cs (ranging from .5 to 9.5 minutes of arc in the break in the 'C') were oriented in one of four random positions (up, down, left and right) and used to determine the threshold stimulus size for each subject. Threshold stimulus size was defined as the stimulus size for which the subject obtained approximately 50% accuracy in guessing the orientation of the break in the C. The signal detection task consisted of two sets of stimuli, 150 solid lines, and 150 'broken' lines, the gap of which was equal to the magnitude of the gap in the threshold Landolt C. The subject's task was to simply report if there the stimulus was a broken or unbroken line. After baseline assessment, subjects received either 15 minutes of relaxation and suggestions for increased acuity, or listened to 15 minutes of relaxing classical music, and were tested again. A <u>t</u>-test of the differences between d' in the pre- and post-conditions indicated that the experimental group increased their sensitivity significantly more than the control group, while there were no differences between bias estimates for the two groups. However, there was no significant correlation between increased acuity and BSS scores.[6]

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[6]Although the statistical significance of the Sheehan et al (1982) study was called into question by Wagstaff (1983), these investigators (Smith, Forrest & Sheehan (1983) succeeded in defending the appropriateness of the statistical procedures they had used. I also evaluated the controversy by examining the magnitude of the effect size

Introduction to the Dissertation Research

As the foregoing review indicates, alterations in sensory and perceptual functioning are among the hallmarks of hypnosis. However, these changes have rarely been studied with the techniques of classical psychophysics and modern signal-detection theory. The purpose of the research reported here was to employ these psychophysical and signal-detection procedures to study the effects of hypnotic suggestions for alterations in tactile sensitivity.

Experiment 1 was inspired by the controversy over the circle-touch test and perceptual adaptation, and thus focused on hypnotically induced tactile anesthesia. This experiment generally follows the protocol set by Hilgard (1967, 1969) in his classical psychophysical analyses of the effects of hypnotic suggestions for analgesia. However, the effects obtained with classical psychophysical procedures are also studied with the methods of modern signal detection theory, in order to isolate the effects of changes in both sensitivity and response criteria.

In light of the provocative findings obtained by Graham and Liebowitz (1972) and Sheehan et al. (1982), Experiment 2 was expanded to encompass hypnotic suggestions for tactile hyperesthesia as well. This experiment employs signal-detection techniques to examine the effects of both anesthesia and hyperesthesia suggestions. In addition, this experiment employs the real-simulating paradigm introduced by Orne

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(Rosenthal, 1986) that Sheehan et al (1982) had obtained. The calculated *r*, or strength of relationship between experimental manipulation and outcome, was .5, a fairly substantial experimental effect.

(1959), in order to evaluate the contribution of demand characteristics to the performance of hypnotic subjects.

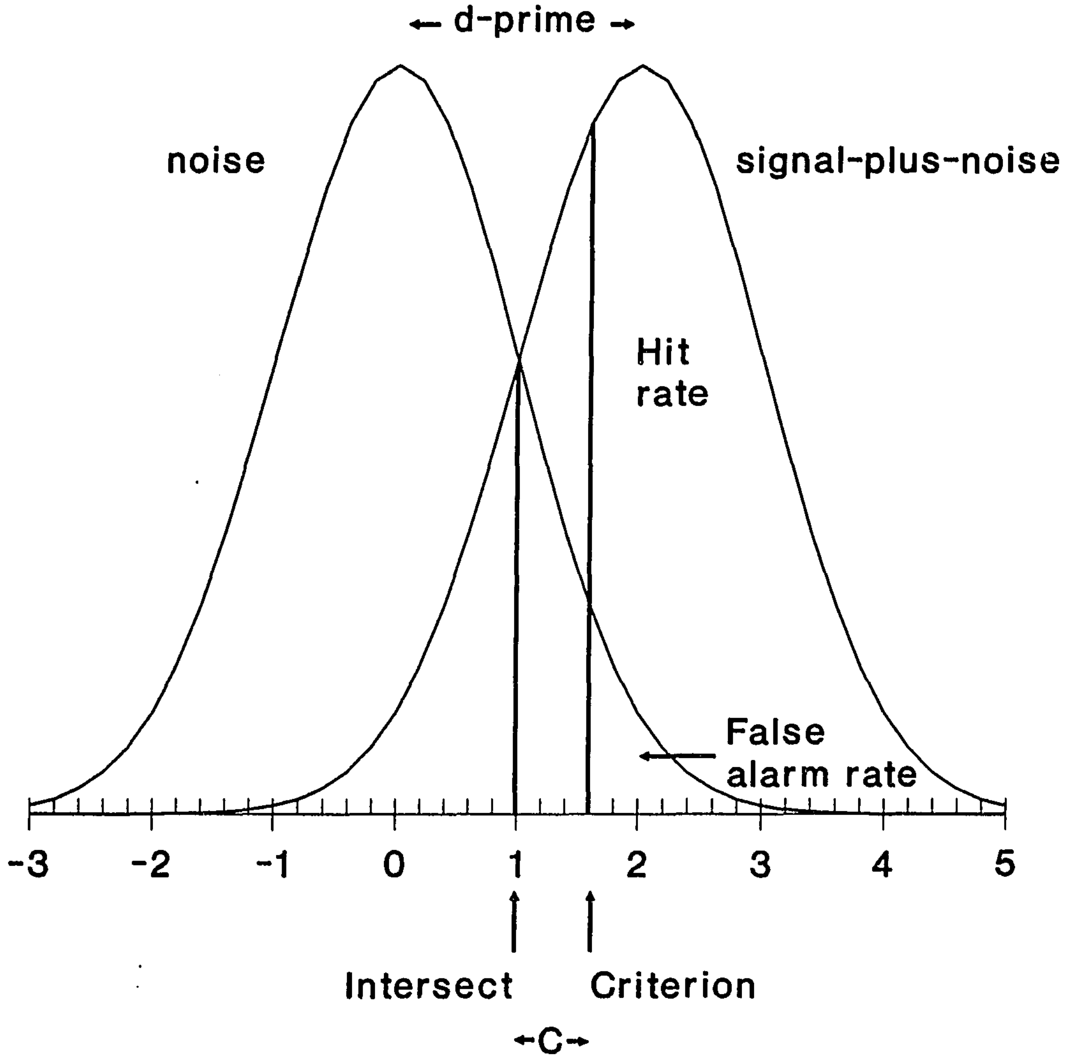
CHAPTER 2

AN INTRODUCTION TO SIGNAL DETECTION THEORY

As mentioned in the preceding discussion, signal detection theory (SDT; Swets, 1961; Green and Swets, 1966; Pastore and Scheirer, 1974) developed as a framework in which sensitivity could be conceptualized and estimated independently of the influences of response bias, or the general willingness of an observer to say that a signal occurred. The following is a short summary of the basic assumptions and framework of signal detection theory.

Signal detection theory postulates that the perceptual system is in a continuous state of activation. This activation, called 'noise', is random in nature, is thought to have a normal distribution (see figure 4), and is the result of the summation of a myriad of both internal and external influences. Any external signal presented to the perceptual system simply increases the activation of the whole system by (some monotonic function of) the signal strength amount. If the total signal strength is greater than a certain level, called the criterion, the observer will report 'perceiving' the signal. The fraction of the trials that the observer responded 'signal present' when a signal had actually been presented is called the observer's hit rate (HR). The fraction of the trials the observer responded 'signal present' when no signal had been presented is the observer's false alarm rate (FAR). As seen in figure 4, varying the criterion changes both the HR and FAR. A conservative criterion means the observer is not willing to make many false alarms and accordingly, will 'miss' a proportion of signal presentations. A liberal criterion indicates that the observer will seldom miss a signal presentation, but will also increase the FAR. By assuming (and encouraging) a relatively constant criterion, and presenting enough signal and no-signal trials, the relative proportions of the HR and FAR rates can be estimated. Then, based on the assumptions (which can be partially tested) regarding the relative shape and sizes of the two underlying distributions in the perceptual and decision systems, researchers can estimate the difference between the average level of activation of noise and signal-plus-noise distributions. This distance, conceptualized as the perceptual systems response to a given signal, is called 'sensitivity'. The placement of the criterion is reflected in the construct of 'bias'.

Figure 4: Graphical representation of signal detection theory



Signal-Detection Parameters

There are a variety of ways in which measures of sensitivity and bias are constructed. The traditional measure of sensitivity is measured in units of standardized distance between the means of the two distributions, called d' (pronounced d-prime). The standardized distance is in reference to the two distributions of signal and signal-plus-noise, which are defined as having unit variance. The bias parameter that usually accompanies d' in explaining a given set of data is β (beta), the ratio of the likelihood of the observer responding 'signal' over 'noise', which is the ratio of the heights of the two curves at the criterion point. The following are mathematical formulas for d' and β.

$$d' = Z_{FAR} - Z_{HR} \quad (1)$$

$$\beta = \exp(-0.5Z_{HR})/\exp(-0.5Z_{FAR}) \quad (2)$$

where Z_{HR} is the Z score (i.e., measured in standardized units of the normal curve) corresponding to the area under the normal curve equal to the HR. Z_{FAR} is the Z score corresponding to the area under the normal curve equal to the FAR. The 'exp' notates the inverse natural log transform.

While d' and β have been the parameters of choice in signal detection experiments since its conceptual origin, recent work by researchers such as Snodgrass and Corwin (1988), and MacMillan and Creelman (1990) have begun to question their continued use. These studies have examined alternate parameters of sensitivity and bias, and shown that some signal detection parameters are superior to others, both in terms of the plausibility of their assumptions, and in terms of their statistical robustness. For instance, Snodgrass and Corwin (1988) have demonstrated β to be inferior to the bias measure C. One of the problems with β is its asymmetrical measurement of liberal and conservative biases. A β of 1 indicates optimal responding, values between 0 and 1 indicate liberal responding, and values between 1 and infinity are indicative of conservative responding. Hence, relatively speaking, liberal responses have a very restricted range and the 'psychologically' real differences between them are minimized by the greater range and hence variance of any conservative responses. Problems with this measure still exist even after log transforms are taken to help correct this range problem. In contrast, the bias parameter C has a symmetrical treatment of liberal and conservative biases, and is quite intuitively interpretable. It is a measure of the distance, in standardized units of the signal-plus-noise distribution, that the observer's criterion is from the point of optimal responding. Values of C that are 0, negative, and positive indicate response criteria that are optimal, liberal, and conservative, respectively. Mathematically C is obtained by the following formula:

$$C = 0.5*(Z_{HR} + Z_{FAR}) \qquad (3)$$

where Z_{HR} and Z_{FAR} are as defined for equations 1 and 2.

Schulman and Greenburg (1970) and Egan and Clark (1966) have demonstrated that the parameter d'_e is superior to d' when estimating sensitivity for a ROC curve. In essence it is less sensitive to error fluctuations in the slope of the standardized receiver operating characteristic (ROC) than is d'. The parameter d'_e is defined as the point of intersection on the standardized FAR abscissa of a positive diagonal running through the intersection of the ROC curve and the negative diagonal. Geometrically, d'_e is obtained through the rotation of the standardized ROC about the point of intersection with the negative diagonal, to a 45 degree angle. The value of d'_e is calculated by the following formula;

$$d'_e = \mathrm{sqrt}[(a / (b + 1))^2] / \sin(45) \quad (4)$$

where a is the calculated intercept of the least squares regression line, b is the slope of that regression line, and sqrt denotes the square root of the bracketed material.

There are also methods for calculating sensitivity and bias that have been conceptualized as a non-parametric indices (Hudos, 1970; Pollack, Norman, and Galenter, 1964), though Macmillan and Creelman (1990) point out that even these calculations make distributional assumptions and, hence, are actually parametric. The sensitivity measure, P(A), is simply the total area under the ROC curve. Chance responding, which is indicated by an ROC curve overlaying the positive diagonal of the ROC plot, subsumes half the area of the total ROC plot, yielding an P(A) of .5. As sensitivity increases, so does P(A). A P(A) of 1.0 indicates perfect responding. P(A) is calculated by decomposing the empirical ROC curve into polygons defined by neighboring HR and FAR pairs (beginning with the origin and ending with the upper-right corner) and the ROC abscissa. The formula for this is:

$$P(A) = \mathrm{SUM}_{i=1..n}[0.5(FAR_i - FAR_{i-1})(HR_i - HR_{i-1})+(HR_{i-1}(FAR_i - FAR_{i-1}))] \quad (5)$$

where $SUM_{i=1..n}$ is the sum of the material in brackets from 1 to n, 1 being the first set of HR/FAR pairs, and n represents the upper-right corner of the ROC graph, where both the HR and FAR equal one.

