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Hypnotic Susceptibility Differences in the Automaticity of Verbal Information Processing

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Abstract

Hypnotic Susceptibility Differences in the Automaticity of Verbal Information Processing

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Three experiments sought to discriminate among three theories of hypnotizability by evaluating whether highly hypnotizable subjects processed verbal information more automatically than low susceptibles. Experiment 1 tested the prediction that relative to lows, highs would show greater Stroop effects (faster congruent trial naming and slower incongruent trial naming). High's significantly slower incongruent reaction times ($p<.01$) were interpreted in parallel distributed processing (Rumelhart and McClelland, 1988) as indicating that highs have greater connection strengths along verbal pathways than lows.

Experiment 2 retested this hypothesis, and assessed whether highs and lows would differ in the implementation of performance optimization strategies in the Stroop task, and in the ability to process information presented below the subjective threshold of awareness. The paradigm of Cheesman and Merikle (1986) used backward masking to present Stroop words above and below awareness, and assessed strategy effects by manipulating congruent trial probability. The verbal connection strength hypothesis was supported by highs showing greater Stroop effects for clearly visible words than lows ($p<.03$). The latter hypotheses could not be tested because of methodological deficiencies.

Experiment 3 retested the three hypotheses using an improved methodology. Highs and lows did not differ in terms of strategies. No differences were in processing information below awareness although the presence of subthreshold strategy effects questions the validity of Cheesman and Merikle's subjective threshold. Highs again showed significantly greater Stroop effects than lows ($p<.02$) reconfirming the verbal connection strength hypothesis. The combined results were shown to support a synergistic approach to hypnotizability, and contradict purely social psychological interpretations.

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HYPNOTIC SUSCEPTIBILITY DIFFERENCES IN THE AUTOMATICITY OF VERBAL INFORMATION PROCESSING

Introduction

Stage hypnotists would have us believe that hypnosis is a mysterious and wonderful phenomenon which is capable of making people do all manner of feats that are "impossible" in the waking state. They hope to increase our credulousness by having us witness, for example the farmer, who "under" hypnosis can sing like Frank Sinatra or the young girl who can support the weight of a full grown man sitting on her stomach while she balances with only her head and shoulders on one chair, and her feet on another chair.

For the scientist who unlike Raveen, Romain, and Svengali sports both a first and a last name, however, hypnosis is a somewhat less mysterious phenomenon than these modern day magi would have us believe. Under the sober scrutiny of the empiricists' microscope, the many feats performed by people under the "trance" of the stage hypnotist, prove to be acts which can routinely be performed without the benefit of hypnosis. Although scientific methods have been able to show that there is little that is magical about hypnosis, many scientists have been forced to acknowledge that there is still much that remains to be explained about this fascinating phenomenon (Nadon, Laurence & Perry, 1989; See also Laurence and Perry 1988 for an historical perspective).

In an attempt to remove hypnosis from the shadows of nineteenth century mysticism into the twentieth century's empirical laboratory researchers have conceptualized hypnosis as a social interaction in which a hypnotist offers verbal suggestions designed to evoke alterations in the perception, memory and voluntary actions of a subject (Khilstrom, 1985).

It has been recognized since the early nineteenth century that such alterations are not experienced by everyone who undergoes an hypnotic procedure. Early clinical observations (Faria, 1819 as cited in Laurence & Perry, 1988); Bernheim, 1884) concur with more recent empirical investigations (Hilgard, 1965; Laurence and Perry, 1980) in noting that only 10-15% of the population can be considered highly hypnotizable, with a further 10- 15% being low in susceptibility, while the remaining 70-80% fall in the moderate susceptibility range. Typically, the modern day assessment of hypnotic susceptibility involves the administration of a standardized scale consisting of a relaxation induction procedure followed by a number of hypnotic suggestions of varying difficulty. Hypnotic susceptibility is determined by the number of these items to which subjects make an objectively discernible response. Such standardized techniques allow hypnotic susceptibility to be operationally defined in terms of the number of measurable responses that are made during the course of the hypnotic procedure.

Despite the fact that these standardized tests of hypnotic susceptibility tend to be based on small numbers of items, they demonstrate very respectable psychometric properties. In fact, test-retest correlations as high as .90 have been recorded, depending on the particular measure employed (Hilgard, 1965). Such reliable measures have enabled researchers to delineate some of the demographics ot hypnotic suscpetibility. A study by Morgan and Hilgard (1973), tor example indicates that susceptibility tends to peak between the ages of 9 to 12 and declines with age. While the population shows a decline in susceptibility as they get older, correlations of .60 have been obtained for subjects who have had susceptibility assessments separated by a 10 year period (Morgan, Johnson, & Hilgard (1974). Such a finding indicates that while susceptibility in general declines with age the relative position of individuals on the hypnotizability continuum does not fluctuate to any great degree.

Although a certain amount of consensus has been reached concerning operationally defining hypnotizability in terms of such standardized test scores, researchers hold widely divergent views concerning why only certain people make such objectively discernible responses to suggestions. A social psychological interpretation of hypnotizability maintains that the "hypnotized" subject is one who merely responds to the complex demand characteristics inherent in the hypnotic context. Thus highly hypnotizable subjects merely behave in ways which are consistent with their preconceived notions of how a good hypnotic subjects is expected to behave. Accordingly, these subjects will voluntarily use goal directed strategies designed to produce behaviours that are consonant with the persona of the "good hypnotic subject". That is, rather than actually responding in an involuntary and automatic fashion, subjects will behave *as if* their responses were involuntary because such behaviour coincides with their perception of how a hypnotized subject is supposed to act (Sarbin, 1984; Spanos, 1986). As such, the perceptual alterations which are associated with hypnosis are merely an epiphenomenon of the social factors embedded in the hypnotic context. Thus, one of the basic premises of the social psychological position is that there is nothing really special about hypnosis or hypnotic phenomenon (Spanos, 1986). According to the social psychological perspective, any behaviour which can be elicited in hypnosis, can also be elicited outside of hypnosis (Spanos and Chaves, 1989). An implicit corollary of this position is that any behaviour displayed by highly susceptible subjects can also be elicited from those not capable of experiencing hypnosis merely by providing the necessary social and cognitive antecedents (Spanos, Cross, Menary, Brett & de Groh, 1987).

A second school of thought, labelled by Spanos as the "special process view" interprets hypnotic phenomena as reflecting processes that are unique to the hypnotic context and are essentially unrelated to waking behaviour. Much of the explanatory power of the special process view of hypnotic phenomenon involves Hilgard's reworking of the concept of dissociation and dissociative abilities (Hilgard, 1977). The structure of cognition according to Hilgard consists of a multiplicity of "cognitive subsystems" each of which are capable of carrying out certain specific functions (Hilgard, 1977 p. 218). These cognitive subsystems are dominated by what Hilgard called the "executive ego" a central control structure responsible for both planning and monitoring functions.

Hilgard viewed hypnosis as a condition in which the normal functioning of the executive ego is temporarily modified so that executive control is divided between the hypnotist and the person being hypnotized (Hilgard, 1977, p. 229). In hypnosis, the hypnotized subject turns over some of the functions of the executive ego to the hypnotist, allowing certain cognitive subsystems to be actuated externally by the hypnotist, rather than internally by the hypnotized subject. Such a division of control creates a unique situation in which the hypnotized subject loses both initiative and the capacity for critical thinking. In this modified condition, certain aspects of the actuated subsystem's activity tends not to be dissociated from the resident part of the hypnotized subject's executive ego. Hilgard gives as an example a subject who is told that their extended arm is getting stiffer and stiffer. The subject is able to report "You said my arm would be stiff and I couldn't bend it; I have tried to bend it and I can't do it." Thus while certain facets of the situation are monitored, other key elements are dissociated from normal monitoring processes. Among the unmonitored elements is the fact that in trying to bend the arm rather than merely contracting one set of muscles, the subject voluntarily contracted two antagonisti 'e groups such as occurs when one "makes a muscle" (Hilgard, 1977, p. 232). In such a situation rather than attributing the inability to bend their arm as a consequence of their own actions, subjects tend to regard the responses to the suggestion as happening "by themselves." Thus, it is because certain facets of the hypnotic response are unavailable to the monitoring aspect of the executive ego, that subjects experience having carried out the hypnotist's instructions in an involuntarily and automatic fashion (Hilgard, 1977, p. 228).

Although the subjective feelings of involuntariness are often a product of dissociative experiences, the hypnotized subject is not a passive automaton that will automatically respond to the hypnotists every suggestion. Rather, in order to pass some hypnotic suggestions, the subject must voluntarily engage in certain activities that allow dissociation to take place. For example in order to experience hypnotic analgesia subjects actively initiate imagery to produce fantasies that are incompatible with the pain experience (Hilgard, 1977, p. 174). In addition, in order to minimize the experience of pain, subjects with the help of the hypnotist must not only actuate a cognitive subsystem to deal with the pain, but erect a kind of amnesic barrier, preventing the executive ego from monitoring the activity in this particular cognitive subsystem (Hilgard, 1977b).

While Hilgard advocates the position that hypnotic responses to suggestions such as those designed to induce analgesia can be extremely powerful, he also recognizes that not all subjects can experience such suggestions. In fact even among highly susceptible subjects only a small minority of subjects are able to eliminate the pain entirely. In attempting to delineate the characteristics which describe such hypnotic virtuosi, Hilgard draws upon J. R. Hilgard's (1974) central concept of "imaginative involvement". Imaginative involvement involves temporarily setting aside ordinary reality and becoming completely absorbed in imaginative experiences relating to literature, music, nature, or theatre. J. R. Hilgard's extensive interview studies revealed that the propensity to engage in such activities was much more evident among high hypnotizables than their low hypnotizable counterparts. As such, the neo-dissociation perspective supports the notion that individual differences outside of the hypnotic context may contribute to a subjects ability to experience hypnotic suggestions.

Thus while the social psychological position postulates that hypnosis is merely an artefact of subjects using goal directed strategies to appear hypnotized, the neo-dissociation position holds that hypnosis is a condition in which normal cognitive functioning is actually modified. In addition to these two somewhat extreme positions, a third camp has emerged that recognizes the strengths and weaknesses of both social psychological and neo-dissociation attempts to explain hypnotic behaviour. This third camp, offers a synergistic approach toward the understanding of hypnotic responding.

While recognizing the role of individual differences that are crucial to the neo-dissociationist theory, the synergistic position also fully recognizes the importance of social psychological variables such as the hypnotic context, expectancies of the subject, and the nature of the subjects belief system. While the synergistic camp supports the social psychologists contention that highly susceptible subjects may actively use goal directed strategies in order to experience the hypnotic suggestion, they differ from the social psychologist camp in suggesting that while such strategies may be necessary for experiencing an hypnotic suggestion they are not in and of themselves sufficient for hypnotic responsivity. In order for highly susceptible subjects to truly experience hypnotic the phenomena suggestede in hypnosis, they must possess certain cognitive abilities that are either less developed or absent in low hypnotizables. Thus, according to the synergistic view, hypnosis is a situation in which subjects attempt to rally certain cognitive abilities in order to successfully alter normal cognitive functioning. The degree to which they are successful depends both on the implicit and explicit demands of the hypnotic context, the beliefs and attitudes of the subject toward hypnosis and the hypnotist, and the degree to which subjects possess certain individual cognitive skills.

Correlates of hypnotic susceptibility

A number of univariate and more recently multivariate investigations, have been conducted in order to discern just what these cognitive skills are that allow certain people to experience the phenomena suggested in hypnosis. One such skill that has been proposed can be described in the broadest of terms as imaginative abilities. Within this general category are specific areas of concern such as individual differences in the ability to generate and maintain images to suggested external stimuli and the degree to which subjects become absorbed in such images (what J. R. Hilgard, 1974, referred to as "imaginative involvement").

The rationale for proposing a relation between imagery in the mental picture sense and hypnotizability can be gleaned by considering some of the more common hypnotic suggestions. For example, subjects may be asked to "imagine" that their arm is getting stiff, as though their arm was in a splint. It seems feasible that the better subjects are able to produce the mental imagery accompanying this suggestion, the more likely it is that they will subjectively experience the arm as being stiff, and thereby find themselves unable to bend the arm. Similarly, it can be proposed that those subjects who can experience visual hallucinations are subjects who can produce mental images with such vividness and clarity, that they experience the suggested objects as being veridically present.

Accordingly, a number of researchers have sought to correlate hypnotizability with pencil and paper measures of imagery ability. One such instrument is the Vividness of Visual Imagery Questionnaire (VVIQ) of Marks (1973) which assesses the quality of visual images. A number of studies have shown significant correlations between the VVIQ and hypnotic susceptibility (Bowers, 1978; Coe, St. Jean, & Burger, 1980; and t'Hoen 1978, Crawford, 1978).

Farthing, Venturino and Brown (1983) postulated that in order to successfully experience certain items on standardized tests of hypnotic susceptibility, imagery abilities are required not only in the visual domain, but also in the kinaesthetic, auditory, and olfactory domains. In an attempt to expand the assessment of imagery abilities beyond simply the visual domain these authors developed two versions of what they called the Mental Imagery Questionnaire (MIQ). One version required subjects to image impersonal objective visual scenes (MIQ:VS), while the other was designed to evoke a mixture of kinaesthetic and visual imagery by having subjects image personal actions (MIQ:PA). Both measures were found to significantly correlate with the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS:A) of

Shor and E. Orne (1962), but contrary to their predictions the MIQ:VS yielded higher correlations.

In a similar vein several laboratories have made use of the Betts' Questionnaire on Mental Imagery (QMI) which assesses imagery abilities in seven different sensory modalities: visual, auditory, cutaneous, kinaesthetic, gustatory, olfactory, and organic. While the patterns of correlations between the QMI and hypnotic susceptibility are a mixture of significant and non-significant correlations a number of studies have found an inherent non-linearity in the data. For example while Sutcliffe, Perry, and Sheehan, (1970) found a significant correlation between the QMI and the Stanford Hypnotic Susceptibility Scale: Form C (SHSS:C) of Weitzenhoffer and Hilgard (1962), a closer inspection of the data revealed that while good imagers were represented across the entire spectrum of hypnotizability, poor imagers invariably tended to be poor hypnotic subjects.

This inherent non-linearity of the relationship between the SHSS:C and the QMI was replicated by J. Hilgard (1979) who found a small but significant correlation, which was largely due to the fact that poor imagery ability predicted a lack of hypnotizability. In addition, a study that failed to obtain significant correlations between hypnotizability and the QMI (Perry, 1973) found that while vivid imagers permeate the entire range of hypnotic susceptibility, poor imagers almost always fall within the low susceptibility range. Thus it appears that good imagery ability may be a necessary but not sufficient skill for high hypnotic ability, whereas poor imagery is almost always a predictor of hypnotic insusceptibility.

Finally a number of studies have used the Preference for an Imagic Cognitive Style (PICS) questionnaire of Isaacs (1982), which focuses on imagery preference as opposed to imagery ability. This questionnaire is designed to determine whether subjects prefer a verbal or pictorial style of mentation while thinking about a number of suggested scenes. In two separate experiments, Nadon, Laurence and Perry (1987), using a multivariate framework, found that the PICS was able to uniquely contribute to the ability to predict whether subjects were of high medium or low hypnotic susceptibility. A positive correlation between these two measures has also been observed by Labelle, Laurence, Nadon and Perry (in press).

Another area which has been promising in terms of revealing individual differences related to hypnotizability involves the subjective report of night dreams. Individual differences have been observed in terms of voluntary control of sleep processes (Evans, 1979), subjective interest in night dreams (Gibson, 1985) and in the ability to control night dreams (Belicki & Bowers, 1982). Gibson (1985) found that women who enjoy dreaming, arrive at creative ideas while dreaming, and report having their future foretold in their dreams are more highly hypnotizable than women reporting the opposite pattern. Belicki and Bowers (1982) found that the ability to modify the content of dreams in response to pre-sleep instructions is positively related to hypnotizability.

Furthermore, recent investigations involving the potential relation between hypnotizability and subjective experiences of "paranormal" phenomena have yielded promising results. Diamond and Taft (1975) reported a significant correlation between hypnotizability and belief in the supernatural. More recently, in an interview study of very highly hypnotizable women, Wilson and Barber (1982) found that 92% of their sample considered themselves to possess certain psychic abilities. Many of these subjects further reported experiencing paranormal phenomena such as telepathy, spiritual apparitions, and precognitions. By contrast only 16% of low and medium hypnotizable subjects reported such beliefs or experiences. Nadon and Kihlstrom (1987) have developed a reliable self-report measure which they call the Paranormal Experiences Questionnaire (PEQ). This questionnaire samples a number of areas that have been labelled as either "paranormal", "psychic", "psi", or "anomalous". These authors report that beliefs in, and subjective experience of these types of experiences are positively correlated with hypnotizability.

Finally, perhaps the most reliable univariate correlate of hypnotizability involves what Tellegen and Atkinson (1974) have referred to as absorption. The concept of absorption can be defined as the dispositional propensity for having episodes of all encompassing involvement towards specific attentional objects. These authors indicate that to experience such episodes people must be able to " operate diverse representational modalities synergistically so that a full but unified experience is realized" Tellegen and Atkinson, 1974 p. 275) The Tellegen Absorption Scale (TAS; Tellegen, 1982; Tellegen & Atkinson; 1974) is the most widely used measure of such synergistic abilities. In their initial study, Tellegen and Atkinson (1974) reported correlations of .27 and .42 (across two samples) between the TAS and hypnotizability as measured by the HGSHS:A. The finding of a relation between hypnotizability and absorption has been replicated on numerous occasions [e.g., Crawford, 1982; Finke & Macdonald, 1978; Kihlstrom et al., 1980; Nadon, Laurence, & Perry, 1987; Roberts, Schuler, Bacon, Zimmermann, & Patterson, 1975; Spanos & McPeake, 1975 (for subjects exposed to favourable information concerning hypnosis)].

Notwithstanding the general reliability of these correlations, a few studies have failed to reveal a significant relation between hypnotizability and TAS scores. For example, Spanos, McPeake and Churchill (1976) failed to observe a relation between absorption and hypnotizability as measured by the Barber Suggestibility Scale (BSS) in a sample dichotomized into 36 females and 55 males. These authors indicate however that the hypnotizability-absorption relation may depend on the scale that is used to measure hypnotizability (Spanos et al, 1976). Since the psychometric properties of the BSS are not as well known as the extensively studied Harvard and Stanford scales, this finding may be of secondary importance.

Finally a study by Spanos and McPeake (1975) failed to observe the usual positive correlation between absorption and hypnotizability. Subjects in this study were, however, exposed to unfavourable information concerning hypnosis prior to the hypnotic induction. As such this study related more to the importance of attitudes towards hypnosis than to the relation between hypnotizability and absorption. Thus despite these isolated failures to replicate, the relation between the TAS and hypnotizability is generally acknowledged to be the most reliable of the cognitive correlates of hypnotic susceptibility.

With the exception of the study of Nadon, et al. (1987) most of these studies have looked at individual correlations between hypnotizability and various cognitive abilities. The synergistic school of thought, as the name suggests, proposes that the whole of the hypnotic experience is greater than the sum of its parts. This is not to say that the understanding of hypnosis and hypnotizability lies beyond the capacity of the scientific method, but rather, that in order for knowledge concerning these areas to advance, correlations must not be considered in isolation, but rather within a multivariate framework, where intercorrelations and interactions among various abilities can be assessed. Thus proponents of the synergistic camp advocate the use of multivariate techniques because high and low hypnotizables differ along a **number** of different dimensions.

Recent investigations using multivariate strategies (Dixon, Labelle & Laurence, 1990) have revealed some interesting findings concerning these interelations among the various cognitive correlates of hypnotizability. For example, in a sample of 94 subjects who had complete data on hypnotizability, absorption, paranormal experiences, and the frequency and control of dreams, hypnotizability was found to be correlated to each of these measures at statistically significant levels. When these data were analyzed using standard multiple regression, however, only the paranormal experiences questionnaire and the dream questionnaire were able to predict a meaningful amount of unique hypnotizability variance. What this finding may suggest is that some of the TAS questions are devoted to cognitive abilities that are more extensively addressed by the dream questionnaire and the Paranormal experiences questionnaire. Thus, for predicting hypnotizability, at least in this sample, the TAS carries information that is redundant to that conveyed by the paranormal experiences questionnaire and Sleep and Dream questionnaire.

While multivariate studies of hypnotizability represent a substantial improvement over univariate techniques in the predicting hypnotic susceptibility it can be argued that the presence of any reliable correlate of hypnotizability (multivariate or univariate) poses a serious threat to the social psychological camp. Specifically, if hypnotizability is determined solely by the willingness of the subject to comply to the complex demands of the hypnotic context, and perform in accordance with what they perceive to be the hypnotists expectations, then there is no a priori reason to predict significant correlations with cognitive attributes that are unrelated to hypnosis per se.

The social psychologist's rebuttle to this argument is that wherever correlations between hypnotizability and cognitive abilities are found, these correlations can be explained by what Council, Kirsch and Hafner (1986), have referred to as a context effect. They claim that significant correlations only occur when measures of imaginative involvement are obtained prior to the assessment of subject's level of hypnotic susceptibility. They propose that testing subjects for cognitive abilities in close temporal proximity to the hypnosis sessions allows subjects to form a logical connection between the two sets of measures, allowing subjects to adjust their degree of hypnotic responsivity so that it is consistent with their previously obtained questionnaire scores. The mechanism by which this context effect operates is subject's expectancy. They claim that filling out questionnaires on imaginative involvement causes changes in subjects expectancies about the degree to which they will be hypnotized, and that this change in expectancy results in the active modification of subjects scores on hypnotizability measures. In other words, proponents of the context effect suggest that subjects look at how they score in terms of absorption, causally link absorption to hypnotizability, derive from this hypothetical relation how they should perform in hypnosis, and adjust their hypnotic responses accordingly.

To substantiate this claim, they contrasted the host of studies which showed significant correlations between hypnotic susceptibility and imaginative abilities (as assessed using the TAS), with a number of experiments in which failures to obtain significant correlations between the TAS and hypnotizability were observed. According to these researchers the factor that determined the statistical outcome of the study was the temporal contiguity between testing for absorption and testing for hypnotizability. In all of the positive outcomes, hypnosis testing followed the absorption measure either immediately or within a relatively short period of time. In each of the studies which failed to find significant correlations between hypnotizibility and absorption, the administration of the absorption questionnaire was either conducted in a situation removed from the hypnotic context (Buckner and Coe 1977; Council, Kirsch, and Hafner, 1986) or used a questionnaire in which absorption items were embedded among a large number of filler items Chiofalo & Coe, 1982, Spanos et al, 1976)[1].

It should be noted that although the context effect has been empirically assessed in terms of absorption, the rationale underlying this effect should hold for all of the cognitive abilities that have been mentioned thus far. Proponents of the social psychological position could claim in order for the context effect to operate, all that is required is that the abilities previously mentioned have at least a face valid relation with the layman's conception of hypnosis. Specifically, if subjects can infer the link between hypnosis and the construct being measured by the questionnaire then they can adjust their hypnotic responsivity to levels that are consonant with their questionnaire performance. Hence, because for the layman hypnosis is a form of sleep, it should be logically connected to the ability to control one's dreams. As such subjects who score low on questionnaires designed to assess the ability to

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[1] Nadon (1989) has correctly pointed out that the significance-nonsignificance distinctions proposed by Kirsch et al., constitute inappropriate statistical procedure. In order to show a context effect, the correlation obtained in context must be shown to be significantly different from correlations obtained out of context. Because the contextual arguments are representative of the type of approach favoured by the social psychological camp, an attempt was made to disprove such an hypothesis on theoretical rather than statistical grounds.

control their dreams would be able to predict a-priori that they should therefore score low in hypnotic susceptibility, and tailor their performance to coincide with such self fulfilling prophecies. Similarly it can be argued that because absorption gauges what are essentially hypnotic-like experiences outside of the hypnotic context, it should not be too difficult for subjects to establish a logical connection between these two abilities and take appropriate action. Likewise, since the layman knows that "under" hypnosis, people are capable of experiencing hallucinations, it can be postulated that they could set up a causal connection between imagery and hypnotic abilities, and adjust their hypnotic responses to correlate with their imagery scores. Finally, because hypnosis is often cited as a means of increasing receptivity to paranormal experiences such as past life regression, it can be connected to test batteries such as Nadon, Register and Kihlstrom's Paranormal Experiences Questionnaire enabling subjects to tailor their hypnotic responsivity so that it becomes directly proportional to their questionnaire scores.

Thus, while followers of the "special process" camp would argue that reliable cognitive correlates of hypnotizability negate the social psychological position, it is actually the mechanisms underlying these correlates of hypnotizability that are of paramount importance in choosing among competing explanations of hypnosis and hypnotizability. If subjects of differing hypnotizability actually do differ in terms of non-social psychological cognitive attributes such as imaginative involvement, or imagery abilities, then the social psychological interpretation of hypnosis and hypnotizability must be deemed untenable as such findings are incompatible with veridical individual differences in cognitive abilities. If however, correlations are not due to actual cognitive differences but are merely an artifact of shifts in expectancies caused by the context effect then such correlations actually support the social psychological position. It is important to note that the synergistic position recognizes the role of context but differs from the social psychological position in the relative importance that they attribute to this phenomenon. While the social psychological position claims that the context effect is exclusively responsible for all correlations between hypnosis and cognitive abilities, the synergistic position maintains that there are certain abilities that correlate with hypnotizability even in the absence of the context effect.

Thus, what is required to differentiate between the social psychological and synergistic position are cognitive tasks which reliably differentiate high and low hypnotizable subjects, yet have no face valid relationship to hypnosis. In general, such tasks involve assessing differences among hypnotizability groups in the performance of simple psychophysical tasks that are measured outside of the hypnotic context. Since these studies are relatively few in number, they will be reviewed in some detail with the aim of uncovering specific cognitive mechanisms that may help to explain both differential performance in these psychophysical tasks, and differential performance in tests measuring hypnotic susceptibility.