Choosing Measures of Sensitivity and Bias

For this study, P(A) was chosen over d' and d', as a measure of sensitivity for several reasons. One is P(A)'s relative independence from assumptions. Both d' and d', assume normal distributions for the both the noise and signal-plus-noise distributions, and d' also assumes that both distributions have equal variances. There is a great deal of research indicating that these conditions are not always met (Markowitz and Swets, 1967; Schulman and Greenberg, 1970; Treisman, 1977; Treisman and Faulkner, 1984). Also both parameters, being based on estimated regression lines, are best calculated with very stable HR and FAR points. This would require a great many trials per subject, and is not feasible where groups are subjects are being compared. In contrast, P(A) makes very few assumptions about the data, is fairly robust with regards to outlier points, and is intuitively understood (Pollack, Norman, and Galenter 1964). With regards to bias, even though C does make some distributional assumptions, it was chosen over β simply because the literature has clearly demonstrated its superiority (Snodgrass and Corwin, 1988; MacMillan and Creelman, 1990)

CHAPTER 3

EXPERIMENT 1:

EFFECTS OF SUGGESTIONS FOR TACTILE ANESTHESIA

The method employed in this experiment was adapted from that of Hilgard (1967) on hypnotic analgesia, with the addition of signal-detection measures of sensitivity and bias.

Method

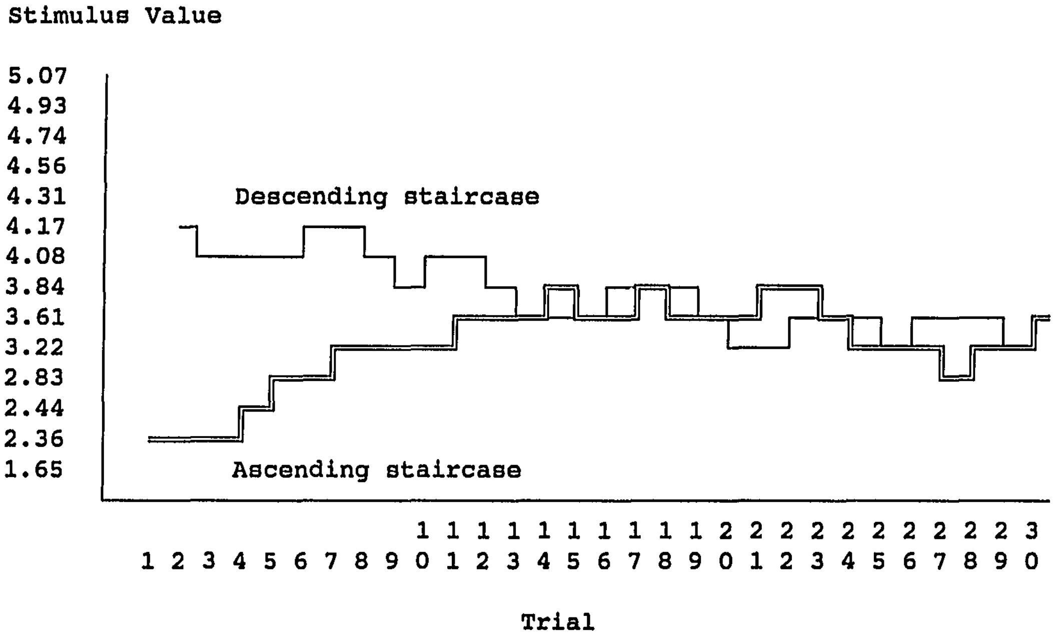
Subjects. Forty undergraduate males and females were selected from the introductory psychology pool first on the basis of their scores on the Harvard Group Scale of Hypnotic Susceptibility, Form A. (HGSHS:A; Shor and Orne, 1962) and then on their scores on the Stanford Scale Hypnotic of Susceptibility: Form C (SHSS:C; Weitzenhoffer and Hilgard, 1962). Subjects received either experimental credits, a monetary payment of $10.00, or a combination of the two as reimbursement for their participation. The forty subjects were divided into four groups of ten: Lows (SHSS:C range: 1 to 4, M = 1.8, SD = 1.14), Mediums (range: 5 to 7, M = 6.2, SD = .79), Highs (range: 8 to 10, M = 8.8, SD = .63), and Virtuosos (all had scores of 11).

Apparatus. A plastic template (1.375' diameter) and red erasable ink was used to draw a circle on the palm of the subject's right hand. Stoelting pressure aesthesiometers, which are similar to Von Frey hairs, were used as tactile stimuli. The aesthesiometers are marked in log force units which yield a linear interval scale suitable for statistical comparisons. An IBM Personal System computer signalled the beginning of each trial with three consecutive beeps, specified to the experimenter the appropriate stimulation for each trial, and collected subject responses (via a computer mouse) and reaction times.

Procedure. During the introductory overview of the session, the subject was told that the experiment dealt with tactile sensitivity and establishing what levels of stimulation they could feel most of the time, but not necessarily all of the time. They were not informed that the experiment would involve suggestions for altered sensitivity. The subjects were then seated in a large, comfortable chair and shown an array of aesthesiometers. They were told that the filaments were of different thicknesses, and used to determine what people can feel on the surface of the skin. A circle was drawn and traced over several times so the subject 'could get a good sense of where it was located'. The subjects then received both threshold measurement and signal-detection procedures, both before and after a hypnotic induction and suggestions for tactile anesthesia. The subjects were told that for the first series of trials they would hear a series of three beeps from the computer. Sometime between the second and third beeps they would be touched inside the circle on the palm. After each trial, they were to respond 'Yes' if they felt the touch, and 'No' if they did not. If they had not felt anything by the end of the third beep, they should respond 'No'. The subjects were informed that their reaction times would be recorded, but that it was much more important to be accurate than to be fast. If they made a mistake, they were instructed to tell the experimenter, so the response could be changed. Subjects were instructed to close their eyes during the testing procedures.

Threshold estimation. Thresholds for each subject were determined using the double random interleaved staircase (DRIS) method of limits (Cornsweet, 1962; Herrick, 1973; Jesteadt, 1980). The DRIS procedure was developed within classical psychophysics because different sensory thresholds were obtained for descending (starting above threshold and going 'down') and ascending (starting below threshold and going 'up') methods. The DRIS method randomly intersperses both methods in the same session, thus eliminating the biases inherent in either of them. Two initial stimuli are chosen, one well above, and the other well below, the average threshold for most observers. If the observer responds positively to the stimulus, the value in the corresponding series (ascending or descending) is decreased one unit, if the response is negative, then a more potent stimulus is used. Over trials, in a staircase-like manner, the two series will converge on one or two stimulus intensities and oscillate at that level. (See figure 5.) This is considered the observers threshold or limen for that sensory domain. The DRIS has two attractive features. As mentioned earlier, it eliminates the bias associated with using either the ascending or descending method alone. Second, non-veridical or random responding on the observers part shows up quite clearly, in that the two staircases never converge.

Figure 5: Example of the double random interleaved staircase threshold estimation procedure.



Signal Detection. After of the first DRIS trials, the weakest stimulus for which at least half the subject's detection responses were positive was selected as a stimulus for the signal detection phase. The subject was told that he or she would be touched about half the trials, and was instructed to respond 'Yes, if you think you were touched, and No, if you think you were not'. Confidence ratings from 1 to 3 were obtained after each decision; three meaning 'very confident', two meaning 'fairly confident, but not completely sure', and one meaning 'not confident at all' in the decision. Confidence judgments were entered into the computer via the experimenter. Reaction times for confidence rating were not recorded. A total of thirty SD trials were given.

The subjects were then hypnotized using the SHSS:C script as a standard induction technique. Each subject was then given a hand lowering suggestion (Item #1 of SHSS:C), and asked to rate his or her hypnotic depth on a 1-10 scale (O'Connell, 1964; Tart, 1972). Suggestions for anesthesia within the area of the circle were given and both the DRIS and signal detection procedures were repeated, in that order. At the end of the testing procedure the subject again rated hypnotic depth, the suggestion for anesthesia was cancelled, and hypnosis was terminated. The total session time was approximately 1.5 hours.

Results

Thresholds. A total of thirty trials was used for all but five subjects, who needed slightly more trials to establish at a stable threshold. The average trial on which convergence occurred for the waking and anesthesia conditions are 11.55 (SD = 2.60) and 12.48 (SD = 2.94) respectively. The threshold was operationally defined for each subject as the arithmetic mean stimulus value on all trials after the ascending and descending staircases converged. As can be seen in table 1 the suggestion for hypnotic anesthesia does induce a threshold change, the magnitude of which is lawfully related to hypnotic susceptibility; lows and mediums show little change, and highs and virtuosos show a fairly large increase in threshold. The main effect of hypnotic group is significant ($F(3,36) = 6.98$, $MS_e = .248$, $p < .0008$). The state Condition is significant ($F(1,36) = 28.82$, $MS_e = .165$, $p < .0001$), as well as the state by hypnotic group interaction ($F(3,36) = 5.57$, $MS_e = .165$, $p < .003$). Tests for simple main effects showed that within the Waking condition, there was a small effect of hypnotic group ($F(3,36) = 3.31$, $MS_e = .087$, $p < .03$), with Newman-Keuls post hoc tests ($p < .05$) showing that the Lows had a slightly lower tactile threshold than the Mediums, Highs or Virtuosos. Within the Hypnotic anesthesia condition, a larger effect of Hypnotic group occurred ($F(3,36) = 7.25$, $MS_e = .326$, $p < .0006$).

Table 1. Means and standard deviations of the threshold aesthesiometer value as a function of hypnotic susceptibility and condition.

	Hypnotic class			
Condition	Lows	Mediums	Highs	Virtuosos
Baseline	2.85	3.24	3.15	3.15
	(.17)	(.28)	(.42)	(.23)
Anesthesia	3.10	3.31	3.74	4.20
	(.41)	(.58)	(.26)	(.85)

Newman-Keuls post hoc tests showed that the Virtuosos and Highs had higher thresholds than the Lows, and that the Virtuosos had higher thresholds than the Mediums. Simple main effects were also obtained in each of the hypnotic groups, testing for difference between waking and anesthesia conditions. The F ratios for the Lows ($F(1,36) = 1.89$, MS_e = .165, $p > .05$), Mediums ($F(1,36) = .148$, MS_e = .165, $p > .05$), Highs ($F(1,36) = 10.17$, MS_e = .165, $p < .005$) and Virtuosos ($F(1,36) = 33.35$, MS_e = .165, $p < .001$) revealed that only the Highs and Virtuosos had significantly different thresholds from waking to anesthesia conditions, both being significantly higher under anesthesia. The effect was larger for the Virtuosos than for the Highs.

Prior to calculating each subject's average reaction time per condition, outliers, defined as four or more standard deviations above each subject's respective mean for that condition, were eliminated. Truncation with reference to an individual's distribution, as opposed to the group distribution, allowed the influence of abnormal reaction times to be eliminated without effecting the intrinsic individual differences found amongst subjects on this variable. Based on this criterion, a total of four trials were eliminated from the analyses, one from each of the Medium and Virtuoso groups, and two from the High group. These reaction times were 10.9, 11.75, 3.9 and 6.0 seconds respectively. A repeated measures ANOVA of the reaction time data showed a only a main effect of state ($F(1,36) = 5.25$, MS_e = .119, $p < .028$), reaction times being slightly slower under hypnosis, regardless of hypnotic susceptibility (waking mean = .87 sec, SD = .55; hypnosis mean = 1.05

sec, SD = .56). This effect was driven by the changes in the reaction times for the Highs and Virtuosos, though the interaction was not significant ($F(3,36) = 1.89$, $MS_e = .224$, $p < .15$). Table DRIS_RT shows the means and standard deviations of the reaction times as a function of hypnotic susceptibility and Condition.

Table 2. Means and standard deviations for DRIS reaction times as a function of hypnotic susceptibility and condition.

	Hypnotic class			
Condition	Lows	Mediums	Highs	Virtuosos
Baseline	0.76	0.94	1.04	0.77
	(.43)	(.74)	(.59)	(.47)
Anesthesia	0.78	0.93	1.32	1.20
	(.39)	(.59)	(.58)	(.72)

Rating Scale Usage. A critical assumption in the use of a rating scale in a signal detection paradigm is that the observer has the capacity to define and maintain the appropriate number of internal criteria by which to evaluate a trial interval and make a decision as to the stimulus presence or absence. This assumption is considered justified if the subject demonstrates a monotonic increasing function between the criterion judgments and the proportion of trials the stimulus is actually present (Swets, Tanner, and Birdsall, 1964). For the purposes of the signal-detection analysis, the three-point confidence ratings associated with the subjects' yes/no responses were transformed into a 1 to 6 criterion scale, with 1 meaning that the subject was very confident that he or she had not been touched, and 6 meaning that the subject was very confident that he or she had been touched. Analysis of the proportion of signal trials associated with each criterion level revealed the monotonicity function to be met for both baseline and anesthesia suggestion conditions (see Figure 6). For example, in the baseline conditions criterion ratings of '1' were associated with signal trials only 20% of the time, while ratings of '6' were associated with signal trials about 95% of the time. Thus, the subjects used the 'yes/no' decision and confidence scale sequence in the manner required by the assumptions of signal-detection theory.

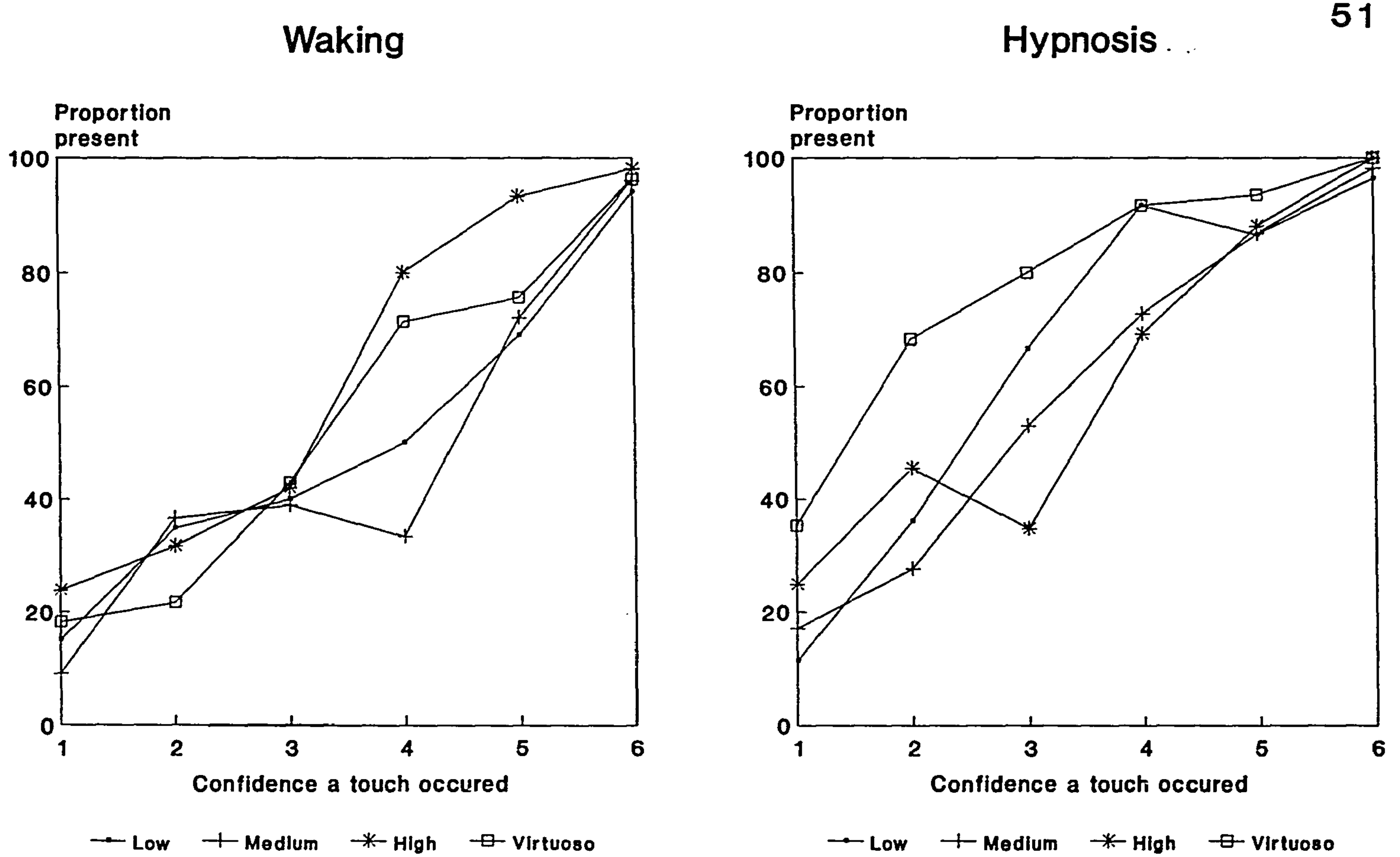


Figure 6: Proportion of signal trials as a function of confidence scale usage, group, and condition

Hit Rates and False Alarm Rates. The means and standard deviations of the hit rates and false alarm rates for the confidence level of 4, for the two conditions and the four classes of hypnotizability are presented in table 3. The confidence rating of 4 was used, as this is the point on the scale at which a verbal 'Yes' response first occurs (i.e., a subjective judgment by the observer that the stimulus was, in fact, present). Note that in general, any changes in hit rates have corresponding changes in the false alarm rates. Signal detection analyses will be used to extract indexes of sensitivity which are independent of any changes in response criteria that the suggestion for anesthesia induced.

Table 3. Means and standard deviations of hit rates and false alarm rates at confidence level four as a function of hypnotic susceptibility and condition.

	Hypnotic class			
Condition	Lows	Mediums	Highs	Virtuosos
Hit Rate				
Baseline	0.76	0.72	0.59	0.74
	(.20)	(.12)	(.20)	(.15)
Anesthesia	0.78	0.66	0.43	0.27
	(.22)	(.19)	(.25)	(.16)
False Alarm Rate				
Baseline	0.13	0.19	0.07	0.11
	(.08)	(.13)	(.07)	(.11)
Anesthesia	0.08	0.08	0.07	0.05
	(.06)	(.06)	(.06)	(.04)

P(A). For each subject the sensitivity measure P(A) (see equation 5, chapter 2) was derived by calculating the area beneath the ROC curve (Green & Swets, 1966). Table 4 presents the cell means and standard deviations. A 4 x 2 mixed-design analysis of variance of P(A) scores with one between-groups factor (level of hypnotizability) and one within-subjects factor (before and after anesthesia suggestion) revealed significant main effects of both groups, $F(3,36) = 4.94$, $MS_e = .015$, $p < .01$, and Condition $F(1,36) = 16.01$, $MS_e = .004$, $p < .001$; these effects were qualified by a significant interaction ($F(3,36) = 8.61$, $MS_e = .004$, $p < .001$).

Table 4. Means and standard deviations for sensitivity parameter P(A) as a function of hypnotic susceptibility and condition.

	Hypnotic class			
Condition	Lows	Mediums	Highs	Virtuosos
Baseline	0.87	0.84	0.79	0.84
	(.07)	(.07)	(.10)	(.10)
Anesthesia	0.89	0.83	0.70	0.68
	(.10)	(.06)	(.13)	(.11)

This interaction was decomposed to show that there were no significant group differences in baseline sensitivity, $F(3,36) = 1.29$, $MS_e = .01$, n.s. During anesthesia, however, the two groups of hypnotizable subjects showed substantially less sensitivity than insusceptible subjects ($F(3,36) = 8.75$, $MS_e = .01$, $p < .001$). Unlike the Jones and Spanos (1982; Spanos and Jones, 1987) finding, the variances of the sensitivity parameter P(A) suggested no pattern of differences amongst the four susceptibility groups.

C. Table 5 presents the cell means for the bias measure C, for the confidence scale rating of 4. ANOVA revealed significant main effects of both Group, $F(3,36) = 4.83$, $MS_e = .296$, $p < .001$, and Condition $F(1,36) = 33.99$, $MS_e = .078$, $p < .0001$; again, these effects were qualified by a significant two-way interaction ($F(3,36) = 8.14$, $MS_e = .078$, $p < .001$). The within-group comparisons of Waking to Anesthesia condition were as follows. Lows: $F(1,9) = .73$, $MS_e = .037$, n.s.; Mediums: $F(1,9) = 8.15$, $MSe = .054$, $p < .05$; Highs: $F(1,9) = 3.3$, $MSe = .064$, n.s.; Virtuosos: $F(1,9) = 24.67$, $MSe = .158$, $p < .001$. Thus while all groups became more conservative during hypnotic anesthesia, but this tendency was significant for the Mediums, and quite pronounced for the Virtuoso subjects.

Table 5. Means and standard deviations for bias parameter C at confidence level four as a function of hypnotic susceptibility and condition.

	Hypnotic class			
Condition	Lows	Mediums	Highs	Virtuosos
Baseline	0.23	0.21	0.66	0.34
	(.36)	(.42)	(.43)	(.37)
Anesthesia	0.30	0.51	0.86	1.22
	(.45)	(.43)	(.55)	(.42)

C' When the mechanism underlying the apparent threshold changes observed with the DRIS technique was analyzed using signal-detection methods, the results did not produce a clear choice between an actual change in sensitivity on the one hand, and a mere change in response criterion on the other. In fact, both sensitivity and response criterion changed. However, this outcome should not be interpreted as indicating that subjects deliberately and strategically changed their criterion for judging the presence of the stimulus in response to the suggestion for anesthesia -- i.e., saying 'No' (indicating stimulus absence) where they formerly would have said 'Yes' (indicating stimulus presence). Subjects do say 'No' more frequently during anesthesia, but a little reflection indicates that this must be so.

Consider a subject who, on baseline trials (without anesthesia), judged the presence and absence of the stimulus with 100% accuracy, saying 'Yes' on the 50% of trials where the stimulus was present and 'No' on the 50% of the trials where the stimulus was absent. Consider, further, the performance of the same subject under conditions of hypnotic anesthesia -- i.e., a subject who can no longer feel stimuli that formerly were palpable. This subject will say 'No' to the 50% of trials in which the stimulus is absent, as before; but he or she will also say 'No' to some portion of the 50% of trials in which the stimulus is present. This will result in an increase in 'No' responses, but not because of bias or any adjustment of a criterion for responding 'Yes'. The increase in 'No' responses occurs because the stimulus is not felt, and thus is judged to be absent.

In other words, signal-detection theory presents the investigator with a paradox: while the parameters estimating sensitivity are independent of those estimating bias, the reverse is not true: the parameters estimating bias depend intimately on those estimating sensitivity.

The essence of this paradox was recognized by Collyer (1981), who has shown that the bias estimate β and the sensitivity measure d' are algebraically related to each other, and hence, are not independent. He illustrates this relationship with the following thought experiment. Suppose that a subject's sensitivity changes from one experimental condition to another. That is, the separation between the noise and the noise-plus-signal distributions either increases or decreases. Now suppose that his absolute criterion for deciding 'signal' did not change across those conditions. The measure of response bias (e.g., β, the relative probability densities or 'heights' of the two curves intersecting his criterion point) indicates a change, even though no absolute change in criteria for responding has occurred. An extension of this rational indicates that any bias parameters that are defined relative to 'optimal' responding (the point of intersection of the two curves) are also inherently dependent on sensitivity.

While this one-way dependency between sensitivity and bias is not problematic within a single observational session, it is problematic when comparisons are made across sessions in which experimental or other manipulations have changed the observer's sensitivity. Under these circumstances, changes in sensitivity contaminate any indexes of bias, possibly causing significant artifactual changes to appear, when in fact the observer had not changed his or her criterion for response. Conversely, a change in sensitivity across sessions can mask a genuine change in the subject's criterion across the sessions, providing the second response criterion is the same relative distance from the new intersection of the two signal and signal-plus-noise distributions.

How can an accurate comparison of response criterions be made across experimental sessions in the presence of a change in sensitivity? By assuming that the noise-alone distribution does not change (neither in location, shape, nor variance) from one condition to the next, its mean can serve as an 'anchor point' by which the two sets of signal and signal-plus-noise distributions can be examined relative to each other. Under these constraints, a new bias measure, in this case C', can be derived.

In defining C', we first 'anchor' our metrics by defining the mean of the noise distributions to be 0. This done, we utilize the fact that C is measured relative to the point of intersection, and that one index of the criterion for responding, Z_{FAR}, is also defined relative to the mean of the noise distribution. Hence, C_1, or the bias measure C at session 1, can be defined as:

$$C_1 = Z_{FAR1} - I_1 \qquad (1)$$

Or simply put, C is the distance between the subject's response criterion and optimal responding (the intersection point). With a simple algebraic manipulation, the intersection point at session one is defined as:

$$I_1 = Z_{FAR1} - C_1 \quad (2)$$

or the difference between the criterion point (Z_{FAR1}) and the measure of bias, C_1. We now define C', a measure of bias relative to optimal responding (the intersection point of the two distributions) at time 1.

$$C' = Z_{FAR2} - I_1 \quad (3)$$

or, by substituting equation 2;

$$C' = Z_{FAR2} - (Z_{FAR1} - C_1) \quad (4)$$

$$= Z_{FAR2} - Z_{FAR1} + C_1$$

Since C_1 is defined as one half the sum of the standardized score of the hit and false alarm rates (see equation 3, chapter 2), we can write equation 4 as:

$$C' = Z_{FAR2} - Z_{FAR1} + .5*Z_{FAR1} + .5*Z_{HR1}$$

$$= Z_{FAR2} - .5*Z_{FAR1} + .5*Z_{HR1}$$

$$= Z_{FAR2} + .5(Z_{HR1} - Z_{FAR1}) \quad (5)$$

which, by substituting in equation 1 of chapter 2, becomes;

$$C' = Z_{FAR2} - .5*d_1' \quad (6)$$

Thus C', which was defined at its inception to be a measure of bias independent of any changes in sensitivity, accomplishes this independence by explicitly incorporating the magnitude of the original sensitivity into its algebraic definition.