Psychophysical performance differences among high and low hypnotizables

One such psychophysical task was used by Ingram, Saccuzzo, McNeill, and McDonald (1979), who required subjects to identify target letters that were presented with varying degrees of stimulus visibility. In this study target letters were presented for very short durations. Initial differences among subjects in terms of information intake (visual acuity, temporal resolution etc.) were controlled by presenting target letters for 1 ms and increasing this presentation duration in steps of 1 ms until four consecutive letters could be identified. These critical durations were obtained for each subject. Backward masking was then used to manipulate the visibility of letters presented using these critical durations. Backward masking in this study involved presenting the target letter for the critical duration, waiting a pre-specified amount of time, and then presenting an irrelevant "masking" stimulus in the same spatial location as the letter. Stimulus visibility was manipulated by varying the duration between the offset of the target letter, and the onset of the masking stimulus. When this duration (called the interstimulus interval or ISI) is long, target identification is relatively easy, but as the ISI decreases, target identification becomes increasingly more difficult. Ingram et al., presented eight high and eight low hypnotizable subjects target letters (at the individually determined critical duration) and used what is referred to as the method of limits to determine the critical ISI at which letters could just be identified. Starting at very short ISI where the letters could not be identified, they then systematically increased the ISI between the word and the mask until subjects could correctly identify four consecutive target letters. High susceptible subjects were found to have significantly lower critical ISI's than lows.

A second study by Saccuzzo, Saffran, Anderson and McNeilı (1982) confirmed this relation. These authors found significant differences between ten high and ten low susceptible subjects in the number of correct identifications of two target letters (T and A) presented using varying target-mask ISI's. Highs correctly identified significantly more letters at low ISI durations than their low hypnotizable counterparts. Interestingly, this significant finding was not maintained in a second replication using the same subjects, but this failure to replicate could be interpreted in terms of a practice effect for lows, which elevated their performance to the level of their high hypnotizable counterparts. Because the highs performed almost at ceiling levels in the first session, they were unable to maintain their superiority over the lows who improved in the second session.

A third study by Acosta and Crawford (1985) attempted to show that the results of Ingram et al. could be an artifact of using the method of limits in determining the critical ISI. In this study 12 highs and 12 lows underwent the same procedure that was used by Ingram et al. That is, critical durations were assessed for single letters, these letters were presented using these critical durations, and the ISI between the letter and mask was systematically increased in steps of 2 ms until the letters could be correctly identified on four consecutive occasions. They then presented highs and lows with 5 letter stimuli (for example AXCZE), followed by a masking stimulus ($$$$$) that was presented at 1 of five randomly selected ISIs (0, 25, 50 100 or 200 ms). The subjects task was for each randomly selected ISI to identify both the letters and their serial location. Their hypothesis was that if Ingram et al.'s results were due to highs having a differential rate of information transfer, then highs should outperform lows both when ISIs were presented in ascending order, (the replication of Ingram et al.), and in the condition where ISIs were randomly presented. If on the other hand hypnotizability differences were an artifact of the method of limits then significant differences between highs and lows should only be found for the ascending ISI condition, but not for the random condition.

As in the Ingram et al. study, highs displayed significantly lower critical ISIs (19. 1 ms) than low hypnotizables (29.1 ms) when the method of limits was employed. This superiority was not maintained in the random condition however, with no hypnotizability differences emerging for either ISI, serial position or their interaction. It can be argued, however, that although a superior psychophysical procedure was used in the Acosta and Crawford study, the random condition of Acosta and Crawford is not comparable to the Ingram et al., condition in terms of both the stimuli employed, and in terms of the sensitivity of temporal resolution parameters. The Ingram et al. study used highly sensitive increments of 2 ms to show differences in the average **threshold** ISIs required to disrupt single letter identification. The random condition of Acosta and Crawford presented sequences of 5 letters in which the temporal parameters differed by relatively large step sizes (0, 25, 50, 100, 200 ms). Thus while the dependent variable employed in the Ingram et al. study looked at whether highs and lows differed purely in terms of temporal resolution, the dependent variable used in the Acosta and Crawford study (accuracy of both the identity and the location of letters in the 5 letter combinations) depended not only on temporal resolution but also other factors such as, primacy and recency effects. Thus, it is not at all clear whether the mechanisms responsible for the critical ISI differences obtained in the single letter paradigm of Ingram et al. and replicated by both Saccuzo et al., and Acosta and Crawford are the same mechanisms that are addressed by the five-letter combinations presented in the latter's random ISI procedure[2].

A final study that called into question the findings of Ingram et al. and Saccuzo et al., was conducted by Friedman, Taub Sturr, Church and Monty (1986). Like the Acosta and Crawford study these authors noted certain

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[2] Furthermore, a close inspection of the data in the random condition of Acosta and Crawford provide cause for speculation. In the Acosta and Crawford study the overall accuracy for high hypnotizables subjects was 36% for highs and 42% for low hypnotizables. Yet according to the cell means depicted in the serial position by accuracy graph, of the 25 possible cell mean comparisons (five ISI by 5 serial positions) highs were more accurate than lows on 21 occasions.

methodological deficiencies that somewhat limited the heuristic value of these studies. They noted that in the Ingram et al. study the authors failed to eliminate variables such as differential motivation for high and low hypnotizables, while in the Saccuzo study they reiterated Saccuzo's contention that ceiling effects may have precluded the appearance of greater discrepancies between the data of high and low hypnotizables.

In an attempt to improve the methodology of these two studies, Friedman et al., used a two alternative forced choice staircase procedure in order to minimize the effects of response bias and eliminate ceiling effects. In their study they also sought to eliminate what they referred to as "idiosyncratic connotations" for the letters T and A by using a test flash as the target in the staircase procedure. In this study, subjects were presented with two intervals preceded by a warning tone. The subject's task was to identify which of the two intervals contained the test flash. The staircase procedure was used to manipulate the ISI between the test flash and a masking stimulus. Using such methodological modifications they eliminated differences among high and low hypnotizable subjects in terms of the ISI required to accurately detect the presence of the test flash. By the author's own admission, however, it is not clear whether this failure to find significant differences between high and low hypnotizables indicates that the previous findings were artifactual, or whether differences only exist when single letters serve as the target stimulus.

Taken together these four studies seem to indicate that highs do differ from lows in the manner in which they process information, but that these differences tend to be stimulus specific. Specifically, in the studies reviewed thus far, highs and lows differ only when single letters are used as targets in masking studies. It can be postulated that letter stimuli may be crucial in obtaining information processing differences among high and low hypnotizable subjects because of the relation between hypnosis and language.

Hypnosis and language

While hypnosis can take many forms (as a dyad involving the hypnotist and the person being hypnotized, in groups, by either a live hypnotist, or a tape-recorded voice etc.) the one underlying commonality that encompasses all of these phenomena is that in each situation changes in the hypnotized person's normal perceptual processes are evoked through the use of language. Because hypnotic suggestions are almost invariably transmitted verbally, it is reasonable to postulate that what may distinguish subjects who are highly susceptible to hypnosis from their low susceptible counterparts is the manner in which they process language. Thus, since letters are the fundamental unit of written language, backward masking experiments involving letters may address a dimension along which highs and low hypnotizables differ- a dimension that is not tapped by the flash detection experiment of Friedman et al.

By looking at recent evidence concerning the manner in which high and low hypnotizables subjectively experience hypnosis, one can deduce a specific hypothesis concerning how language processing among these two groups differs. A number of studies have shown that what distinguishes the subjective reports of high and low hypnotizable subjects is the degree of involuntariness associated with responses to suggestions (Bowers, 1982; Bowers, Laurence, & Hart, 1988; Lynn, Rue and Weeks, 1989). Specifically, subjects who respond well to an hypnotic induction usually describe their experiences as happening without them being aware of carrying out the suggested behaviour or experience. Lows on the other hand, either fail to make any objectively discernible movement, or if they do respond, claim responsibility for the generation of the response rather than attributing it to the effect of the hypnotic suggestion. One possibility that could account for such discrepancies in the subjective experiences of high and low hypnotizables is that highs are processing the instructions of the hypnotist more automatically than low hypnotizable subjects. That is, highs may process language with a greater degree of perceptual automaticity than subjects who are insusceptible to hypnosis.

Automaticity can be defined as processing that is effortless, fast, and involuntary (Posner & Snyder, 1975; Shiffrin, Dumais & Schneider, 1981). Strategic or "controlled" processing, on the other hand, requires voluntary initiation, is slower, and draws upon limited cognitive resources. Thus, during hypnosis, if highs are automatically processing the repeated suggestion that their arm is getting heavier and heavier, they are more likely to make a hand lowering ideo-motor movement, than are the low susceptible subjects who may be processing the repeated heaviness suggestion in a more strategic fashion. Thus, while lows are strategically carrying out repeated reality testing procedures (verifying whether what they feel on a kinaesthetic level matches the heaviness suggestions that they are hearing), highs, because of greater amounts of automatic processing, are much more likely to experience the ideo-motor hand lowering response as occurring involuntarily.

While the hypothesis that highs process verbal information more automatically than lows is difficult to test within the hypnotic context (where social factors may interact with cognitive individual differences), it can easily be tested using strategies similar to those adopted by Ingram et al, and Saccuzo et al. That is, high and low hypnotizables can be compared on simple perceptual measures that are assessed outside of the hypnotic context. What is required is a perceptual task that is designed to quantify the degree of automaticity with which subjects processes language. While the backward masking studies of Ingram et al., Saccuzo et al., and Acosta and Crawford use the fundamental units of language, they do not quantify automaticity per se. One such task that does meet this criterion, however, is the Stroop phenomenon.

The Stroop phenomenon

The classic Stroop phenomenon involves presenting either colour words (BLUE or RED) or control stimuli (e.g., a series of Xs) in different colours (Stroop, 1935). The reaction time to naming these colours is fastest when the words and colours are congruent (RED painted in red ink), slightly slower when unrelated (a series of Xs painted in red ink), and much slower when the word and colours are incongruent. When the task is to read words presented in congruent (RED painted in red), control (RED painted in black), or incongruent (RED painted in blue), however, no differences in reaction time are found among these three types of stimulus pairings.

Although the reasons underlying differences in reaction time for congruent, control, and incongruent trials in the Stroop colour naming task have been a matter of some debate, a number of authors have suggested that discrepancies in the reaction times of the three types of trials may be due to the fact that word reading and colour naming lie along a continuum of automaticity-where word reading is more automatic than colour naming (MacLeod & Dunbar, 1988). Thus, for congruent trials-despite instructions to ignore the word and simply name the colour as quickly as possible-the colour word is processed automatically and involuntarily, causing slightly faster (20 to 50 ms) reaction times for congruent trials relative to reaction times for control trials. This discrepancy between control and congruent reaction times is referred to as facilitation. When the word and the colour are incongruent, however, the involuntary processing of the word elicits more pronounced effects, causing increases in reaction time ranging in magnitude from 100 to 200 ms in excess of control reaction times. The discrepancy between incongruent and control reaction times is referred to as interference[3].

One theory that supports such a continuum of automaticity is the Parallel Distributed Processing (PDP) model or Rumelhart, McClelland and the PDP research group. The general PDP model consists of a network of connected processing units which link sensory input to response. In this system neighbouring units are joined by connections that have either a positive (excitatory) or negative (inhibitory) connection strength. Each individual unit has an activation value which is computed by the addition of the activation values of units to which it is directly connected, multiplied by their positive or negative connection strengths. The activation levels of the units in the PDP system are constantly updated over time, causing the system to settle on a fixed number of response alternatives. The updating of activation levels proceeds in a continuous feed-forward fashion from sensory input to response. When one of the units corresponding to a particular response achieves a sufficient amount of activation, a response will be generated.

Cohen, Dunbar and McClelland (1988) have provided a PDP model of the Stroop phenomenon where units are arranged along separate word

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[3] Interference is far more robust a phenomenon, and has been much more widely investigated than facilitation (Cohen et al., 1986)

reading and colour naming pathways. These pathways consist of input units, intermediate or hidden units and response units as shown in Figure 1. While words and colours have separate input and intermediate units, the two pathways converge on common response units (whether the task is to read the word or name the colour, the response will be the same i.e. "red" or "blue").

In this model attentonal processes are served by the two task demand units depicted in Figure 1. These units work in conjunction with the intermediate units of the word reading and colour naming pathways. Intermediate units calculate activation values using a logistic function that ranges from zero to one. A mathematical property of the logistic function is that when it set to the middle of this range (.5), input from units at lower levels will have a much greater effect than when the logistic function is set at values that deviate from .5. In their resting state the intermediate units are assumed to have a large negative bias (graphically represented by the two negative fours in Figure 1), which sets the logistic function to a relatively unresponsive part of its range. The task demand units have the effect of counteracting this bias. In fact placing a value of 1 in the task demand unit will completely counteract this bias and set the logistic function to .5-the most dynamic portion of its range. Thus, instructing subjects to ignore the word and concentrate their attention on naming the colour as fast as possible is akin to placing a value of 1 in the colour naming task demand unit, and a value of zero in the word reading pathway.