A repeated measures ANOVA was done using this new measure, C', as a function of Group and Condition. Again, the analyses was carried out for the confidence criterion of 4. Similar to the analyses of C, there was a Condition effect ($F(1,36) = 10.15$, $MS_e = .120$, $p < .01$). However, unlike the analyses of C, the main effect of Group was not significant

($\underline{F}(3,36) = 1.15$, $\underline{MSe} = .264$, n.s.), nor was there a significant interaction between Group and Condition ($\underline{F}(3,36) = 1.59$, $\underline{MSe} = .120$, n.s.). Thus, while the initial analysis of response bias using C indicated that the Highs had become significantly more conservative than the other groups in setting their response criterion (relative to the waking condition), the analyses of C' showed this to be artifactual, a function of this group's greater decrement in sensitivity. Table 6 show the means and standard deviations of C'.

Table 6. <u>Means and standard deviations for bias parameter C' at confidence level four as a function of hypnotic susceptibility and condition.</u>

	Hypnotic class			
Condition	Lows	Mediums	Highs	Virtuosos
Baseline	0.23	0.21	0.66	0.34
	(.36)	(.42)	(.43)	(.37)
Anesthesia	0.48	0.67	0.64	0.62
	(.40)	(.44)	(.48)	(.56)

Summary of Experiment 1.

Assessment of tactile sensitivity via classical psychophysical methods indicated a significant interaction between hypnotic suggestions for anesthesia and hypnotic susceptibility. Lows and Mediums showed no changes, while Highs and Virtuosos showed respectively greater increments in threshold. Initial analyses of tactile sensitivity with traditional signal detection parameters P(A) and C suggested that these changes were mediated by changes in both sensitivity and response criterion, and that Highs were significantly more conservative in responding, relative to baseline, than the other groups. Subsequent analyses using the bias parameter C' showed that the apparent interaction between Group and Condition in response criterion changes were artifactual, a result of the Virtuosos experiencing larger changes in sensitivity than the other groups, and signal detection theory's inability to accurately access changes in bias in the presence of such changes.

CHAPTER 4

EXPERIMENT 2:

ANESTHESIA AND HYPERESTHESIA COMPARED IN REALS AND SIMULATORS

Experiment 1 established that suggestions for hypnotic anesthesia actually produce decrements in a person's tactile sensitivity, the magnitude of which is related to hypnotic susceptibility. However, there are still other factors to be examined. First, can tactile sensitivity be enhanced as well as diminished? Experiment 2 replicates the basic findings of Experiment 1 and augments that study with suggestions for hyperesthesia -- increased sensitivity -- as well. Moreover, Experiment 2 was designed to take account of certain methodological and potential methodological problems pertaining to demand characteristics and baseline and carryover effects.

Demand Characteristics

As Orne (1959, 1962, 1969, 1979), and many others have noted, experimental outcomes reflect more than experimental manipulations. Subjects in psychological experiments are sentient beings, who are motivated to discover what the experimental hypotheses are -- if they are not also motivated to demonstrate that the experimental hypotheses are correct! Accordingly, Orne argued that it is important to evaluate the demand characteristics of any psychological experiment -- the totality of cues that inform the subject of the true nature of the experiment, the hypotheses being tested, and the way in which he or she is expected to behave. The notion of demand characteristics is different from that of experimenter bias (Rosenthal, 1966). In experimenter bias, the experimenter treats the subject in such a manner as to elicit from the subject behavior that confirms the experimenter's hypotheses. Hence, experimenter bias can be controlled by keeping the individual who tests the subject blind to the hypothesis being tested.

Unfortunately, demand characteristics cannot be controlled in such a manner, because they can arise from sources that are outside the experimenter's control. The experimenter's behavior can be a source of demand characteristics, but so can the behavior of other people involved in the experiment, not all of whom can be blinded to the experimental hypotheses. Subjects can learn about the experiment from campus scuttlebut. And, most important, the behavior of subjects in experiments can be influenced by their beliefs about how subjects are to behave. This last source is beyond the experimenter's control in principle.

Demand characteristics cannot be controlled, but they can be evaluated. One method for this purpose is the careful post-experimental interview, in which the experimenter inquires about the subject's perceptions of the experiment, and beliefs about appropriate behavior, as they evolved through the experimental encounter. However, as Orne (1962) noted, even the most careful postexperimental inquiry may not suffice, because subjects are under considerable pressure not to impeach their own performance in the experiment. Consider, for example, a subject who catches on to the hypothesis early in the experiment, and behaves accordingly. To admit doing so would be to admit to wasting not only his or her own time, but that of the experimenter as well.

Accordingly, Orne (1962) proposed that a special group of subjects be enrolled as co-investigators in the experimental enterprise, for the express purpose of evaluating the demand characteristics of the experiment. For this purpose, he recommended the use of a quasi-control group, called simulators, in which subjects who are insusceptible to hypnosis are instructed to simulate the behavior of their highly hypnotizable counterparts. Because they are known to be insusceptible to hypnosis, their behavior cannot be attributed to hypnosis per se. Rather, their behavior must be attributed to their beliefs about how hypnotized subjects behave -- beliefs that they bring with them into the experimental setting, and that develop further as they participate in the experiment itself.

The comparison of real hypnotic subjects versus those who are simulating hypnosis is based on an analogy with the double-blind placebo design familiar with drug research. Thus, like those who receive an inert substance instead of an active pharmaceutical agent, their behavior reflects the belief that they have received the drug, rather than the effects of the drug itself. Simulators of hypnosis are not strictly a control for the effects of hypnosis, because they differ from truly hypnotized subjects in a number of ways -- beginning with the fact that hypnotic subjects are hypnotizable, while simulators are not (hypnotizable subjects are not used as simulators because of the chance that they might cease simulating and slip into hypnosis instead).

Rather, simulators comprise a quasi-control group in the sense that they provide useful information about the demand characteristics of the experiment in which they participate. If the simulators differ from reals on a given task, then demand characteristics are not likely to responsible for the effects seen in the hypnotized group (but see Jones and Flynn, 1989). If, on the other hand, the two groups do not differ in outcome, then it is possible that the behavior of the real hypnotic subjects was a product of demand characteristics. Note that the failure to find real-simulator differences does not prove that demand characteristics account for the behavior of the reals. It could be that the beliefs acted on by the simulators are accurate, but they achieve the same behavioral outcomes as the reals by different psychological and cognitive processes. Thus, the real-simulator design is only informative in the case that significant difference are found between the two groups.

Baseline Effects

There is a fairly extensive literature in hypnosis regarding the effects of various motivational factors on the observed behavior of hypnotic subjects (Jones and Flynn, 1989; London and Fuhrer, 1961; Orne and Evans, 1965, Stam and Spanos, 1980; Zamansky and Brightbill, 1965). While the details of these paradigms are somewhat complex, this line of research has well-established that a subject's knowledge that he or she is participating in a hypnotic experiment will often change baseline performance. For example, a subject, knowing that in the next condition he or she will be asked to increase sensitivity, may intentionally or unintentionally lower performance during baseline assessment in order to demonstrate a subsequent gain. In this study, by having each subject participate in both the anesthesia and hyperesthesia, as well as the baseline condition, there is little a subject can do to strategically influence the baseline sensitivity. Any simple alteration of baseline performance will necessarily cause a detriment in one of the other two conditions. The only viable strategy that could be employed, is one of lowering baseline performance enough to show an improvement in the hyperesthesia condition, but not so much that performance could not be lowered further in the anesthesia condition. It is also unlikely that such strategic tampering of baselines will occur, as subjects were kept blind as to the experimental conditions of the experiment until that condition was encountered. As well, the order of conditions is counter-balanced within each group, and any effects that may occur as a result of encountering a given condition first, will be cancelled out. As well, simple between-subjects comparison of baseline levels of performance with experiment one will determine if this strategy is being employed.

Related to these baseline effects, is the work by Watson and Clopton (1969) in the area of signal detection theory, which has demonstrated that subjects will vary as to when they reach stable asymptotic performance. This is of relevance, as if baseline assessment is terminated before the subject's performance has reached asymptote, the changes attributed to an experimental manipulation may simply be part of the subject's continued movement towards asymptotic responding. Each condition in the present study has been partitioned into five blocks of 30 trials each, which will allow an empirical determination of any effects of non-asymptotic performance.

Method

Subjects. Twenty-two undergraduate males and females were selected from the introductory psychology pool on the basis of their scores on the SHSS:C. One subject was used as a pilot subject. Procedural difficulties resulted in the loss of two subsequent subjects, leaving nineteen subjects for the final analyses. Ten subjects scored between 9 and 12 and constituted the real group. Nine subjects scored between 1 and 4 and constituted the simulator group. Subjects received either experimental credits, a token monetary payment of $10.00, or a combination of the two as reimbursement for their participation.

Apparatus. The apparatus used was the same as that utilized in Experiment 1, except for two changes. Subjects' responses were collected via a specially constructed, six button response box, rather than the earlier two-step process employing a computer mouse. Moreover, while all assessments of sensitivity in Experiment 1 were obtained while the subject had his or her eyes closed, a box-blind was employed in Experiment 2 in order to ensure that subjects could not utilize any visual cues for making their tactile judgements. The box-blind was made of white styrofoam board, 20' long, 8' x 8' at one end and 12' x 12' at the other. The wider end was open to the experimenter, allowing full access to the palm of the subject's right hand. A small pillow allowed the subject to rest his or her arm comfortably inside the box.

Procedure. The basic procedure was identical to that of Experiment 1, with the following exceptions. At the beginning of the session, each subject was met by a second experimenter who administered either 'real' or 'simulating' instructions to each subject (see below). Upon entering the experimental room, each subject was familiarized with the response box until they could reliably push the button that corresponded to each response judgement. The response judgment criteria were explained to each subject while they were being shown a card with the following definitions.

'1' will be 'Very confident a touch did not occur'

'2' will be 'Fairly confident a touch occur'

'3' will be 'Just guessing a touch did not occur'

'4' will be 'Just guessing a touch did occur'

'5' will be 'Fairly confident a touch did occur'

'6' will be 'Very confident a touch did occur'

The DRIS threshold determination procedure was performed only once, during the waking state, for purposes of selecting the threshold stimulus to be used for the signal detection conditions in the experiment. Signal detection assessments of baseline sensitivity and of the two main perceptual alteration conditions utilized five blocks of thirty trials each.

The order of the suggestions for anesthesia and hyperesthesia was counterbalanced by a co-experimenter for both reals and simulators. The main experimenter was blind to the real/simulating status of the subject. The experimenter recorded his judgement of the real/simulating status of each subject after completion of the hypnotic induction. Judgements were done on a 0 to 1 probability scale, with 1 representing high confidence the subject was a real, 0 representing high confidence the subject was a simulator, and .5 denoting an inability to decide either way.

At the end of each suggestion condition the subject rated hypnotic depth and the suggestion for altered sensitivity was canceled. Ratings of hypnotic depth were also taken after each block of trials within each condition. A brief rest period was given between each condition during which suggestions for increasing hypnotic depth were given. Also, the subject was asked to move his or her hand after the third block of trials in each suggestion condition, in order to alleviate the effects of any physical fatigue on tactile sensitivity. After completion of these three conditions, and a brief rest period, two more conditions, manipulating the subject's strategy for responding, were conducted. Subjects whose prior suggestion was for hyperesthesia had this suggestion canceled and re-received suggestions for anesthesia. Subjects whose final suggestion was for anesthesia did not have this suggestion canceled, but simply continued to the next conditions. In the 'Sure' condition the subject was instructed to respond only if he or she was 'absolutely sure' a touch had occurred. To further emphasise this strategy, the subject was instructed to use only buttons 1 and 6 (the two 'very confident' response buttons). In the 'Guess' condition, the subject was told to respond using buttons 3 and 4, the two 'guessing' buttons; pressing button 4 if he or she had 'any kind of a leaning or intuition' that a touch had occurred. One block of thirty trials was run for each condition. The order of occurrence for these two conditions was randomly counterbalanced across subjects. The hypnosis session was terminated after all five conditions had been run. Total session time for each subject was approximately 2 hours. After the experiment proper had terminated, each subject was given two post-experimental interviews, one by the main experimenter, and one by the second experimenter who had administered the real or simulating instructions. The second interview was conducted after the simulators were finished 'simulating'. Thus, this second interview is generally taken to be an accurate depiction of the subjective experience of simulators during the time of the hypnosis session.

<u>Instructions to reals.</u>

We really appreciate your participation in several of our sessions so far. Today I would like your to take part in a very interesting experiment similar to those that you have participated in so far.

As you know people vary in their ability to respond to hypnosis. Some people find it very easy, while others find it very difficult. Interestingly, this ability does not seem related to any other personality characteristics.

You have gone into hypnosis several times and it seems that a lot has happened for you. You have probably been able to experience interesting changes -- like feeling flies that are not there, and not smelling odors that are there ... things like that.

In this particular study you will be working with Doug Tataryn, who is a graduate student in the laboratory. He is a very experienced and competent hypnotist, who will be carrying out an important piece of research on hypnosis.

When you are completely finished with the experiment, Doug will dismiss you and ask you to return to my office. If I should happen not to be here, just wait for me in the reception area and I'll be right with you. We'll discuss your experiences back in this office.

Do you have any questions?

All right, good luck, and I'll see you back here in a little while.

Instructions to simulators.

In this particular study; we are using a special group of subjects to which you belong. All of you are not able to enter hypnosis despite your best efforts to do so.

What we would like you to do in this study is to simulate a highly hypnotizable subject.

You will be working with Doug Tataryn, a graduate student who is very experienced and competent hypnotist, who is carrying out an important piece of research.

In this experiment, your task will be to behave as though you are a highly subject who is able to enter deep hypnosis.

There will be only 2 kinds of subjects in the experiment: those who are highly hypnotizable and can enter deep hypnosis and those people like yourself who are unable to do so, and will be trying to simulate hypnosis.

Doug does know that some subjects will be trying to simulate hypnosis, but he has no idea who these subjects will be. Your task is to convince him that you are in fact a highly hypnotizable subject.

Some people think this is a difficult task, but we have found that most people are able to do it. But you may well think you've given yourself away at some point in this experiment.

Don't worry about this possibility. If Doug recognizes that you are simulating he will stop the experiment immediately... as long as he continues the experiment, you will know you have been successful in faking hypnosis.

I'm pointing this out to you because in the past we have found that some subjects would suddenly stop, thinking they had goofed and given themselves away. When in fact their behavior had been quite appropriate and the experimenter had no idea they were simulating.

So keep in mind, then that as long as Doug continues with you, you are doing fine. If he catches on, he will stop immediately.

We realize that you have no experience with this sort of thing. You were chosen simply because you have not been able to enter deep hypnosis.

However, there have been a lot of studies using this procedure, and we know that most people are able to do this task. It may seem difficult, but it is possible.

I can't tell you how to behave or what to do. You have to use whatever you know about hypnosis, whatever cues you get from Doug and whatever you learn from the situation to figure out how a highly hypnotizable subject would behave.

Keep in mind that you will be simulating the behavior of a highly hypnotizable subject and that your task is to maintain that you are going into hypnosis, to perform during hypnosis and when you are awakened, to respond as if you had been in hypnosis. In other words this includes simulating not only while you are being hypnotized, but before and afterwards as well.

If Doug should ask you about your experience you should answer the way highly hypnotizable subjects would answer, if they had been hypnotized.

If Doug asks you how you did on prior occasions, keep in mind that you <u>are</u> a highly hypnotizable person and would have gone into deep hypnosis on your previous efforts. You would have had several previous experiences with hypnosis, just as you'll actually have, except that you would have entered deep hypnosis. All subjects will have had at least two sessions with the laboratory: the initial group session and the following session.

Results

Thresholds. During the DRIS procedure, all subjects converged on a stable threshold within the allotted thirty trials. The average trial on which convergence occurred was 10.30 (SD = 2.00) and 11.22 (SD = 1.99) for the reals and simulators respectively. This difference is not significant ($F(1,17) = 1.01$, $MSe = 3.97$, n.s.). The average tactile threshold was identical for both reals and simulators, falling between the 2nd and 3rd aesthesiometers of the series; approximately 51.28 milligrams of force.[7] The average reaction time (with outliers removed) for all trials after convergence was 1.50 (SD = .54) seconds for reals, and 1.75 (SD = .39) seconds for simulators. This difference was not significant ($F(1,17) = 1.28$, $MS_e = .226$, $p < .05$).

Rating Scale Usage. Figure 7 illustrates the relationship between criterion scale usage and the proportion of trials a stimulus was actually present. This is illustrated separately for reals and simulators under all three conditions. As can be seen, the function for the anesthesia condition, for both groups, readily satisfied the criterion. The baseline and hyperesthesia conditions met the criterion for five of the six points for both reals and simulators, and the single departure does not deviate enough to be considered a violation of the monotonicity criteria. Hence the subjects utilized the response rating scale for signal judgments in a manner consistent with the assumptions of signal detection theory.

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[7] The untransformed value of the average threshold aesthesiometer was 2.71 (SD = .21).

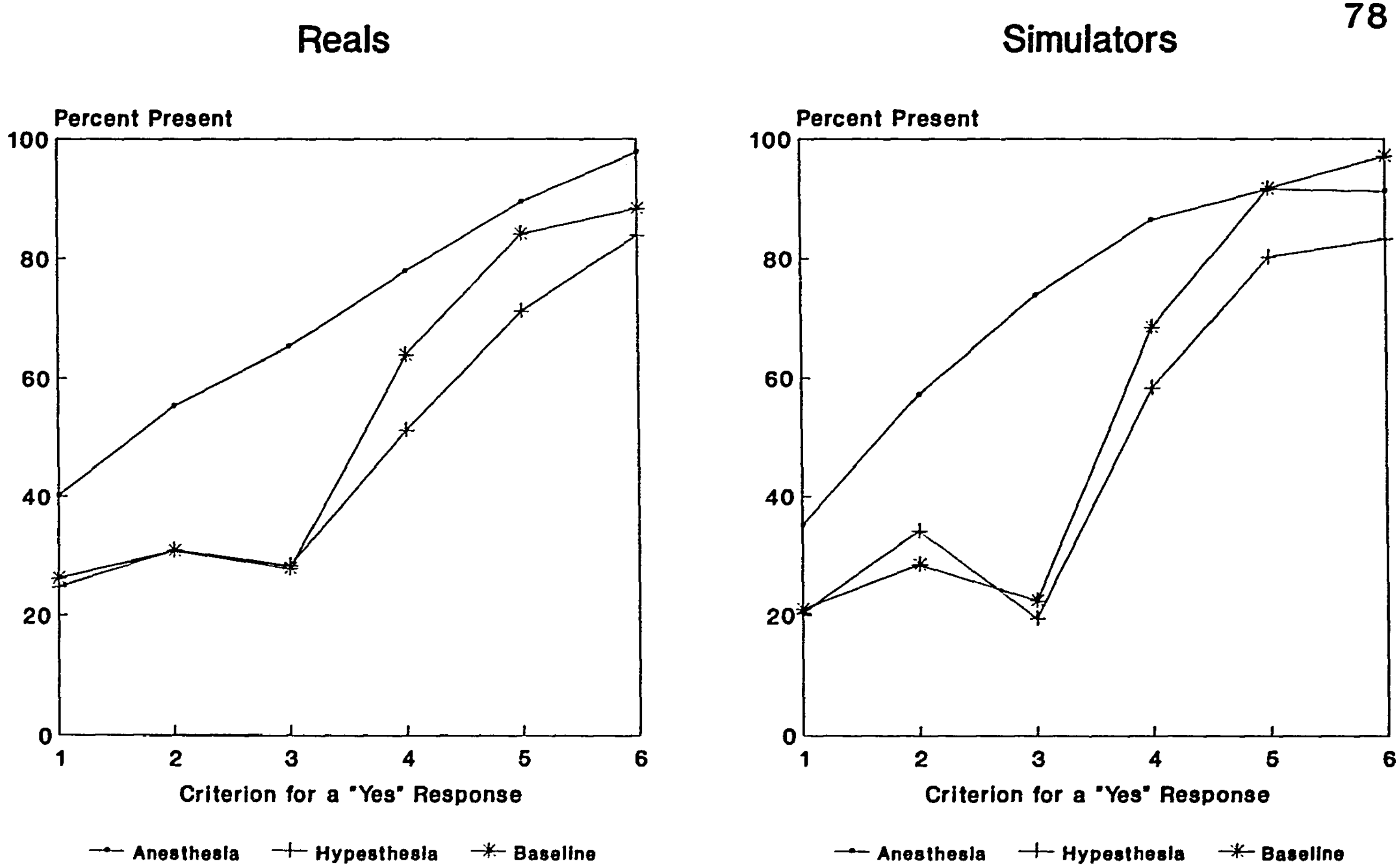

Figure 7: Proportion of signal trials as a function of confidence scale usage, condition, and group

Hit Rates and False Alarm Rates. Table 7 displays the means and standard deviations of the hit rates and false alarm rates at confidence level 4, for the two groups of subjects in each of the three conditions.

P(A). As in Experiment 1, the area underneath the actual ROC curve was calculated for each subject as a function of blocks within conditions. The Block factor was included in this analyses, as P(A) is more robust with respect to the individual stability of each rating scale point, and in fact can be estimated for single HR and FAR values. The inclusion of the Block factor will allow any temporal effects of the repeated testing on sensitivity to evaluated.

A mixed Analyses of Variance (ANOVA) with the two within factors, Condition and Blocks (five blocks of thirty trials each) and one between factor, Group, was performed on P(A). Only the experimental Condition effect was significant ($F(2,34) = 34.01$, $MS_e = 0.487$, $p < 0.0001$). The means for the baseline, anesthesia, and hyperesthesia conditions, collapsed across Groups were 0.80 (SD = .10), 0.66 (SD = .12), 0.76 (SD = .13) respectively. Newman-Keuls post-hoc analyses revealed the mean sensitivity for the anesthesia condition was significantly lower than the means of both the baseline and the hyperesthesia conditions, but that the latter two means were not significantly different from each other. Table 8 shows the means and standard deviations of the three conditions for reals and simulators. As in Experiment 1, highly hypnotizable subjects do not have higher variances than the hypnotizable subjects.

Table 7. Means and standard deviations of hit rates and false alarm rates at confidence level four as a function of real/simulator status and condition.

		Condition		
Group	N	Baseline	Anesthesia	Hyperesthesia
Hit Rate				
Simulators	9	0.68	0.17	0.70
		(.24)	(.15)	(.16)
Reals	10	0.76	0.24	0.70
		(.12)	(.24)	(.14)
False Alarm Rate				
Simulators	9	0.07	0.03	0.15
		(.03)	(.02)	(.13)
Reals	10	0.17	0.05	0.31
		(.13)	(.07)	(.25)

Table 8. Means and standard deviations of sensitivity parameter P(A) as a function of real/simulator status and condition.

		Condition		
Group	N	Baseline	Anesthesia	Hyperesthesia
Simulators	9	0.81	0.67	0.76
		(.08)	(.10)	(.13)
Reals	10	0.78	0.64	0.75
		(.09)	(.09)	(.12)

C. Parallel to Experiment 1, the point on the criterion scale at which the subjects indicated their first 'Yes' response (confidence = 4) was utilized to analyze the index of bias, C. A mixed ANOVA with two within factors (Block and Condition) and one between factor, Group, was performed. Similar to the results of the P(A) analyses, only the Condition factor was significant, ($F(2,34) = 65.18$, $MS_e = .178$, $p < .0001$), with no effect of Block or Group. Both reals and simulators became more conservative for the anesthesia condition, and more liberal in the hyperaesthesia condition. Table 9 illustrates the means and standard deviations as a function of Group status and Condition.

Table 9. Means and standard deviations of bias parameter C at confidence level four as a function of real/simulator status and condition.

Group	N	Baseline	Anesthesia	Hyperesthesia
		Condition		
Simulators	9	0.48	1.67	0.30
		(.37)	(.50)	(.61)
Reals	10	0.25	1.51	-0.05
		(.33)	(.76)	(.51)

As in Experiment 1, this apparent change in response criterion may be an artifact of the change in sensitivity experienced by the subjects. Accordingly, as before, analysis of C' was performed.

C'. The ANOVA for C' at the confidence level of 4, revealed a significant effect for only Condition, ($F(2,34) = 26.79$, $MS_e = .229$, $p < .0001$), and no effect of Group, either alone or in interaction with Condition. As expected by the significant changes in sensitivity in the anesthesia Condition, the examination of table 10, which contains the means and standard deviations of this analysis, reveals much smaller changes in response criterion than suggested by the analyses of C (see table 9). In table 9, the average difference between the baseline and anesthesia condition is approximately one and a quarter standardized units, approximately half a standard deviation greater than the difference indicated by table 10. Also note that the differences between the hyperesthesia and baseline sensitivity for the two tables are quite similar, which is expected given the insignificant change in sensitivity.

Table 10. Means and standard deviations of bias parameter C' at confidence level four as a function of real/simulator status and condition.

		Condition		
Group	N	Baseline	Anesthesia	Hyperesthesia
Simulators	9	0.48	1.03	0.17
		(.37)	(.31)	(.70)
Reals	10	0.25	1.23	-0.13
		(.33)	(.69)	(.76)

The Effects of Response Strategy on Sensitivity and Bias.

P(A). The repeated measures ANOVA contrasting the effects of the 'Sure' and 'Guessing' conditions, as a function of real/simulator status, revealed only a significant effect of Condition ($F(1,17)$ = 14.18, MS_e = .002, $p < .01$). Table 11 illustrates the means and standard deviations for P(A) as a function of Group and Condition. The difference between the two conditions, collapsed across Groups, is approximately .06 units. This represents an 85% increase in above-chance responding as the subjects changed their strategy for responding from 'very confident' to 'just guessing' a touch occurred. While earlier analyses did not find a significant block effect, the fact that the sensitivity estimate for both Groups in this condition is less than the prior estimates of sensitivity in the anesthesia condition, suggests that fatigue was effecting the subjects' performances.

Table 11. Means and standard deviations of sensitivity parameter P(A) as a function of real/simulator status and sure/guess condition.

		Condition	
Group	N	Guess	Sure
Simulators	9	0.64	0.57
		(0.06)	(0.07)
Reals	10	0.62	0.57
		(0.12)	(0.12)

C. The ANOVA of the bias parameter C showed only a significant effect of Condition ($F(1,17) = 22.67$, MSe = .068, $p < .002$). This effect was in the expected direction, with the 'Sure' condition invoking a more conservative response set in both groups. Table 12 shows the means and standard deviations as a function of Group by Condition.