In this system the connection strengths along a given pathway are determined by the amount of training each pathway receives. That is, the more a given type of stimulus (word or colour) is presented the greater the connection strengths will be in that pathway. Cohen et al. (1986), simulated

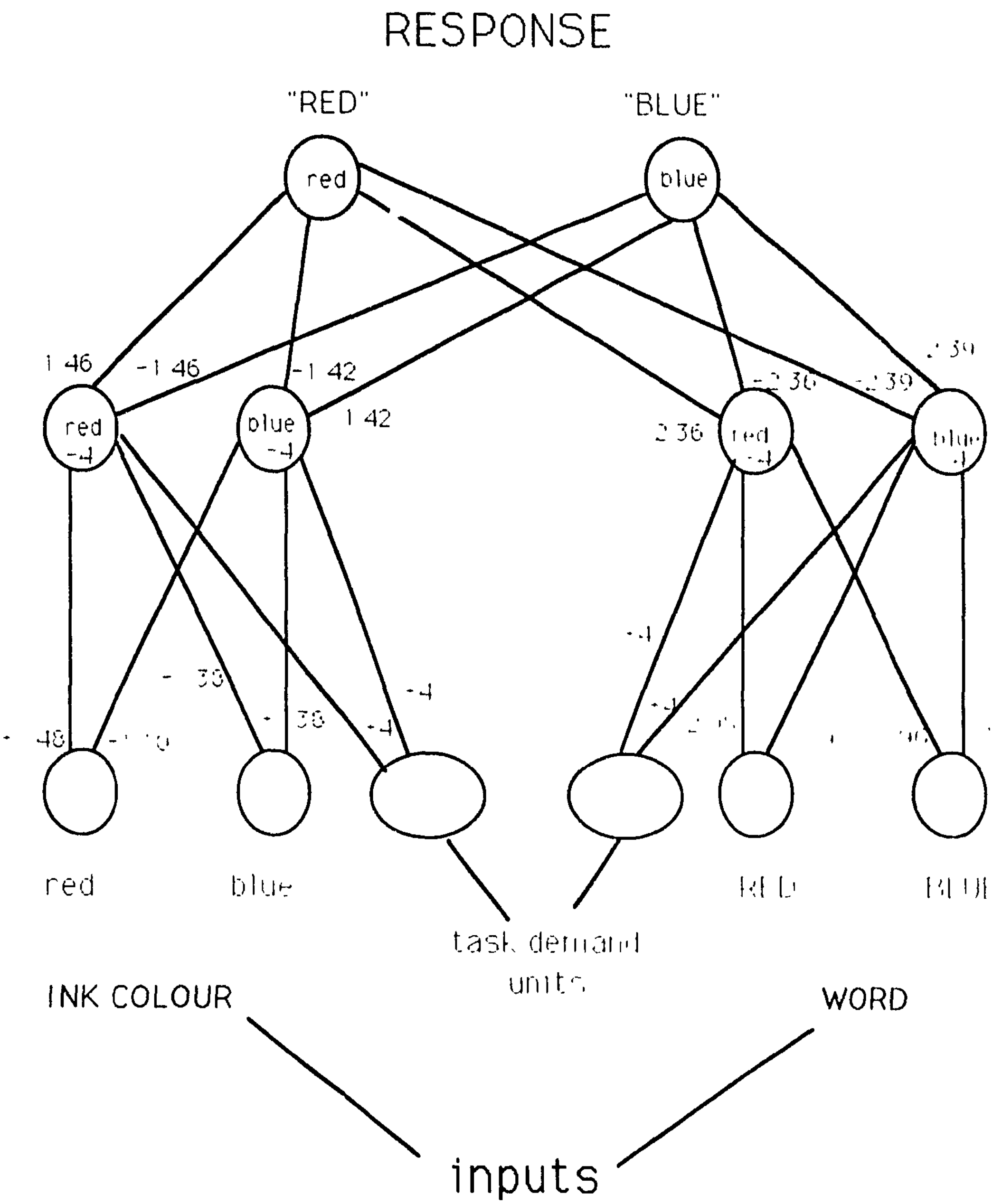

Figure 1 Diagram of the network showing the value of the weights after training on the word reading and color naming tasks. (These weights were obtained from the training simulations of Cohen, Dunbar and McClelland, 1986)

the fact that our educational system puts more emphasis on reading than on colour naming, by exposing the circuit to more words than colours, resulting in the relatively greater connection strengths in the verbal pathways.

In such a system, the colour words are processed "automatically" because the connection strengths along the word reading pathway are greater than the connection strengths along the colour naming pathway. Such a situation makes it impossible to voluntarily ignore the colour words (if the task is to attend to their colour), and it is the automatic processing of these words that leads to the facilatory and inhibitory Stroop effects for congruent and incongruent trials.

For example when the word RED is presented in red ink, both the word reading and colour naming pathways will serve to increase the activation of the "red" response unit. Because both pathways contribute to the activation of the "red" response unit, this unit will achieve its threshold activation level quite quickly, resulting in relatively fast reaction times. When a series of Xs are presented in red ink, only the colour naming pathway contributes to the activation of the "red" response, resulting in somewhat slower reaction times. Finally on incongruent trials (BLUE in red ink), while the colour naming pathway activates the correct "red" response node, the word reading pathway excites the incorrect "blue" response, and inhibits the correct "red" response[4]. Thus a greater amount of time is required for the correct "red" response unit to reach its activation threshold. (A description of the

4 The reason the incorrect response is not always given in this system is that the task demand unit serves to sensitize the colour naming pathway. In the model of Cohen et al., sensitization of this pathway is carried out by setting the logistic function to an initial value of zero-the point at which inputs from units below will have the greatest impact on the updated activation value.

algorithms used to update activation values, and a computer simulation of the Stroop phenomenon using these values is presented in simulation 1 of A).

One of the distinct advantages of PDP theories of cognition is the ability to account for performance differences among subjects merely by postulating individual differences in either the task demand units, or in the connection strengths along various pathways. Of these possible alternatives a number of factors suggest that high and low hypnotizables may differ in the connection strengths along verbal pathways. One factor that suggests that highs may have stronger verbal connection strengths than lows involves J. R Hilgard's previously mentioned concept of "imaginative involvement." To reiterate, imaginative involvement concerns the predisposition to become totally absorbed in endeavours such as reading, listening to, or performing music, or observing nature. In a study comparing highly susceptible subjects to low susceptible subjects, Hilgard found that while 93% of the highs illustrated a deep involvement in reading or drama, only 20% of the lows showed similar degrees of involvement in such endeavours. Because highs enjoy reading more, it follows that they will probably engage in this activity more often than lows. Connection strengths are determined by the number of exposures to specific types of stimuli (Cohen et al., 1988), so highs, because of their increased exposure to written stimuli, should show elevations in their connection strengths along verbal pathways relative to their low hypnotizable counterparts.

The ramifications of highs having stronger connection strengths along verbal pathways is presented in Simulation 2 of Appendix A. Basically, this simulation shows that increases in verbal connection strengths lead to marginally faster congruent trial reaction times, and slower incongruent trial reaction times. Such a situation enables the Stroop paradigm to provide an even more rigorous challenge to social psychological theories of hypnosis and hypnotizability than the backward masking studies previously mentioned. Although there is no face valid connection between performance on backward masking studies and hypnotizability, social psychologists have in the past contended that subjects may construe their roles as being "better" and "poorer" performers in perceptual tasks according to their evaluation of how susceptible to hypnosis they are. Indeed, in the backward masking studies (Ingram et al., 1979; Saccuzo et al., 1982, Acosta and Crawford, 1985), the direction of performance is consonant with such appraisals; highs were found to be more sensitive to masked stimuli than their low susceptible counterparts. In the case of incongruent trials in the Stroop phenomenon, however, this is not the case for despite instructions to name colours as quickly as possible, highs are predicted to perform at levels that are **inferior** to lows.

A number of studies have looked at the differential performance of high and low hypnotizable subjects in Stroop performance. In a study designed to discriminate high susceptible subjects from lows simulating hypnosis, Blum and Graeff (1971) compared the Stroop interference effects of six highs and two low simulators across five levels of post-hypnotically manipulated arousal. Highs showed a monotonic increase in interference as arousal level was reduced from "very aroused to stuporous" while the lows followed a U-shaped function. The most important finding of this study in terms of the proposed automaticity hypothesis is that highs showed a greater amount of interference than lows for all five arousal conditions. It must be noted, however, that using only two low hypnotizable subjects precluded statistical comparisons between groups; thus interpretations of the Blum and Graef's data must be made with caution.

Further support for the proposed verbal connection strength/ hypnotizability relation, comes from the results obtained by Sheehan, Donovan and MacLeod (1988) for incongruent trials on a Stroop type task, administered both before and during hypnosis. These authors tested the hypothesis that high hypnotizables would show a greater reduction of Stroop interference than low hypnotizables when testing was conducted during hypnosis. They also investigated the role of strategies for reducing interference among the two groups. They conducted three Stroop sessions: one prior to hypnosis, and two during hypnosis. In the first hypnotic session subjects were not given any special instructions, while in the second session subjects were given instructions designed to make it harder to read the colour word. The reaction times for incongruent trials were faster for lows than highs both prior to, and during the first hypnosis session. The induction of hypnosis caused a significant increase in reaction time for highs, but not for low hypnotizables. Finally, compared to lows, highs showed a marked reduction in Stroop interference when they were given specific instructions designed to make word reading more difficult.

The finding that Stroop interference prior to hypnosis was greater for highs than for lows, and that hypnosis exacerbated the interference effects for highs but not for lows, provides indirect evidence in accordance with the hypothesis that highs have stronger verbal connection strengths than lows. Since in hypnosis subjects are given instructions to "just let whatever happen, happen", such a context should increase automaticity effects for those subjects (highs) capable of carrying out such instructions. Tellingly, only by adopting a strategy designed to make the word reading more difficult were highs able to reduce their incongruent reaction times to levels comparable to lows. It should be pointed out that because Sheehan et al. (1988), only measured incongruent trial reaction times, statements concerning automaticity effects must be made with caution; in order to fully test the automaticity/hypnotizability hypothesis, both congruent, control, and incongruent trials should be tested.

Thus while the Blum and Graef study, and the Sheehan et al., study provide tentative support for the proposed relation concerning hypnotizability and verbal connection strengths, in order to provide stronger evidence for this postulate a study is required in which meaningful numbers of highs and lows are compared on congruent, control and incongruent trials. Finally, an attempt should be made to assess whether subjects perform the colour naming task in ways that are consistent with their own subjective appraisals of how they responded in hypnosis. That is, if highs predict that they are to do "better" than lows who surmise that they should do "poorer" than highs, then differential motivation may cause overall reaction time differences that have nothing to do with automatic processes. If such processes are at work, then they should become most apparent in the control conditions where language processing is not involved. Specifically, the ramification of differential motivation should manifest itself as a superiority for high hypnotizables in the speed with which the colour of control stimuli are named. Because such a situation could cause unnecessary complications in testing the automaticity hypothesis, an attempt should be made to equate the performance of high and low hypnotizables in terms of motivation.

The Present Study

In the study proposed below, two conditions will be implemented. One condition will involve a simple administration of the classic Stroop phenomenon. If highs are more motivated than lows, their reaction times should be shorter for control trials[5]. Such motivational differences among high and low hypnotizables may unnecessarily complicate the testing of automaticity hypotheses which (in its simplest form) assumes equivalent control reaction times for highs and lows. Thus, in an attempt to obtain control reaction time equivalence, in the second condition subjects will be given periodic feedback concerning their reaction time performance (with the hope that such feedback will drive the performance of lows down to levels where they can be meaningfully compared to highs in terms of automaticity).

Such a study would provide an experimental paradigm that is beneficial in a number of ways. One advantage is that Stroop phenomenon enables the researcher to test the hypothesis that highs process language more automatically than low hypnotizables. If, as the PDP model suggests, verbal automaticity is merely a byproduct of the imbalance in connection strengths between verbal and other pathways, then the predictions in terms of this automaticity hypothesis are clear: if highs have higher verbal connection strengths than lows, then they should show greater facilitation and interference in the Stroop task relative to their low susceptible counterparts. That is, the reaction times of highs should be faster for congruent trials, and

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5 For congruent trials highs should be much faster than lows because of the potentially additive effects of motivation and increased verbal connection strengths. For incongruent trials motivation and automaticity would operate in opposite directions.

slower for incongruent trials, compared to subjects of low hypnotic susceptibility. A second, and more general advantage of using the Stroop phenomenon in the investigation of hypnotic susceptibility is that, like the backward masking studies previously reviewed, it is a perceptual task that has no face valid relationship with hypnosis, and, at least for incongruent trials actually predicts poorer performance for highs relative to low hypnotizables. As such, the Stroop phenomenon should enable the researcher to distinguish between social psychological theories of hypnosis, and theories which recognize the role of cognitive individual differences in determining hypnotic susceptibility. Finally, if, as social psychological theorists suggest, high and low hypnotizable subjects attempt to adjust their performance on perceptual tasks such as the Stroop phenomenon so that it becomes directly proportional to their level of hypnotizability, then lows should show slower reaction times for control stimuli in the no-feedback condition.