C'. As with the other analyses of Experiment 1 and 2, the bias index C' was calculated to obtain an index of response bias uncontaminated by the change in sensitivity which occurred between the Sure and the Guess conditions. The repeated measures ANOVA produced a significant effect of Condition ($F(1,17) = 5.86$, MSe = .055, $p < .05$), and no effect of Group nor interaction. Note that as with the other comparisons between C and C', this analysis indicates a much smaller change in response criterion between the two conditions. Interestingly, even though subjects have been instructed to guess, the response criterion is still quite conservative in comparison to either the baseline or hyperesthesia conditions (Table 13).

Table 12. Means and standard deviations of bias parameter C as a function of real/simulator status and sure/guess condition.

		Condition	
Group	N	Guess	Sure
Simulators	9	0.96 (0.30)	1.46 (0.39)
Reals	10	1.07 (0.50)	1.38 (0.60)

Table 13. Means and standard deviations of bias parameter C' as a function of real/simulator status and sure/guess condition.

		Condition	
Group	N	Guess	Sure
Simulators	9	1.23	1.46
		(0.40)	(0.39)
Reals	10	1.23	1.38
		(0.58)	(0.60)

Analyses of Experimenter Judgements and Expectancies.

Judgments of real/simulator Status. While the experimenter judgements were initially collected on a 0 to 1 probability scale, initial analysis indicated a binary outcome, with a cutpoint of .5, to be as accurate as any other cutpoint. Table 14 shows a cross-tabulation of actual subject status (real/simulator) by the experimenter's rating of subject status. The hit rate is .67 and the false alarm rate is .50. Calculation of accuracy (sensitivity parameter P(A)) indicated slightly above chance performance (P(A) = .58). While signal detection theory does not allow for a test of significance of this parameter, a X^2 analysis based on the 2X2 contingency table indicated non-significance ($X^2(1)$ = .88, n.s.). The bias parameter C suggested a small, and likely non-significant, bias towards responding 'Real' (C = -.22).

Table 14. Cross-tabulation of actual Real/Simulator status by experimenter rating of status.

Experimenter Rating	Actual Status		
	Reals	Simulators	Totals
Reals	8	5	13
	(.67)[a]	(.50)	(.59)[b]
Simulators	4	5	9
	(.33)	(.50)	(.41)
Totals[c]	12	10	22

[a] - Parenthetical material represents percent accuracy in rating the actual (column) status.

[b] - Hit rate and false alarm rate of this row were used to calculate sensitivity (P(A) = .58) and bias (C = -.22).

[c] - Total includes the pilot subject and the two subjects not used in the main experiment because of procedural difficulties.

Assessment of Experimenter Expectancy Effects. In order to examine the possible influence of the experimenter's perception of the real/simulating status of a subject on the subject's response to the hypnotic suggestions, sensitivity and bias parameters were recalculated using Perceived Status in place of actual Group status. A repeated measures ANOVA of Perceived Status by Condition was run for the sensitivity parameter P(A) and response bias parameter C at the confidence level of 4. There was a main effect of Condition for both P(A), $F(1,17) = 30.29$, $MS_e = .003$, $p < .0001$, and C, ($F(1,17) = 62.47$, $MS_e = .169$, $p < .0001$). Neither the main effect of Perceived Status nor the interaction of Perceived Status and Condition approached significance. In the absence of any experimenter expectancy effects on these condition, no further analyses of possible effects were conducted.

Post-Experimental Interviews.

During the first interview with the main experimenter, all subjects (i.e., regardless of their actual real/simulating status), claimed to experience genuine alterations in tactile sensitivity for each of the two hypnotic suggestions. This was not true during the second interview. For instance, in response to the question 'On what basis did you give the hypnotic depth ratings', ten of the ten reals reported to have responded according to how relaxed or deeply hypnotized they felt, with two mentioning distinct physiological concommitants of the relaxation. In contrast, only three simulators said they responded according how relaxed they felt. The rest stated that they had deceived the experimenter in some way, by attempting to respond as they thought a genuinely hypnotized person would.

With regards to the different subjects' experiences during anesthesia, all subjects were asked two questions. The first was open-ended, designed to elicit spontaneous descriptions of their experience. To this, eight of the ten reals reported experiencing a genuine decrement in sensitivity, usually described as the hand becoming numb or tingly, or in one case, cold. Only one simulator described a similar experience. Two simulators stated they had concentrated less during the anesthesia suggestion and six others did not mention experiencing any numbness. When asked the second more specific question, to the effect of -- 'Did you actually lose sensitivity or did you just change what you considered a touch?' -- five reals maintained that they had simply lost tactile sensitivity in the area of the circle, three described that the had changed their definition of a touch, and one said both had happened. To this question, seven simulators described changing the definition of a touch.

Interestingly, an equal number or reals and simulators (four) spontaneously reported experiencing an increase in sensitivity in response to the general question about their experience of hyperesthesia. In response to the specific question, regarding whether they were more able to tell when they had or had not been touched, eight reals and seven simulators responded positively. Three of these simulators had reported concentrating more in an effort to do so, while two reported doing so by changing their definition of what they considered a touch. In contrast, two reals reported an increase in sensitivity by the latter mechanism, while the rest offered no explanation for their experience of increased sensitivity.

Summary of Experiment 2

Experiment 2 confirmed decrements in sensitivity for the anesthesia condition, but found no evidence for increased sensitivity under suggestions of hyperaesthesia. Assessment of bias across conditions indicated the expected results, with suggestions for anesthesia producing a more conservative response criterion, and suggestions for hyperesthesia invoking a more liberal one. The more appropriate analyses of bias using C' indicated that the response criterions were much less affected by the experimental manipulations than the C analyses suggested, and thus, that the much of the magnitude of the change in C was a function of changes in sensitivity. No significant differences were found between reals and simulators for any of the analyses. Having the subjects change their response strategy from only responding 'yes' if they were certain they were touched to allowing their responses to be based on guesses or intuitions increased sensitivity a significant amount. A signal detection analysis of the experimenter's ratings of real/simulator status indicated chance responding and no bias -- the experimenter was unable to differentiate reals from simulators. Thus the ratings of Perceived Status were not significantly related to the subject's performance in the experiment. Examination of the post-experimental interviews conducted by the second experimenter indicated that contrary to the behavioral similarities between the two groups, the subjective experiences were quite differences. Only one simulator had the subjective experience of anesthesia, which is in contrast to the reals, of which eighty percent experienced a genuine anesthesia. Approximately equal numbers of reals and simulators reported a subjective experience of hyperesthesia. Just under half of the simulators who did so indicated they felt they had done so by increasing their concentration, while no reals reported using such strategies.

CHAPTER 5

DISCUSSION

Both Experiment 1 and Experiment 2 showed apparent threshold changes during hypnotic anesthesia, as measured by traditional psychophysical methods. These changes in sensitivity were confirmed by the signal detection analyses. Signal detection analyses also indicated changes in response bias in both experiments, with suggestions for anesthesia inducing a large conservative response criterion shift, especially so for the Virtuosos in Experiment 1. Analyses of C' showed that much of the magnitude of these changes were artifactual, a result of changes in sensitivity across the conditions. In fact, once the changes in sensitivity were accounted for, the Virtuosos showed no greater change in response criterion that the other groups. This general result, of a reduction in the estimation of the shift in response criterion, was replicated in Experiment 2. In contrast to suggestions for anesthesia, suggestions for hypnotic hyperesthesia had no effects on sensitivity. Experimentally manipulating the subject's response strategy from responding only if certain, to responding according to his or her feelings or best guess, while under suggestions for anesthesia, increased sensitivity. Insusceptible subjects instructed to simulate hypnosis showed a pattern of performance in the anesthesia and hyperesthesia conditions that closely mimicked that of the real hypnotic subjects. The post-experimental interviews however, indicated that the reals and simulators had very different subjective experiences during the different hypnotic suggestions. Finally, analyses for possible experimenter effects indicated the experimenter to be unable to differentiate reals from simulators and that these perceptions did not influence the subjects' responses to the experimental manipulations.

While suggestion-induced differences in thresholds, as estimated by traditional psychophysical methods, are readily dismissed as being a function of suggestion-induced changes in response biases, this can not be said for differences that are maintained in the context of a signal detection paradigm. Hypnotic suggestions for anesthesia produce real changes in tactile sensitivity. These changes vary linearly with hypnotic susceptibility, with Virtuosos showing the greatest effects, and Lows showing none. While several virtuosos showed a complete loss of tactile sensitivity, the average decrement in this group, as measured by the change in above chance responding, was 47%. These basic results were replicated in Experiment 2. These outcomes are likely not an artifact of baseline or carryover affects as examination of table 4 demonstrates that Lows, Mediums, Highs and Virtuosos all had nearly identical baseline sensitivity. This result, in conjunction with the fact that Lows do not show any effect of anesthesia suggestions, indicates that the baseline assessments of sensitivity are uncontaminated by strategic responding on the part of the more hypnotizable subjects. Looking across experiments, from Experiment 1 to Experiment 2, we find a small but insignificant decrease in baseline responding for the Virtuosos ($\underline{t}_{18}$ = .99, n.s.) and Lows/simulators ($\underline{t}_{17}$ = 1.26, n.s.). Even if the changes had be significant, the fact that they were both negative, suggests that such an alleged strategy would be for subsequently exhibiting hypersensitivity. However, this hypothesis is made untenable by the fact that there was only a significant effect of suggestions for anesthesia in Experiment 2, and a small insignificant decrease in the hyperesthesia condition (likely an affect of fatigue). Finally, assessment of experimenter effects indicated only chance classification of subjects into real and simulators, and no relationship between perceived status and experimental outcome. The final conclusion is that suggestions for anesthesia produce genuine decrements in tactile sensitivity.

There was no significant effect of suggestions for hyperesthesia in this experiment. This contrasts with the significant, rather large effects on visual acuity obtained by Graham and Liebowitz (1972) and Sheehan et al (1982). There are several possible reasons for this. One is that this present study used near-liminal stimuli and tried to increase sensitivity beyond this, while the visual enhancement studies used myopic individuals, individuals who suffer from chronic below-optimal sensory functioning and attempted to bring this sub-optimal functioning to more normal functioning levels. This latter endeavour might be more amenable to change by some aspect of hypnotic suggestions. Related to this, the nature of the tasks in the two studies are quite different -- threshold detection versus sensory acuity. The first has to do with the raw ability to detect a stimulus, while the latter has to do with the ability to discriminate stimuli once detection has occurred. It is possible that perceptual acuity, having to do with the ability to recognize objects in the external world, involves more 'top-down' than 'bottom-up' processes. In contrast, threshold detection is largely mediated by bottom-up processes. Since hypnosis is postulated to work via 'higher' cognitive processes by a variety of different theories (e.g., Hilgard, 1973; Spanos and Chaves, 1989), it is more likely to influence the former than the latter. Another difference, is that these visual acuity studies gave rather indirect suggestions for increased visual functioning ('relax the muscles of the eye'), while the present experiment used direct, explicit suggestions to enhance performance. The two suggestions are quite different for this reason alone, but the indirect suggestions also contained a strategy by which to achieve the ends. The present study suggested the ends, but offered no means by which to achieve them. Perhaps suggesting an effective strategy, like 'concentrating more' (i.e., increasing attentional allocation to the task), or 'becoming very quiet inside' (i.e., decreasing the magnitude of the noise distribution) might allow subjects to manifest hypersensitivity. Of course considerable research would be needed to find such a strategy, but it does leave open the possibility of finding hypnotically-induced tactile hyperesthesia in the future.

One important aspect of Experiment 2 was in replicating and investigating the findings of Experiment 1 with regards to the possible influence of demand characteristics and experimenter expectancy effects. The real-simulator design, by placing unhypnotizable subjects in he same conditions as hypnotizable one, is able to ascertain the degree to which demand characteristics and situational factors are present in the experimental situation, and the extent to which the experimental effects can be volitionally enacted. Experiment 2 found no differences between reals and simulators in any of the conditions or interactions. The conclusion from this is that the experimental context and dynamics are sufficient to guide an actor to behave in such a way as to be indiscernible from a genuinely hypnotized person. This in no way, however, impeaches the accomplishment of the latter, nor informs as to the actual mechanism by which the reals achieved their decrements in tactile sensitivity. Further inquiry into these mechanisms is accomplished through critical examinations of the post-experimental questionnaires. As expected, both groups responded similarly to the post-experimental interview when it was administered by the main experimenter -- the reals were describing their phenomenal experiences during the course of the experiment, and the simulators continued to generate the responses they thought appropriate of a highly hypnotizable subject. However, during the second post-experimental interview, when the demands of the experimental context had been withdrawn, and both groups were re-interviewed, the reals continued to describe their experiences, and the simulators were now, for the first time, allowed to do so. Under these conditions it became clear that while the behavioral manifestations had been identical, they had been carried out by very different cognitive mechanisms. The reals described reporting hypnotic depth as a function of how relaxed or deeply hypnotized they felt. In contrast, simulators indicated (by omission) that they had not been relaxed, but had attempted to respond as they deduced a highly hypnotizable subject would. Similarly, during this second interview, the majority of the reals continued to report the phenomenal experience of losing tactile sensation during the anesthesia condition while only one simulator expressed a similar claim. The simulators described either changing their definition of what they would call a touch, or of other strategies, such as concentrating less during that condition. This same pattern is holds for the testimonies regarding phenomenal experience during suggestions for hypersensitivity. Here, even though an equal number of reals and simulators felt they had experienced genuine hyperesthesia, over half of the simulators again reported using intentional strategies to do so (e.g., increasing concentration). The reals did not. This general result, in which reals and simulators behave similarly but via different mechanisms or with different subjective experiences, is consistent with the recent literature in the area (e.g., Miller and Bowers, 1986; McConkey, Bryant, Bibb, and Kihlstrom, 1991), and will be examined in more detailing the next section.

Both the psychophysical and signal detection methods of analysis found decreased sensitivity in the anesthesia condition and no effects of suggestions for hyperesthesia. These results are consistent with Hilgard's (1973) neodissociation theory of divided consciousness. According to Hilgard, normal human behavior and functioning reflects an integrated interaction between executive control functions and the various subsystems of control needed to execute given tasks. Under certain circumstances however, this integrated functioning is sometimes disrupted, explaining both 'normal' (e.g, not falling out of bed while sleeping, tip-of-the-tongue phenomena) and abnormal phenomena (e.g., fugue states, multiple personality disorder). Another aspect that can occur during these disruptions is the erection of an amnesia-like barrier between the executive control functions and the cognitive subsystems which have been responsible for the cognitive processes and actions during the disrupted state. Hilgard employs this model to explain many of the core phenomena of hypnosis, such as spontaneous amnesia, the ubiquitous experience of non-volition, and hypnotic analgesia. Hence hypnotic anesthesia occurs because the subsystem responsible for tactile sensitivity has been cut off from executive monitoring, and thus the phenomenal experience of being touched is either lost or greatly diminished. Greater degrees of dissociation are associated with increasing hypnotizability, thus explaining the pattern of results in Experiment 1, in which the magnitude of the decrement in tactile sensitivity increased as a function of hypnotic group. The absence of any affect of suggestions for hyperaesthesia, found in Experiment 2, is also predicted by this model -- executive control can be dissociated from a subsystem's output, but there is no mechanism by which a subsystem's output can be augmented.

While neodissociation theory explains the results for the reals, as they are predicted to have the ability to dissociate executive and subsystem mechanisms, it does not explain the ability of lows to produce decrements in sensitivity. However, as evidenced by the post-experimental interviews, only one simulator had the phenomenal experience of losing sensitivity and in a sense, there is nothing for a theory of hypnosis to explain. Simulators simply successfully attempted to comply with the task demands by some sort of strategy, such as changing their definition of a touch, or by concentrating less on the hand being stimulated. This strategic enactment by the simulators is consistent with Spanos and others' (e.g., Barber, 1969; Spanos and Chaves, 1989) notion that hypnotic effects such as analgesia are produced by intentional strategies. Hence we find that while both reals and simulators manifested similar behavior (i.e., decrements in tactile anesthesia), Hilgard's neodissociation explanation is consistent with the results and phenomenal experience (as evidenced by the post-experimental interviews) of the reals, and Spanos' intentional strategy hypothesis is consistent with the results and phenomenal experience of the lows. As mentioned earlier, this type of single-behavior/different-processes outcome is consistent with recent research done in Bowers' hypnosis laboratory.

In one study (Miller and Bowers, 1986) 18 highs and 18 lows (using the same definition as the present study), examined the effects of different methodologies for inducing analgesia during the cold pressor test, on concurrent reading ability. In terms of reducing the experience of pain, they found no difference between hypnotic analgesia and cognitive strategies, though both strategies were more effective for Highs than Lows. The effect of the cold pressor condition alone was to cause an overall decrement in reading ability by about 35% for all subjects. For both the high and low hypnotizable subjects, the use of cognitive strategies to reduce pain caused an additional drop of 30% in the reading ability. In the hypnotic analgesia condition however, things were quite different. Lows showed only an 8% drop in reading ability from cold-pressor-alone baseline, while Highs actually showed an <u>increase</u> in reading ability of about 10% over baseline performance. This is in spite the fact that cognitive strategies and hypnotic analgesia were equally affective in reducing experienced pain.

In another experiment reported by Bowers and Davidson (1989) changes in heart rate and self-report ratings of effort and fear during two imaging conditions -- fearful trials and neutral trials -- were examined. The subjects were 30 Highs and 30 Lows, defined by scores of 8-12 and 0-4 first on the HGSHS:A and then on the group version of the SSHS:C scale. As predicted by past research, Highs showed approximately twice the mean heart rate increase as Lows, and significantly higher ratings of fear, during the fearful imagery condition. Neither group showed appreciable increases in heart rate during the neutral condition, though Lows reported significantly more effort to produce the images. Of particular interest is the pattern of correlations amongst the dependant variables for the two different groups. For the Lows, the correlation between mean heart rate increase and self-reported effort was about .50 for both imagery conditions. The correlation between this effort and fear ratings is about .66. However, the correlation between fear ratings and heart rate increases was only about .16. While past literature indicates that heart rate increases are associated with both cognitive effort and emotional arousal, it seems that in the case of the

Lows, it is reflecting cognitive effort. This is not the case for the highly hypnotizable subjects. Only in the fearful imagery condition did heart rate correlate with self-reported cognitive effort, but it did so in the negative direction (r = -.52), indicating that the less effort involved in constructing the image, the more fearful it was. This interpretation is consistent with the strong positive correlation between heart rate increase and self-reported fear (r = .59), and the strong negative correlation of -.59 between cognitive effort and reported fear. Clearly, while both groups showed an increase in heart rate during the imagery conditions, they were being brought about by different mechanisms -- effort on the part of the Lows, and emotional arousal on the part of the Highs. Taken together, both studies lend considerable support the present findings that similar behavioral outcomes can be brought about by different cognitive mechanisms, and that lows produce such outcomes by intentional strategies (i.e., inducing tactile anesthesia by 'concentrating less') while highs are likely to simply experience the effects as 'happening to them' -- without their conscious or executive involvement (i.e., 'my hand went numb').

Orne's (1959) original intent of the real-simulator design was to ascertain the extent to which demand characteristics are present in the hypnotic situation, and could be guiding the performance of the hypnotizable subject. In other words, the degree to which simulators responded 'appropriately' but differently than genuinely hypnotized subjects would reflect the degree to which hypnotic involvement was critical for the phenomena in question. In actuality, simulators seldom behave differently than hypnotizable subjects, and when they do, they tend to overplay, or appear <u>more</u> hypnotizable than the real subjects (Levitt and Overlay, 1971; McConkey et al, 1991). Despite this preponderance of no-difference findings, the real-simulator design has proved useful for gaining insight into the <u>subjective</u> experience of hypnosis. Paradigms such as the Experiential Analyses Technique (Sheehan and McConkey, 1982), the use of post-experimental questionnaires and interviews such those employed in the present study, and the strategic use of physiological and self-report measures (e.g., Bowers and Davidson, 1989; Miller and Bowers, 1986) have consistently revealed that the subjective experience and cognitive processes of the real and simulating subject are quite different from one another. It would appear that evolving and refining the existing methods for assessing such differences, in conjunction with the real-simulating paradigm, will continue to provide valuable insights into the subjective perceptions and processes of the hypnotized person.

While the prior discussion has focused on the phenomenal experience of the subjects during the experiment to help delineate the cognitive processes involved in hypnosis, there is still an anomaly to be explained with regards to the present results and signal detection theory. While it is conceivable that reals maintained their increments in tactile threshold under the scrutiny of a signal detection analyses -- i.e., they were actually experiencing less sensitivity -- this was not the case for the simulators, who also maintained their increments in tactile threshold throughout the signal detection condition. According to signal detection theory, if an observer simply adopts a different criterion for responding positively to a signal, this should be reflected not by a change in the index of sensitivity, but in the index of response bias. Why was this not the case with the performance of the simulators? Obviously they have found an effective intentional cognitive strategy for appearing less sensitive, even under the close scrutiny of the signal detection paradigm. An examination of different possible strategies and how each is reflected in the various signal detection parameters will be useful. To facilitate doing so, we will consider a hypothetical, but parallel experiment, in which signal detection methods are used to assess sensitivity twice, once in baseline conditions, and once in anesthesia condition. For this example, the baseline condition the observer has veridical knowledge as to the state of the world (i.e., believing the stimulus is present when it is, and believing it is not present when it is not) about 80% of the time. For each of the hypothetical possible strategies, each strategy will effect only 20 of the 200 trials, or 10% of the total signal detection trials. The 2x2 contingency tables, the HR and FAR, the sensitivity parameter P(A), and the bias measures C' are presented in tables 15a-e.

Table 15a, b The effects of different response strategies on various indexes of signal detection theory.

Strategy				HR	FAR	P(A)	C'
				Signal detection parameters			
a)			Baseline				
	Real World						
	1	0	Total				
Yes	80	20	100				
No	20	80	100				
Total	100	100	200	0.8	0.2	0.8	0.0
b)			Increase Criterion				
	Real World						
	1	0	Total				
Yes	70	10	80				
No	30	90	120				
Total	100	100	200	0.7	0.1	0.8	0.44

Table 15c, d The effects of different response strategies on various indexes of signal detection theory.

Strategy				HR	FAR	P(A)	C'
				Signal detection parameters			
c) Self-distraction: Random responding							
	Real World						
	1	0	Total				
Yes	70	30	100				
No	30	70	100				
Total	100	100	200	0.7	0.3	0.7	-0.32
d) Self-distraction: Bias to negative responding							
	Real World						
	1	0	Total				
Yes	70	10	80				
No	30	90	120				
Total	100	100	200	0.7	0.1	0.8	0.44

Table 15e The effects of different response strategies on various indexes of signal detection theory.

Strategy				Signal detection parameters			
				HR	FAR	P(A)	C'
e)			Faking				
	Real World						
	1	0	Total				
Yes	64	16	80				
No	36	84	120				
Total	100	100	200	0.64	0.16	0.74	0.15

The discussion of the post-experimental interviews indicated that several lows attempted become anesthetic by 'concentrating less', while other did so, by 'changing the definition of a touch'. The social-psychological model (Spanos and Chaves, 1989) of hypnosis, which the Miller and Bowers (1986) and Bowers and Davidson (1989) studies have shown to be appropriate for describing the cognitive processes of simulators, would suggest that cognitive strategies such as self-distraction are responsible for mediating the effect. Since 'concentrating less' and self-distraction are operationally similar strategies, they will be referred to as self-distraction and examined together. A final possible strategy for inducing anesthesia is simply 'faking' -- responding 'no' in the presence of information to the contrary.

It is not immediately clear what is meant by the phrase 'changing the definition of a touch'. One interpretation is that the observer will respond positively to a touch if and only if it also has another particular characteristic associated with it, such as occurring near the edge of the circle or seeming to last longer than most touches. Another interpretation is that the subject will simply become more stringent about what is considered a touch. While both of these are valid (and essentially identical) interpretations of a 'different definition' of a touch, neither strategy effects the index of sensitivity. Rather, as seen in table 15b, both will simply lower the hit and false alarm rates and manifest as a conservative response bias with no change in the sensitivity index. Hence neither of these interpretations suggests this strategy to be a viable way of simulating anesthesia.

By actively distracting one's attention from the stimulus (or 'concentrating less') the observers state of knowledge about the stimulus will decrease. This decrease in knowledge will manifest equally in both classes -- hits and correct rejections. It must, for if one is not attending to the stimulus, there can not be any differential responding between the two real world states of 'stimulus present' and 'stimulus absent'. If the observer responds in a random fashion for these trials, both the hit rate and the correct rejection rate will decrease by the same percentage. Accordingly, the false alarm rate, which is unity minus the correct-rejection rate, will increase. As seen in table 15c, the decreased hit rate, in conjunction with an increased false alarm rate, will lower the magnitude of the index of sensitivity. Because responding for these trials is random, there will be no change in the bias parameter C. However, relative to baseline responding, the FAR has increased, suggesting a more liberal response criterion. This is reflected in the negative sign of the bias parameter C'. Hence, while this strategy does produce a decrement in the index of sensitivity, it also produces an increase in the false alarm rate. Since table 7 indicates that the false alarm rate decreased in the anesthesia condition, relative to baseline, this strategy could not have been employed by the simulators in this study. There is however a second way of responding in the distraction condition. If, rather than randomly, the observer has decided that in order to appear 'anesthetized', he or she should, in the absence of information, should respond 'no', then both the false alarm rate and the hit rate will decrease an equal amount. As seen in table 15d the magnitude of the sensitivity measure will not change, while the index of bias will indicate more conservative criterion. The lack of a decrement in the sensitivity index rules out this strategy.