EXPERIMENT 1

Method

Subjects

Volunteer subjects were screened for hypnotizability on the HGSHS:A and their susceptibility level was verified using the SHSS:C. Seven subjects who scored between 8 and 12 on the SHSS:C (highs) were compared to seven subjects who scored between 0 and 3 (lows). Of the 14 subjects, 5 were males (3 highs and 2 lows). The mean age of highs was 29.14 and for lows it was 25.0. During the recruitment of the fourteen subjects, a description of the experiment was read over the phone. At this time subjects were informally assessed for colour blindness and recruited only if their mother tongue was English. No mention of hypnosis or hypnotizability, was made in describing the study; instead the experiment was described as a perceptual study concerning reading processes. Subjects were, however, told that their names were obtained from the hypnosis laboratory and underwent Stroop testing in the room adjacent to where they were administered the SSHS:C.

Stimuli and Apparatus

Apparatus. All stimuli were displayed on an Electrohome colour Monitor that was interfaced to an Apple II+ computer via an Electrohome Supercolour board. Trials were initiated by having subjects press a start button on each trial. A voice activated relay was used to record reaction time for colour naming trials. The start button and the voice activated relay were interfaced to the computer by a John Bell Board which afforded ± 2 ms accuracy. Stimuli were observed through a 1 meter viewing tube.

Stimuli. All stimuli were preceded by a 2 pixel white fixation dot against a black background. The stimuli consisted of the words RED, GREEN, BLUE, YELLOW and XXXXX whose dimensions were .4 cm (5 pixels) by .6 (7 pixels). These words or control stimuli appeared so that they were spatially centered in terms of both height and width around the location of the fixation dot. All stimuli were presented an equal number of times in one of four colours, red, green, blue, yellow. The exact hues of these colours were informally selected by two independent experimenters with the criterion that they were to select the hue that was prototypical for that particular colour. The background luminance against which all stimuli were presented was within the photopic luminance range[6], in order to circumvent problems associated with differential dark adaptation between and within blocks.

On any given trial, the fixation dot appeared and remained on until the subject pushed the start button, whereupon the fixation dot disappeared and a 250 ms blank field appeared followed by the colour word or control stimuli. Reaction times were recorded from the appearance of the colour word, until the colour was named. Both the fixation dot and Stroop stimuli were yoked to the vertical sync pulse of the monitor, thereby ensuring that all stimuli were painted within a single video frame.

Procedure

Subjects were seated by the experimenter beside the viewing tube, where they were asked to read and sign a standard consent form. In the consent form was a description of the procedure which was reiterated verbally upon their agreeing to participate in the study. Subjects were requested to look at the fixation dot in the middle of the screen, informed that the appearance of this dot meant that a new trial was ready to begin, and that in order to initiate the trial they had to push the start button. They were then told that after they pushed the button, one of four words would appear, RED, GREEN, BLUE, or YELLOW or a series of five Xs, and that these words or Xs would appear in one of four colours-red, green, blue or yellow. Subjects were instructed that their task was to ignore the word or Xs and just concentrate on naming out loud the colour that they were painted in. They were then told that the voice activated relay would pick up their response and the computer

6. Range of luminance in which there is minimal rod activity.

would record their reaction time to naming the stimuli. (A verbatim transcript of the instructions to subjects appears in Appendix B).

Subjects were then shown the four colours painted on the control stimuli in order to ascertain that the colours could be distinguished. After these colours had successfully been named, subjects were reminded that their job was to focus on the fixation dot at all times, then name the colours out loud as quickly as possible while making as few errors as possible.

Subjects were presented with the no-feedback condition first. This condition consisted of six blocks of 36 trials. Stimulus combinations were presented in random order, with the restriction that no two physical colours were presented consecutively and that there was a total of 12 congruent, 12 control and 12 incongruent trials per block. In addition to recording reaction time, the computer recorded colour naming errors. Such errors caused the computer to emit a low frequency buzz audible to the subject, and the stimulus combination on which the error was recorded was presented at the end of the block in which it occurred. Reaction times over 2000 ms were recorded as subject errors, while reaction times under 150 ms were regarded as equipment errors; in either case trials were repeated at the end of that block.

The first block of 36 trials was considered a practice block on which data were retained but not analyzed. During this practice block any technical difficulties were cleared up by the experimenter (e.g., saying colour combinations "bred", yeblue" etc.) and subjects were specifically admonished against using strategies such as defocusing their eyes in order to make word reading more difficult. After the practice block, and prior to each successive block, subjects were reminded to focus on the fixation dot, and name the colours as quickly as possibie without making any errors.

After completing the six block no-feedback condition, the feedback condition was tested. In this condition subjects were told that following each block they would be presented with their average reaction time, and they were to treat this task like a video game in which they were to try and beat their previous score each successive block. Five experimental blocks were presented, and subjects were given as feedback the mean of the 12 control-trial reaction times for that block. Control means were used in order to maximize overall speed without penalizing subjects who were excessively prone to interference.

Results

In order .o discount the undue influence of outliers on the reaction time data, each individual subject's mean and standard deviation were calculated for congruent, control and incongruent trials for both the feedback and no-feedback condition. (Since the practice trial block of the no-feedback condition was eliminated each of these means were based on 60 individual trials). When a specific reaction time was more than three standard deviations from the subject's mean it was considered an outlier and discarded. New means were then recalculated using these outlier-free distributions. These revised means served as the subject's raw data and were the basis for a three-way analysis of variance with hypnotizability (high, low) as a between subjects factor, and word-colour relation (congruent, control, incongruent) and reinforcement (no feedback, feedback) as repeated factors. (The source table for this analysis appears in Appendix C.) This analysis revealed a significant main effect for word-colour relation [$F(2,24)=281.886$, $p<.001$], reinforcement[$F(1,24)=26.243$, $p<.001$, and a significant interaction between these two variables [F(2,24)=11.351, p<.001]. There was a significant hypnotizability main effect [F(1,12)=6.234 p<.05], which was qualified by a significant interaction between hypnotizability and word colour relationship [F(2,24)=6.496, p<.01]. Simple main effects (Howell, 1987) revealed that this interaction was caused by highs and lows not significantly differing on congruent trials [F(1,24)=4.15 p>.05] or control trials [F(1,24)=3.262 p>.05], but showing significant differences on incongruent stimuli - with highs being significantly slower than their low hypnotizable counterparts [F(1,24) = 11.34 p<.01].

Because of a severe restriction of range in errors on both congruent and control trials (less than .1% of all trials) highs and lows were compared only in terms of the number of errors made on incongruent trials. A two way analysis of variance compared the number of errors made by highs and lows on both the feedback and no feedback conditions. No significant differences were found between highs and lows [F(1,12)=.038, p>.1], reinforcement [F(1,12)=.19, p>1] or their interaction [F(1,12)=.08, p>.1]. A summary of mean reaction times and errors appears in Table 1, and are graphically depicted in Figure 2.

Discussion

An inspection of Figure 2 reveals that there is no evidence to support the social psychologists contention that highs and lows would modulate their reaction time performance to be concordant with their hypnotizability level. In fact subjects who were better at hypnosis showed poorer performance on all trials, although the simple main effects revealed that these discrepancies were only statistically significant for incongruent trials Such a finding indicates that the precautionary measure of providing feedback was

Table 1

Mean colour naming reaction times (in ms) of high and low hypnotizable subjects for congruent, control and incongruent trials in the feedback and no feedback conditions

No feedback

	congruent	control	incongruent
Highs	**630.28** (.35)	**631.85** (.39)	**838.85** (1.67)
	(56.44)	*(54.44)*	*(72.94)*
Lows	**551.00** (.25)	**564.28** (.32)	**704.00** (1.21)
	(77.71)	*(61.94)*	*(90.5)*

Feedback

	congruent	control	incongruent
Highs	**555.71** (0.0)	**580.00** (.09)	**725.42** (1.31)
	(69.76)	*(72.73)*	*(76.76)*
Lows	**499.71** (0.0)	**527.71** (.45)	**636.85** (1.40)
	(53.62)	*(46.46)*	*(61.95)*

Note Mean reaction times (in ms) are in boldface; mean errors are in standard type; and standard deviations are in italics.

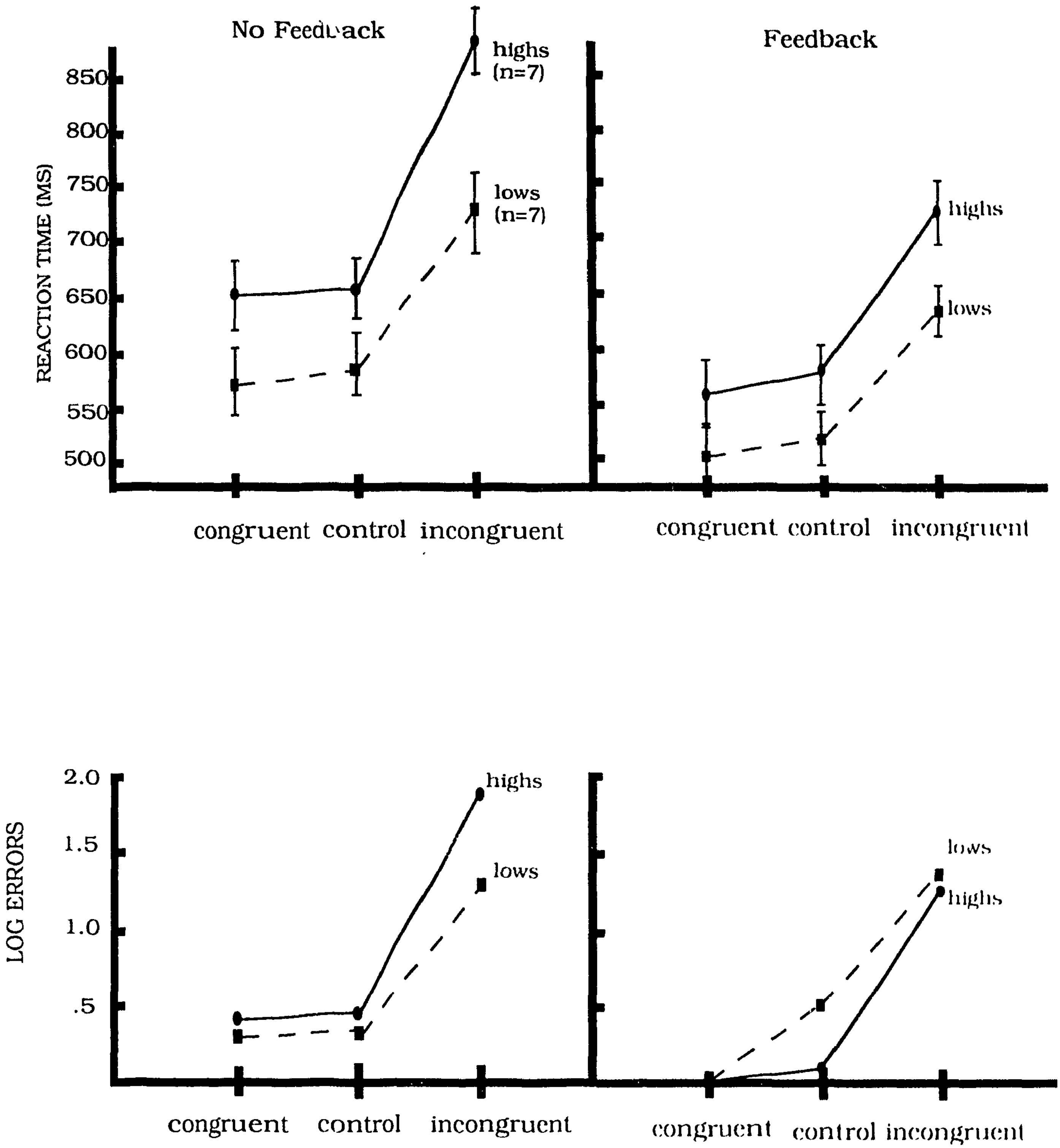

Figure 2. Stroop colour naming reaction times (top), and errors (bottom) for high and low hypnotizables, with and without reinforcement.

unnecessary, as the failure to find an interaction involving feedback and hypnotizability indicated that highs and lows benefited equally from reinforcement.

While not finding differential reinforcement effects for the colour naming performance of highs and lows argues against the postulate that differential motivation was at play, it should be noted that other strategic differences in the manner in which highs and lows performed the Stroop task were not explicitly assessed in this study. The importance of such factors is evident in the results of Sheehan et al., (1988). These authors showed that although highs showed greater interference both prior to, and during hypnosis, when given an appropriate strategy they were able to reduce interference to levels equal to their low hypnotizable counterparts. Such a finding suggests that it is of paramount importance to assess both strategic and automatic components of Stroop performance before making definitive statements concerning strategy differences among high and low hypnotizables in this task. Thus, in the subsequent series of investigations, attempts were made to examine the role of strategies that were specific to the performance of the Stroop task.