Finally, consider the strategy of 'faking', in which the observer has information about the state of the world and uses it to simulate anesthesia. By responding normally for the majority of the trials, but negatively when a second criteria is reached -- when he or she is very certain a touch has occurred -- responses that would normally distribute themselves on the 'Yes' side of the table are now distributed on the 'No' side (table 15e). This is not a response bias or change in criterion per se, as it is only those stimuli that pass the second criteria that are effected. Since the observer does not have perfect information about the state of the world, as evidenced in the imperfect responding on baseline assessment (table 15a) an equal proportion of hits and false alarms are affected. If we assume for the sake of simplicity that the proportion of hits and false alarms stays constant at the second criterion, then of the 20 trials affected, 80% or 16 of them which would have contributed to the hit rate, will now contribute to the 'miss' category. The other four trials, which would have been false alarms, will contribute to the correct rejection rate. The sensitivity index will decrease and the bias index will reflect a slightly more conservative criterion. Note that while the effect is considerable with regards to the hit rate and sensitivity index, the false alarm rate remains relatively unchanged, just slightly lower than the baseline. Examination of table 7 indicates this pattern of change is consistent with that seen by the simulators. The hit rate for simulators was .68 in the baseline condition, dropping by over 50 points, to .17 in the anesthesia condition. In contrast, the false alarm rate dropped from .07 to .03, a considerably smaller change.

Hence, of the various strategies that could have been employed in attempting to decrease tactile sensitivity, only self distraction with random responding and faking produce decrements in measured sensitivity. However, self-distraction with random responding also increases the false alarm rate, while a faking strategy decreases the false alarm rate. Hence, the pattern of change across conditions suggests the simulators did indeed fake -- intentionally respond negatively in the presence of contrary information -- their anesthesia.

What are the implications of the simulators' behavior for the application of signal detection theory to such circumstances? The obvious one is to question the ability of signal detection theory to operate in the presence of intentional strategies intended to have the observer appear either more or less sensitive than he or she really is. However, by the absence of any ability, by either group, to increase sensitivity in the hyperesthesia condition, it appears that signal detection theory is actually quite robust in this circumstance. This is contrary to what is easily imagined to have happened using a traditional psychophysical approach to measuring hypersensitivity. A subject who wished to appear hypersensitive, in the absence of catch trials (trials in which no stimulus is presented), and being prompted each time to respond after a stimulus had been presented, could simply respond 'yes' to all trials. The descending and ascending staircases would simply converge on the smallest stimuli, the subject would appear hypersensitive, and there would be no mechanism by which a traditional assessment of sensitivity could detect such a deception. In a sense, traditional methods of psychophysical estimation fail because the subject has perfect information at each trial -- he or she knows that a stimulus occurred, and this information <u>can</u> be used advantageously. Note the emphasis on the word 'can'. Early researchers in psychophysics attempted to take care of this problem by training their observers. By making observers allies in their quest to the find the 'limits' of the various faculties of human perception (Swets, 1961), they could assume well-motivated and veridical responding. The application of signal detection theory to human perception took some of this responsibility away from the observer. By incorporating trials in which no stimulus was presented, the observer no longer had perfect information about the state of the world. In essence, this allowed the individual's bias with regards to setting a response criterion to be factored into the equation and out of the results. Thus determining the <u>limits</u> of human perception became more objective and less subject to individual differences. Notice the emphasis on the word 'limits'. Now consider the situation in which the simulators in the anesthesia condition find themselves. In the baseline trials, responding can be veridical to experience; each subject will make a certain proportion of genuine hits and false alarms, and produce an above chance index of sensitivity. In the anesthesia condition, the subject is now placed in a situation in which the same stimulus is utilized, but he or she is motivated to 'lose sensitivity'. As the faking strategy in the prior discussion illustrates, the subject can now use the information he or she has about the stimulus event, as indexed in the baseline sensitivity, in an attempt to meet the demands of the condition. The overall problem with the paradigm, is that we are no longer attempting to find the limits of a perceptual domain. A subject motivated to become hypersensitive, can not, as the signal detection paradigm operates appropriately in this mode, weighing the false alarm rate against the hit rate to extract a sensitivity parameter uncontaminated by the motivational aspirations of the subject. A subject motivated to become anesthetic however, has the information at his or disposal to differentially manipulate the hit and false alarm rates in his or her favour. In other words, his or her 'bias' is not randomly distributed between 'stimulus present' and 'stimulus absent'. Note that because the information about the stimulus world is not perfect (i.e., genuine misses and false alarms in the baseline condition), some of this motivational factor is reflected in the (accidental) decrease in the false alarm rate. Had a stimuli well-above threshold been utilized in the present experiment, the subject could have carried out his or her intentional decrement in performance transparently. Thus, as the results of this study and the present rational has clarified, signal detection methods are appropriate only for finding the limits of a given stimulus or stimulus-noise combination -- situations in which the information available to the observer is not perfect and decreases as a function of the experimental manipulation. If the experimental manipulation either increases or maintains the subject with the same amount of information, researchers are once again left to trusting the integrity of the subject for unbiased results with regards to their manipulation. This is the situation in which traditional psychophysicists found themselves prior to the development of signal detection theory, which was the very motivation for that theory.

With further regards to signal detection theory, this study also clarified and resolved a problem regarding the dependency of the bias index on the sensitivity index (Collyer, 1981). Original signal detection studies did not make across-condition comparisons of bias, as the intent was simply to make estimates of sensitivity uncontaminated by individual differences in bias. Once bias per se becomes of interest, such as in the present research, or in studies of individual or group differences in memory (e.g., Murdock, 1982), pain (e.g., Chapman, 1977; Rollman, 1976, 1977), and dementia (Mohs and Davis, 1982; Snodgrass and Corwin, 1988), this dependency become problematic. To overcome this problem, a new bias estimate, C', was derived, which makes valid across-condition comparisons of bias possible. This was accomplished by assuming that the shape of noise distributions was not affected by the experimental distributions, 'aligning' the noise distributions from the various conditions, and defining the mean of these distributions to be

0. Any estimates of bias (i.e., relative placement of the observer's response criterion) in the different conditions are then be made relative to baseline parameters, specifically, the point of intersection (i.e., optimal responding) of the initial noise and signal-plus-noise distributions. Algebraicly, the definition of C' is

$$C' = Z_{FARx} - .5*d_{I'}$$

where Z_{FARx} is the Z-score associated with the FAR in condition x, and d_I' is the estimate of sensitivity for the initial baseline or control condition. The present study found this parameter to be very useful, reducing estimates of bias across all subjects, and completely eliminating an artifactual interaction in Experiment 1, which had suggested that Virtuosos had differentially set a more conservative response criterion in the anesthesia condition that any of the other hypnotic susceptibility groups.

While this paper has clarified a weakness of, and extended, the signal detection paradigm with regards to properly accessing changes in response criterion in the presence of changes in sensitivity, it also presents results which can not be integrated by present signal detection theory. The 'Sure/Guess' condition manipulated subjects' response strategies to a given stimulus. In the Sure condition, subjects were told to respond positively if they were 'absolutely sure' a touch had occurred. In the Guess condition, subjects were told to respond positively if 'they had any leaning or intuition' a touch had occurred. Traditional signal detection would describe such a manipulation as changing the subject's response criterion -- making it very conservative in the first condition, and very liberal in the second. The results of the present study are at odds with this prediction -- the manipulation of response criteria did cause changes in the subject's sensitivity. This result is not completely anomalous however, and parallel findings have been reported in others areas of psychology, though not under the theoretical rubric of signal detection theory. For example, in research motivated to decide either the primacy of affect or cognition, Kunst-Wilson and Zajonc (1980) presented subjects with randomly shaped closed polygons for durations of one millisecond. In a subsequent forced-choice task, subjects were unable to identify previously presented polygons from new ones. Asking the subjects which one they 'liked' better however, induced significant discrimination between the old and the new. This effect has subsequently been demonstrated for dimensions other than 'likability', including 'brightness' and 'darkness' (Mandler, Makamura, and Van Zandst, 1987). As well, Marcel (1983) reported a word priming experiment in which subjects were told that another word (the prime) may have preceded the word they could consciously see on the screen (the mask), and were asked to make several judgements about it. These were: 1) Which of two new words was related in meaning?; 2) Which of two words looked most similar to it?; And 3) Did a word or a blank field precede the mask?. The results showed that under certain conditions, performance for semantic decisions was well above graphic similarity decisions, which was well above the presence/ absence judgements. While the original interpretation of these results were with regard to the possible non-conscious cognitive processes involved in reading, an equally valid interpretation might be that of different response strategies being invoked, each accessing different amounts of information. The progression of the questions, from 'what a word there?' to 'what did it look like?' to 'what did it mean?' could be construed as having differential probabilities of invoking a 'Sure' strategy versus more of a 'Guessing' or intuitive strategy. These examples in conjunction with the present results leads one to question the fundamental postulate of signal detection theory, that of a single underlying informational system. Is it possible these two strategies produce different magnitudes of sensitivity by invoking different informational systems?

Recent work in a variety of subdisciplines of memory have led researchers to postulate the existence of two different memory systems -- the implicit and the explicit (e.g., Graf and Schacter, 1985, 1987; see Schacter, 1987 for a review; Schacter, 1990).

> [I]mplicit memory is revealed when previous experiences facilitate performance on a task that does not require conscious or intentional recollection of those experiences; explicit memory is revealed when performance on a task requires conscious recollection of the previous experiences (p. 501, Schacter, 1987).

Similarly, drawing on examples from the hypnosis literature, the conversion disorder literature, the neurological literature, and on other examples similar to those just cited, from the cognitive/ perception literature, Kihlstrom, Barnhardt, and Tataryn, (in press) Kihlstrom, Tataryn and Hoyt (in press), Tataryn (1990), and others (e.g., Shevrin and Dickman, 1980, Bowers, 1987) have made analogous arguments for the existence of two perceptual systems. This general concept is not entirely new, as some of the first laboratory work on perception by Pierce and Jastrow (1884, cited in Kihlstrom, Barnhardt and Tataryn, in press), argued for the subconscious registration of stimuli, a concept that has continued to return in various guises (e.g, subliminal perception: Dixon, 1971). Indeed, Fechner, one of the first psychophysicists, and Swets, the originator of signal detection theory in psychology, each recognized a concept of 'negative' or subliminal stimuli (Swets, 1961). What is unique in the present conceptualization, is that the difference of consciousness is qualitative, not quantitative, as supposed by signal detection theorists. From this new perspective, the different response strategies access either the explicit system, in the case of 'being sure', or the implicit system in the case of 'just guessing' -- relying more on feelings and intuitions. Tataryn (1990) speculates as to the methodological reasons why these 'anomalies' (different sensitivities for identical stimulus information) were not detected by earlier signal detection researchers. Certainly further research into the nature of the two systems and the different methods of accessing them is of considerable importance to a complete psychology of information processing, one in which the cognitive unconscious is fully recognized (Kihlstrom, 1984, 1987; Shevrin and Dickman, 1980).

Finally, the present research represents an effort to establish the validity and psychophysical characteristics of hypnotic suggestions for anesthesia. Hypnotic anesthesia is an experimental manipulation currently used to investigate two other hypnotic phenomena, trance logic as indicated by the circle-touch test (Eiblmayr, 1987; McConkey, Bryant, Bibb, Kihlstrom, & Tataryn, 1990; Orne, 1959), and prism adaptation under suggestions for anesthesia (Spanos, Dubreuil, Saad, and Gorassini, 1983; Spanos, Gorassini and Petrusic, 1981; Wallace and Garrett, 1973; Wallace and Fisher, 1982, 1984). The results of the present research suggests strong evidence for the effectiveness of hypnotic suggestions for anesthesia. On the surface, this suggests that the circle-touch paradigm should not work -- subjects should not be able to respond with a paradoxical 'no' when they are touched inside the circle. This line of reasoning also indicates that the perceptual adaptation involved with wearing prism glasses should be impaired. On the other hand, the possible existence of two systems of perception, one implicit, the other explicit, suggests that the trance logic of circle-touch paradigm could produce paradoxical responses -- if both systems of perception are engaged in the task. More specifically, based on information from the explicit perception system the subject is unable to sense any perceptual stimulation; based on the implicit perception system the subject may have 'a feeling' that a touch has occurred. If indeed, a highly hypnotic subject has a propensity to process information, in this case contradictory, from both systems simultaneously, then trance logic should occur. If he or she does not, then it should not occur. Such a rational certainly implicates the importance of the task instructions on the outcome of such an experiment. With regards to prism adaptation, instructions will again be crucial. To the extent that the task of pointing is guided by the implicit perception, as is likely in the processing of muscular proprioception, perceptual adaptation in the prism goggles paradigm should not be impaired. To the extent that explicit processes guide the performance, perceptual adaptation should be quite impaired. Future research in these paradigm would be well-informed to manipulate task instructions, attempting to vary the involvement of the two different perceptual systems. In conclusion, while the psychophysical properties of hypnotic anesthesia have been established, it seems that the reality of hypnotic anesthesia might at least be partly dependant on how we define reality -- by what we know we know, or by what we feel we know.

CHAPTER 6

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