While no evidence was found for the social psychological hypothesis concerning differential motivation, the synergistic postulate concerning the automaticity of verbal information processing was supported by the significant interaction of hypnotizability and word colour relation. The finding that relative to lows, highs showed significant elevations in incongruent trial reaction times is consistent with the notion that highs have greater connection strengths than lows along verbal pathways. To reiterate the example used earlier, when the word RED is painted in the colour blue a positive activation is received by the "blue" response node from colour naming pathways, but negative activation is received from the word reading pathways, thereby causing a greater period of time to be required for the "blue" response node to surpass its threshold activation. In such a situation, if highs have greater connection strengths along verbal pathways than lows do, then larger amounts of negative activation would be received by their "blue" response nodes causing longer incongruent trial reaction times for highs, relative to their low hypnotizable counterparts.

While highs responded in the predicted direction for incongruent stimuli, for congruent trials it was predicted that highs would show faster reaction times than their low hypnotizable counterparts – a prediction that was not borne out by the results of this study. This failure to find reaction time superiority for highs is not detrimental to the verbal automaticity hypothesi,s however, for in the majority of Stroop studies facilitation is neither as robust, nor as reliable as interference. In parallel distributed processing terms, the relatively small magnitude of facilitation can be attributed to the numerical properties of the logistic function that hidden units use to update their activation values. Just as facilitation effects within a given individual are smaller than interference effects because of this logistic function, so too are the magnitude of facilitation differences that would be predicted between subjects with different verbal connection strengths (See simulation 2 in Appendix A). Thus, while the more robust interference differences between highs and lows were obtained, the predicted slight superiority of high hypnotizables for congruent trials was more prone to being offset by sampling error – resulting in nonsignificant differences between the two hypnotizability groups.

Although the predicted superiority for highs on congruent trials was not obtained, the significant difference between highs and lows on incongruent trials was quite robust, and cannot be attributed to non-automaticity factors such as a speed-accuracy tradeoff. In terms of accuracy, highs and lows did not significantly differ in the number of errors that were made in naming incongruent stimuli. Thus reaction time performance differences between highs and lows are not merely a consequence of of highs being more careful about making mistakes than low hypnotizables.

The incongruent trial findings of Experiment 1 support the synergistic notion that hypnotizability differences are at least in part attributable to cognitive differences in the way members of different hypnotizability groups process verbal information. Such a finding runs contrary social psychological theories of hypnotizability for two reasons. Firstly, the Stroop experiment was conducted in a setting that was removed from the hypnotic context and, as such, was unlikely to have been influenced by high hypnotizables attempting to fulfil the role of a good hypnotic subjects. Secondly, even if such factors were at play, then given that subject's instructions were to name the colours as fast as possible, then high hypnotizables (being subjects who, according to social theorists, are more likely to respond to the inherent demands of the experimental situation) should have shown faster, rather than slower incongruent reaction times.

Given the inability of the social psychological theories to account for this finding, the incongruent findings of Experiment 1 must be interpreted as supporting the notion that highs have stronger verbal connection strengths than low hypnotizables Such a cognitive difference may at least in part account for the tendency of high hypnotizable subjects to categorize their hypnotic responses as being automatic and involuntary (Bowers, Laurence & Hart, 1988). In the hypnotic context, subjects are told to focus on verbal cues (the hypnotists voice) and set aside critical judgement, and " just let whatever happens, happen" (SHSS:C, Weitzenhoffer and Hilgard, 1962). Such a situation would tend to maximize non-volitional, automatic processing. Thus, if the previously mentioned suggestion that an extended hand is getting heavier is interpreted in parallel distributed processing terms, the hypnotic suggestion would yield two competing alternatives. One alternative is the suggested situation that the hand and arm are "heavier." The second alternative is the the veridical somatosensory situation that the hand and arm are not any heavier than usual. If, as the incongruent findings of Experiment 1 suggest, highs have greater connection strengths along verbal pathways than lows, it can be postulated that of the two competing responses, highs would be more likely to adopt the verbally suggested response. Lows, on the other hand, having equal connection strengths for verbal and somatosensory pathways will be more likely to adopt the veridical response, and therefore fail to lower their hand. Such a situation would not only cause highs to respond to the suggestions, but also to categorize their responses as being automatic and involuntary.

Experiment 2

An important corollary of the subjective feeling of involuntariness experienced by highs in hypnosis involves the relative lack of awareness of the processes leading to a hypnotically suggested response. Just as subjects are unaware of the processes that cause interference or facilitation in the Stroop phenomenon (e.g., the constant updating of activation levels of input, intermediate and response units), subjects who respond well to hypnotic suggestions are unaware of the means by which they do so. In fact, for highly susceptible subjects, much of what goes on in hypnosis seems to require active processing of information outside of awareness. For example, in a hypnotically induced hallucination, the subject is required to actively construct a mental representation of the suggested object. If the subject were aware of such reconstruction, then it is unlikely that they would categorize their response to the suggestion as being involuntary (unless of course they were actively being deceitful).

One account of how such cognitive construction can take place out of awareness is offered by Hilgard's Neo-dissociation theory of cognitive processing. In Hilgard's model, a network of cognitive subsystems are initiated and monitored by a central controlling structure called the executive ego. While the executive ego is required to activate these subsystems, once activated, certain subsystems seem to be able to carry out their functions in a relatively autonomous fashion. Numbered among the most autonomous of these subsystems are those responsible for carrying out highly practised acts such as the fine motor movements of the touch typist, or the sophisticated adjustments made by the experienced driver, who can guide his/her car through city traffic while engaged in conversation. Thus, although the executive ego is capable of monitoring these subsystems, the functional integrity of these subsystems does not depend on this central cognitive control. In more modern terminology, the subsystems could proceed without the benefit of conscious awareness. In terms of below awareness processing what seems to differentiate high and low hypnotizable subjects is the complexity of the cognitive processes that are carried out. While both highs and lows can effectively drive a car while attending to a conversation, only highs can carry out more complex tasks - such as the aforementioned task of constructing mental representations of suggested objects in order to produce a positive hallucination.

If this hypothesis were true then not only should highly susceptible subjects show a greater degree of verbal automaticity than low susceptible subjects, they should also show greater below awareness information processing capabilities than lows. What is required to assess the veridicality of these hypotheses experimentally is a methodology that objectively illustrates that people differ in the degree of automaticity with which they process information, and which also illustrates that highs and lows show differences in the ability to process information of which they are unaware.

One such paradigm that looked at both automaticity and below awareness processing was proposed by Cheesman and Merikle (1986). Because of the importance of their study to the present series of investigations, the Cheesman and Merikle paradigm will be described in some detail.

<u>The Cheesman & Merikle Paradigm.</u>

Cheesman and Merikle's study used a novel approach to the empirical question pertaining to whether subjects could process information that was presented below the level of awareness. In contrast to the majority of researchers who have used the tenets of signal detection theory to define "awareness", these authors postulated that awareness boundaries could be more adequately defined in terms of subjective rather than objective criteria. Thus, on a detection task where subjects are asked to identify degraded stimuli, awareness was not defined in terms of performance that was above chance, but rather in terms of whether the subject was "confident" of the identity of the stimulus, as opposed to just guessing. They argued that such a definition of awareness is superior to one based on signal detection methodology, for it better captures the subjective essence of the experience of awareness, while still remaining amenable to empirical assessment. Cheesman and Merikle (1984) defined this confidence based definition of awareness as the "subjective threshold" of awareness.

These authors found that signal detection type strategies were impractical when applied to the subjective threshold, since both clearly visible stimuli, as well as stimuli presented below the subjective threshold, resulted in above chance performance. Such a situation is somewhat problematic, for if the subjective threshold cannot be objectively validated, then it must be regarded as just another label, and of little heuristic value (Cheesman and Merikle, 1986). To circumvent this problem, they used what

Merikle (1984) referred to in an earlier paper as the qualitative difference criterion. This criterion involved demonstrating qualitatively different behaviourial effects for stimuli presented below as opposed to above the subjective threshold.

In an attempt to fulfil this criterion, Cheesman and Merikle combined backward masking with the automatic and strategic components of the Stroop phenomenon to show that when people process information below awareness, the resulting behaviours are qualitatively different from the behaviours evoked when the same information is processed above awareness. In their experiment the subjective threshold was established for the words BLUE, RED, GREEN and YELLOW by varying the ISI between the word and a backward mask. Subjects were presented blocks of 24 trials and asked to estimate the percentage of words that they could see. The ISI was systematically decreased until the claimed level of awareness was at chance levels. These words then served as primes in the Stroop colour naming test. In this task the words BLUE, GREEN, RED and YELLOW were presented prior to the appearance of a coloured rectangular border, which was painted blue, red, green, or yellow. The subject's task was to name the physical colour of the rectangle as quickly as possible. Thus, the prime words would serve to facilitate colour naming reaction time when the priming word was congruent with the colour (e.g., RED followed by the physical colour red), and inhibit reaction time when the prime word was incongruent with the colour to be named (e.g., RED followed by the colour green).

In order to establish that information could be automatically processed below the subjective level of awareness, these authors showed that facilitatory and inhibitory effects of the prime word on colour naming reaction time were not only evident when the prime was clearly visible, but also when the prime was presented below awareness via backward masking.

In order to fulfil the qualitative difference criterion Cheesman and Merikle made use of a strategy component inherent in the Stroop Task (Logan, Zbrodoff and Williamson, 1984). They purported to show that subjects could use a performance optimization strategy for above awareness processing, but not for below awareness processing. This performance optimization strategy involved manipulating the probability that a colour word would accurately predict the colour of a subsequently presented colour patch. If, for a given series of trials, the congruent trial probability for Stroop presentations is 25% (only 1 time out of 4 will the word predict the colour) then the best strategy is in fact no strategy, and subjects should merely attempt to ignore the word stimuli on all trials, and concentrate on naming the colour as quickly as possible. Such a situation results in a minimization of differences between congruent and incongreunt trials illustrated in the 25% Suprathreshold condition in Panel A of Figure 3. When the congruent trial probability is increased to 75% (3 out of 4 times the word predicted the colour), the best strategy is to pay attention to the word, and use this word to predict what colour would appear. The adoption of such a strategy serves to decrease subject's reaction times for congruent trials. On the one time out of four where rather than predicting the colour, the word primed an incorrect response, this strategy costs subjects, and reaction times for incongruent trials are increased dramatically. The effect of adopting a conscious strategy to improve performance is graphically illustrated in the 75% suprathreshold condition of Figure 3, showing decreases in congruent trial reaction times and increases in incongruent trial reaction times (relative to the 25% condition)

In parallel distributed processing terms it can be hypothesized that there are two task demand units operating in parallel. One task demand unit serves to sensitize the color naming pathway, and the other the word reading pathway. Because the instructions in the Stroop task are to name the colour as fast as possible, the task demand unit would be manipulated so that the

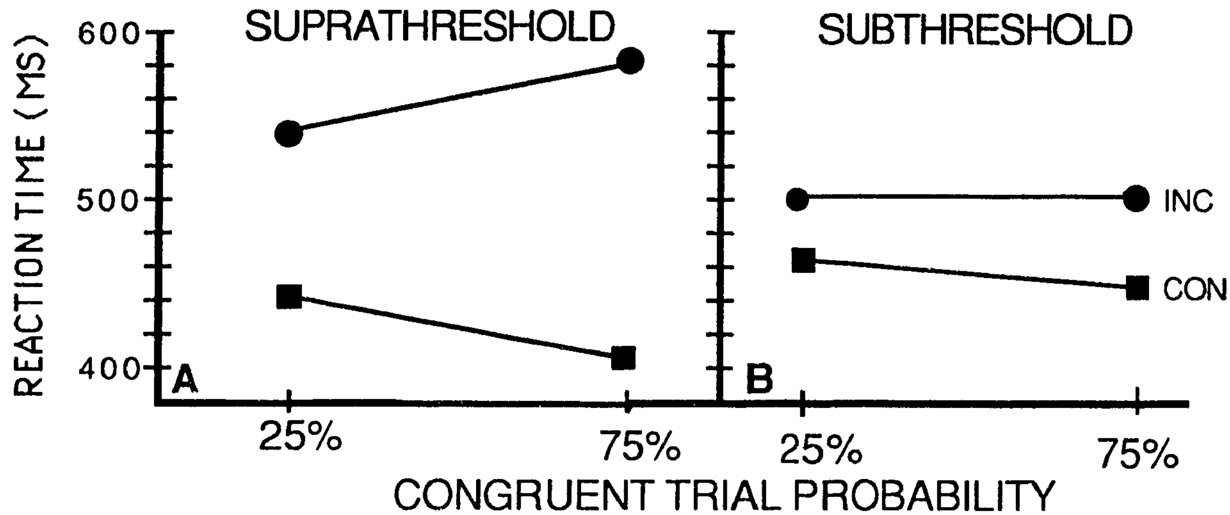

Figure 3. Data from Experiment 3 of Cheesman and Merikle (1986) showing reaction time as a function of word-colour relation, congruent trial probability and stimulus visibility.

logistic functions of the hidden units of the colour naming pathway would be set to the most responsive part of their ranges (See simulation 1 of Appendix A). Since the performance optimization strategy used by Cheesman and Merikle's subjects involved paying attention to the words in the 75% condition, but not in the 25% condition, it is reasonable to assume that in addition to task demand units senisitizing colour naming pathways, a second task demand unit should be employed to senisitize the word reading pathway in the 75% condition. Simulation 3 of Appendix A reveals that increasing the sensitivity of the word naming pathway would account for the pattern of suprathreshold results obtained by Cheesman and Merikle.

Panel B of Figure 3 represents the same colour naming task using words presented below the subjective level of awareness. According to Cheesman and Merikle, the difference between congruent and incongruent trials in the two 75% conditions illustrated the qualitative difference between information processed above and below awareness. For clearly visible stimuli, increasing the congruent trial probability from 25% to 75% results in the adoption of a conscious strategy to improve performance which exacerbates the difference between congruent and incongruent trials. When the primes are presented below awareness, however, subjects do not illustrate this pattern, presumably because they are unaware of the words upon which the strategy is based. (In PDP terms task demand units of the verbal pathway are in their normal resting state). The fact that information concerning the meaning of the primes is still processed, however, is indicated by the fact that incongruent trials still elicited slower reaction times than congruent trials. Thus, according to Cheesman and Merikle, information was processed above and below awareness, but it affected the individual's behaviour in qualitatively different ways.

While Cheesman and Merikle used this variation of the Stroop paradigm to distinguish conscious from unconscious processes, it can, with some modifications, also be used to evaluate hypotheses concerning both automaticity and strategy differences among subjects of high and low hypnotic susceptibility, as well as the hypothesis concerning hypnotizability differences in the ability to process information below the level of awareness.

Looking at Cheesman and Merikle's data it is clear that there are two different components to the Stroop phenomenon. One component involves the automatic processing of the verbal prime. Such processing lead to facilitation when the word was the same as the colour of the border and inhibition when the word was incongruent with this colour. These automatic processes are reflected by the pattern of congruent and incongruent reaction times in the 25% Suprathreshold conditions, and according to Cheesman and Merikle, in both the 25% and 75% conditions of the subthreshold conditions. The second component is the strategy which subjects choose to adopt in attempting to name the colour of the border as quickly as possible. This strategy component of the Stroop phenomenon is reflected by the increase in the discrepancy between congruent and incongruent reaction times for the Suprathreshold 75% condition. The reason that congruent and incongruent trials are more discrepant in this condition is that in addition to resident automaticity effects, using the colour word to predict what colour would be presented, caused faster congruent reaction times, but slower incongruent reaction times relative to the 25% ("pure automaticity") condition.

Thus, if, as Experiment 1 suggests, highs have stronger verbal connection strengths than lows, then these differences should be reflected by greater discrepancies between congruent and incongruent trials in all conditions (as automaticity effects are present in the 25% and 75% conditions of both suprathreshold and subthreshold trials). If, as Sheehan et al (1988), suggest, highs make better use of specific colour naming strategies than lows in the Stroop task, then this difference should be reflected in the suprathreshold 75% congruent trial probability condition, where strategy plays a key role in determining congruent and incongruent reaction times. Specifically, it can be predicted that highs should show discrepancies between congruent and incongruent trials that are much larger than lows because of the additive effects of increased strategy use on top of already larger automaticity effects. That is, highs should show discrepancies between congruent and incongruent trials that are so much larger than lows that they cannot be attributable to baseline automaticity differences alone (See Simulation 5, Appendix A for a simulation of differential strategy use by high and low hypnotizables).

While Cheesman and Merikle's study affords the ability to test strategic and automaticity hypotheses, it may, with some modifications, also provide a means of testing the hypothesis that high hypnotizable subjects can process more information below the level of awareness than their low hypnotizable counterparts. What is required is first, to show that highs and lows can process information below the level of awareness, and second, to show that the amount of information that is being processed below awareness is greater for highs than for lows. Cheesman and Merikle's paradigm can be used to accomplish the former task by assessing whether subthreshold congruent trials differ significantly from subthreshold incongruent trials. The latter task can be accomplished by presenting the subthreshold prime words in a forced choice procedure. That is, have subjects attempt to discriminate the masked prime words from a fixed number of competing alternatives, and see if highs can correctly identify significantly more prime words than highs[7].

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7. Although, in hypnosis, the suggestions are given supraliminally, such suggestions may trigger a series of cognitive subsystems that then proceed to operate outside of awareness. Thus presenting subthreshold information in Cheesman and Merikle's task may mimics the subliminal activation of one cognitive subsystem by a subsystem that is itself operating outside of awareness.

It must be noted, however, that the interpretability of statements concerning hypnotizability differences (in terms of below awareness processing) depends on the validity of Cheesman and Merikle's contention that the subjective threshold is the true boundary between conscious and unconscious processing. If the subjective threshold does not represent this border, then the performance of subjects in the subthreshold conditions merely assesses the effects of degrading stimulus visibility, and has little to do with conscious-unconscious distinctions. As Cheesman and Merikle themselves note, the utility of the subjective threshold depends on whether they were able to validate this threshold empirically using their qualitative difference criterion. Because of the importance of such issues to the hypothesis concerning hypnotizability differences in subthreshold processing, the methodology and data of Cheesman and Merikle will be considered in some detail.

Problems Inherent in Cheesman & Merikle's Study

While evaluating the suprathreshold conditions of Cheesman and Merikle is relatively straightforward, unfortunately, a number of problems in the methodology of Cheesman and Merikle's study make interpretation of their subthreshold stimuli somewhat ambiguous. These problems primarily concern the memory component inherent in their method of setting the subjective thresholds for the four colour words, and in the differences between the stimuli used in the threshold setting task and in the actual colour naming task. In the threshold setting procedure used by Cheesman and Merikle, subjects were presented the four colour words in blocks of 24 trials. The ISI separating the words and masks were varied according to subject's estimations of how many words they felt they could correctly identify in the block. ISI's were systematically decreased until subjects estimated that less than 3 out of 24 words could be confidently identified. Two potential problems arise from such a procedure. First, a potential eight percent of the stimuli are confidently identified, yet these words are still considered as being presented below awareness. Second, the memory component involved in remembering what and how many words could be confidently identified may have led to imprecise estimates of the subjective threshold.

The second set of potential problems involve the stimuli used in setting the subjective threshold. Subjects were instructed to fixate on the centre of a white rectangle. In the centre of the rectangle a forward mask comprised of eight capital letters (QYGRUEWN) was briefly presented to one eye, followed by the prime word to the other eye, a variable ISI ensued, and finally a backward mask consisting of seven capital letters (RYBULOG) was presented to the first eye. In the threshold assessment one must assume foveal fixation. In the colour naming task, however, the colour to be named appeared around the border of the fixation rectangle in which the colour words were embedded. Given that the best strategy of subjects in the 25% congruent trial probability condition is to ignore the word completely, it is possible that subjects shifted their focus to the outer border of the fixation rectangle in order to reduce the interference caused by naming the centrally displayed prime word. Thus, it can be proposed that what was purported to be a straightforward backward masking task may actually have been a parafoveal viewing task in which the primes were presented away from where the subject was fixating (Holender, 1986).

Further problems in the threshold setting procedure may also have occurred due to the word length of the different primes. While it may have been difficult to distinguish between BLUE and GREEN based on the stimulus energy alone, the same cannot be said for distinctions made between RED and YELLOW. Since Cheesman and Merikle's experiment concerned semantic activation, attempts should have been made to preclude subjects from basing decisions on feature detection attributes such as stimulus energy.

The most crucial problem in Cheesman and Merikle's study, however, is one of interpretation. In order to fulfil their qualitative difference criterion, "no evidence for strategy effects should be found when primes are presented below the awareness threshold" (Cheesman and Merikle, 1986). Although they satisfy this criterion in two experiments when congruent trial probability is set at 33% and 66%, in the experiment described above, where congruent trial probabilities were more extreme (25% and 75%), they found a significant difference between congruent subthreshold trials in the 25% and 75% congruent trial probability conditions. Thus, at least for congruent trials, subjects benefited from the strategic manipulations even when the words were purportedly presented below awareness. This finding is extremely problematic in terms of their theory, for this qualitative difference criterion must then be weakly postulated only in terms of inhibition. It is also problematic for hypotheses concerning strategy differences among members of different hypnotizability categories, for Cheesman and Merikle's results indicate that strategy effects occur below as well as above awareness. It can, however, be proposed that by using too liberal a criterion in estimating the subjective threshold, Cheesman & Merikle's subjects were aware of the primes on enough trials to give a small but significant congruent trial facilitation effect. If this were the case, then this problem could be rectified by setting more conservative thresholds for the words used in the subthreshold Stroop trials. Until these problems are overcome, however, Cheesman and Merikle's subthreshold trials (according to their own "qualitative difference criterion") must merely be considered degraded trials of which subjects were at least partially aware.

Irrespective of whether masked stimuli are below awareness, or merely degraded, the Cheesman and Merikle study provides a paradigm that can adequately assess the effects of both automatic and strategic effects within the Stroop paradigm. Ideally, by modifying the threshold setting procedure and correcting other methodological flaws, pure automaticity effects should be elicited for the suprathreshold 25% congruent trial probability condition, as well as both their 25% and 75% subthreshold conditions. In the suprathreshold 75% congruent trial probability condition, automaticity would be combined with strategic effects, causing a greater discrepancy between congruent and incongruent trial reaction times.

As such, this paradigm affords the opportunity of testing the automaticity hypothesis that high hypnotizable subjects have stronger verbal connection strengths than low hypnotizables by seeing if they show larger overall differences between congruent and incongruent trials in all conditions. Secondly, if as Sheehan et al., (1988) suggest, highs are better than lows at using strategies designed to improve their performance, then in the suprathreshold, 75% congruent trial probability condition, where automaticity and strategy effects are mixed, highs should show a significant exacerbation of the Stroop effects relative to their low hypnotizable counterparts. Finally, by implementing a forced choice procedure for subthreshold words, the hypothesis that highs can process more information outside of awareness than lows can be tested. The following study was conducted as a preliminary test of these three hypotheses.

Method

Subjects.

Four male and six female undergraduate students served as subjects in the experiment. These subjects had been tested in the previous year on either one of two hypnotizability measures; the Harvard Group Scale of Hypnotic Susceptibility; Form A (HGSHA;A Shor and Orne, 1962), or the Stanford Hypnotic Susceptibility Scale; Form C(SHSS:C Weitzenhoffer & Hilgard, 1962).

Apparatus and Stimuli

Apparatus. All stimuli were displayed using the same equipment as described in Experiment 1. In addition to the start button four other buttons were interfaced to the Apple computer via the John Bell Board.

Stimuli All stimuli were presented inside a white rectangle (5 cm by 2 cm) containing a small centrally located fixation dot The priming stimuli consisted of words, as well as non-words (YELLOW, YOLLEW, RED, ERD, GREEN, GENER, BLUE, BUEL) presented using 5 by 7 pixel block letters that were 4cm by 6cm Word length, and therefore stimulus energy was approximately equated by presenting sets of vertical bars on either side of the words The pattern mask consisted of eight figures composed of all possible dot locations making up each letter of the prime words. The colour patches consisted of 8 cm by 2 cm rectangles in the same spatial location as the prime words and masking stimuli. These stimuli are depicted in the first five rectangles in Figure 4. Once again the background luminance against which all stimuli were presented was within the photopic luminance range in order to circumvent problems associated with differential dark adaptation for detection and colour naming trials.

Procedure

Familiarization task Subjects underwent a practice session designed to familiarize them to the prime words, non - words and masking stimuli. In

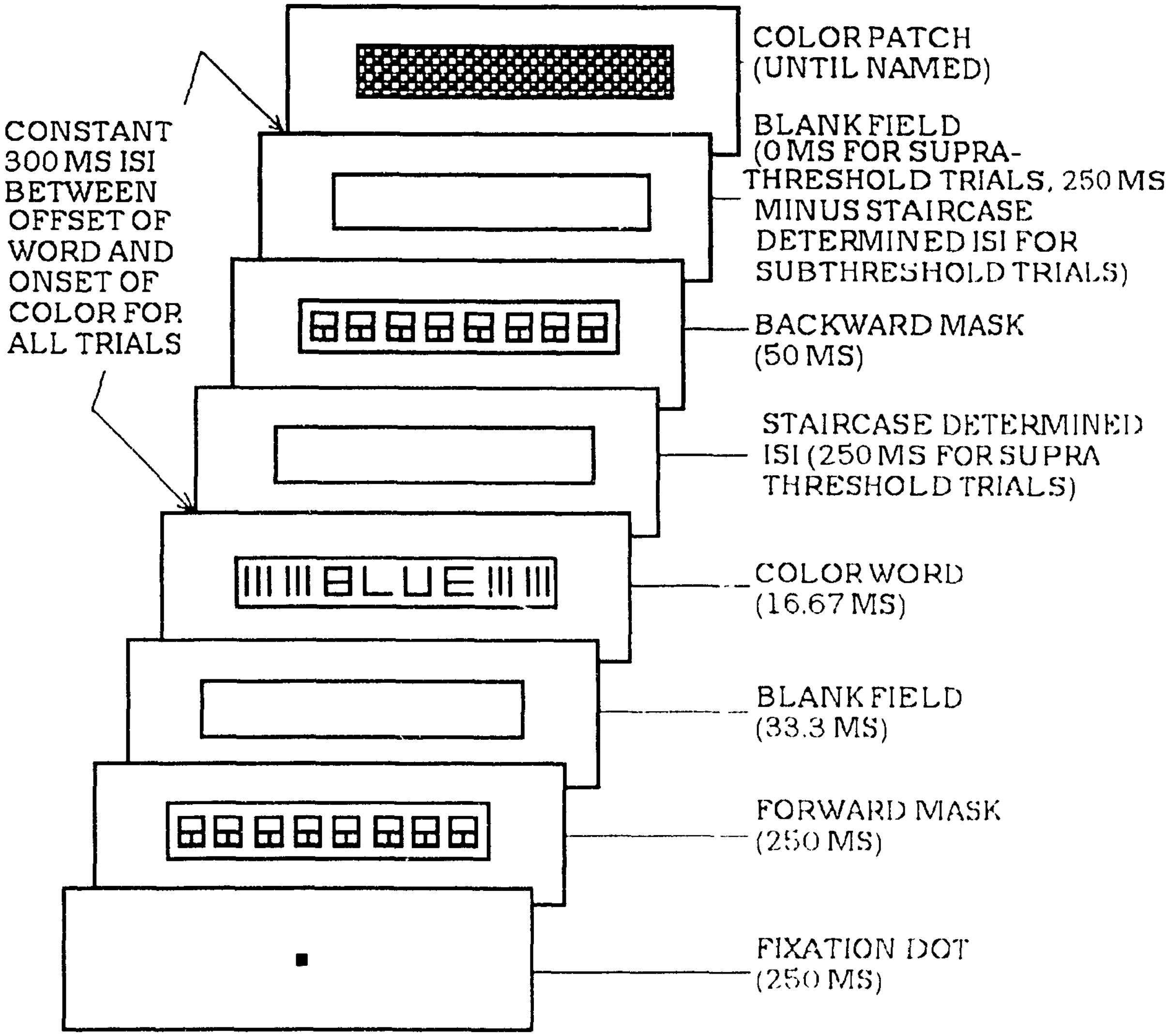

Figure 4 Temporal relations between the colour-word colour patch, and forward and backward masks

this session, subjects initiated trials via a button press. After a 250 ms delay a 250 ms forward mask was presented followed by a 33.4 ms delay, whereupon the word or non-word prime was presented for 16.7 ms. Following a 250 ms ISI the pattern mask appeared for 50 ms. These temporal parameters caused the stimuli to be somewhat degraded but clearly identifiable. Subjects were required to indicate by pushing an appropriately labelled button which of the words or non-words had been presented. Two blocks of 32 such trials were presented.

The threshold setting procedure consisted of a having subjects make a confidence-guessing distinction for words or non words which were presented in random order. One button was pushed if words could confidently be identified, another button was pushed if subjects felt they were guessing. Inclusion of the non-words, therefore, ensured that subjects based their identification on the actual word, rather than single letters. Stimulus visibility was manipulated by varying the ISI between the prime word and the backward mask using a psychophysical staircase procedure (Cornsweet, 1962). This procedure entailed decreasing the ISI between target and mask when subjects pressed the confident button, and increasing this ISI when subjects claimed to be guessing. The 8 (one for each word and non-word) staircases began at long ISIs of 200 ms (rendering the word or non-word clearly identifiable) and were systematically decreased in steps of 16.67 ms until subjects pressed the guessing button. The next time that particular word or non-word appeared in the random sequence, the ISI would be increased by 16.67 ms rendering the word or non-word more visible. If subjects still claimed to be guessing, the ISI would again be increased until subjects changed their response from guessing to confident. Such a change in direction of the subject's response is called a reversal (the ISI moving from ascending ISI durations to descending ISI durations). An example of such a staircase is presented in Figure 5.

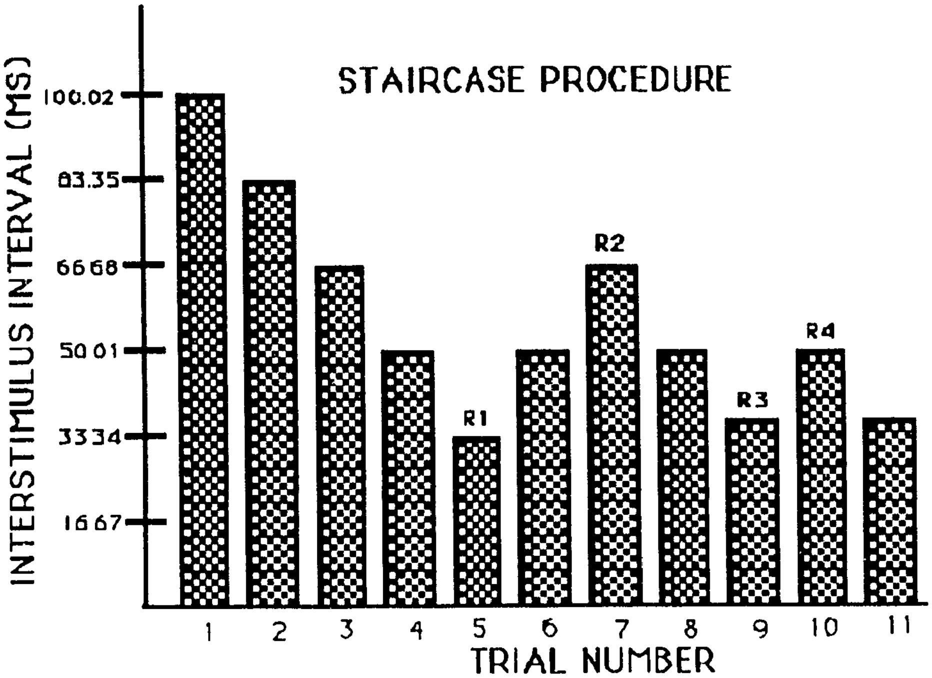

Figure 5. Interstimulus intervals as a function of trials. Reversals occur on trials 5, 7, 9 and 10.

In order to assess the subjective threshold for each word and non-word, ten such reversals were obtained. A number of procedures were adopted to ensure that stimuli were below the level of awareness. First rather than having half the staircases start at ISIs that would render stimuli below awareness, all staircases were initiated at long ISI's and systematically decreased. Secondly, rather than taking the average of all reversals as being the true threshold value, subthreshold stimuli were associated with the shortest ISIs at which a confident to guessing reversal occurred in the staircase. Thus, word-mask combinations were always associated with guessing responses and never with confident responses.

The ISI values obtained from this staircase procedure were then used to present the colour words below the level of awareness in the Stroop test. In order to maintain 25% and 75% congruent trial probabilities, the non - words were not used in the Stroop test.

Stroop Task; 25% Congruent Trial Probability In the Stroop task after the button was pressed a 250 ms delay was followed by a 250 ms presentation of the forward mask which was followed by a 33.4 ms blank field. Following the blank field one of the prime words (RED, GREEN, BLUE or YELLOW) was presented, followed by, an ISI of variable duration, a backward mask of 50 ms duration, followed by a second blank field of variable duration, followed by the onset of a colour patch which remained on until the subject named out loud the hue of this patch The display and timing for the Stroop test is depicted in Figure 4 The duration of the second blank field was fixed so that there was a constant 300 ms delay between the offset of the word and the onset of the colour patch Subjects were instructed to name as quickly as possible the physical colour of the patch while maintaining accuracy. Thus, on a given trial the word could either match the colour to be named (congruent trials) or be incompatible with the colour patch (incongruent trials) In the first session subjects were presented blocks of 32 trials, in which only 8 out of the 32 trials (25%) were congruent. Following the procedure of Cheesman and Merikle, subjects were presented with two practice blocks, in which the ISI between word and mask was fixed at 200 ms (Suprathreshold trials). Such a procedure was designed to allow subjects to become familiar with the congruent trial probability of 25%. A third practice block ensued on which both suprathreshold trials (ISI = 200 ms), and subthreshold trials (in which the ISI associated only with guesses in the staircase procedure), were randomly intermixed. Subjects were then presented with nine experimental blocks of 32 trials, where the computer recorded the reaction times for naming of congruent suprathreshold, congruent subthreshold, incongruent suprathreshold, and incongruent subthreshold stimuli. Trials on which errors were made were recorded and presented again at the end of each block Reaction times under 150 ms or over 1000 ms were automatically considered as errors in order to normalize the distribution of reaction time data At the end of each block subjects were given their average reaction time and asked to try and beat their own score on subsequent blocks Subjects would then initiate via a button press the beginning of a new block after a brief rest period. The first portion of the experiment was terminated after the completion of the nine experimental blocks

Stroop Task, 75% Congruent Trial Probability The following day, or later that week, subjects returned to the testing room and were administered the Stroop task with a congruent trial probability of 75% Thus, on 24 out of 32 trials the prime word accurately predicted what colour was to be named Once again the first two practice blocks consisted only of suprathreshold trials in order to allow subjects to establish an appropriate strategy for this increase in the predictive efficacy of the priming word A third practice block consisted of a random mixture of 16 suprathreshold and 16 subthreshold trials ensued, followed by nine experimental blocks of 32 trials, during which the reaction time for each stimulus combination was recorded

Forced Choice Decision Task. Upon completion of the 75% congruent trial probability condition, subjects were required to complete an eight-alternative, forced-choice decision task. Words and non-words were presented using the staircase-determined ISI's associated with subthreshold stimulus presentations, and subjects were required to press an appropriately labelled button which matched the word or non - word presented. Six, 32 trial blocks of these subthreshold presentations were administered. This procedure was designed to ascertain the percentage of correct responses associated with the words presented below the subjective level of awareness. Following the administration of the forced choice procedure, subjects were debriefed and paid $12.00 for their time and effort. (For a verbatim transcript of the instructions to subjects see Appendix D).

Results

Because there were eight (four word, four non-word) stimuli in the initial familiarization task, chance performance was equated with 12.5% accuracy. All subjects performed well in excess of chance - ranging from 28% to 96.9% correct detection

The staircase determined ISI's corresponding to awareness thresholds ranged from 16.67 to 166.7 ms, with an average ISI of 62.1 ms. No significant differences were found between the four (RED, GREEN, BLUE and YELLOW) prime words.

In order to assess whether subjects who differed in terms of hypnotizability also differed in terms of automaticity, a median split of hypnotizability scores was used to divide the 10 subjects into high (n = 5) and low (n = 5) hypnotic susceptibility groups. No significant differences were found between hypnotizability groups performance in the familiarization task, the staircase procedure, or the eight-alternative, forced-choice procedure.

The Stroop data for high and low hypnotizables were analyzed using a two (high and low hypnotizability) by two (suprathreshold and subthreshold) by two (25% and 75% congruent trial probability) by two (congruent vs incongruent) analysis of variance. The relevant means and standard deviations for this analysis appear in Table 2, and the source table for this analysis appears in Appendix E. This analysis revealed the same threshold by word colour relation by congruent trial probability interaction ($F(1,8) = 12.769$, $p<.01$) that was obtained by Cheesman & Merikle. Figure 6 indicates that this interaction is due to a smaller amount of congruent trial facilitation on subthreshold compared to suprathreshold trials.

In addition, a hypnotizability by threshold by word-colour relation interaction ($F(1,8)= 7.983$, $p <.03$) was found. This interaction indicates that when colour words are clearly visible, high hypnotizable subjects show greater discrepancies than lows between congruent and incongruent trials for both 25% and 75% congruent trial probabilities. This interaction is depicted in Figure 6. Because subjects made errors on less than 1% of the trials the error data were not analyzed because of this severe restriction in range

The eight alternative forced choice decision task yielded a range of 19.4% to 89.4%. There were no significant differences involving hypnotizability in this task ($F(1,8)= .026$, $p> .1$)

Discussion

In terms of the strategy hypothesis derived from the results of the Sheehan et al. (1988) study, the current investigation revealed that relative to lows, highs did not show the disproportionate increase in incongruent trial reaction times in the 75% condition an outcom, which if obtained would have been indicative of greater use of performance optimization strategies. This finding (statistically reflected by the absence of any interactions

Table 2

Mean Reaction times (in ms) for high and low hypnotizable subjects as a function of word - colour relation, congruent trial probability, and stimulus visibility.

	Highs			
	Suprathreshold		Subthreshold	
Congruent Trial Probability	25%	75%	25%	75%
Incongruent	**561.00**	**554.00**	**540.00**	**531.00**
	(34.50)	(39.96)	(38.47)	(35.92)
Congruent	**494.39**	**420.79**	**504.39**	**452.00**
	(28.23)	(73.85)	(37.77)	(46.56)

	Lows			
	Suprathreshold		Subthreshold	
Congruent Trial Probability	25%	75%	25%	75%
Incongruent	**499.00**	**486.00**	**488.20**	**482.2**
	(39.03)	(25.81)	(40.92)	(14.13)
Congruent	**496.79**	**392.79**	**475.60**	**421.6**
	(50.19)	(69.21)	(45.65)	(46.65)

Note. Mean reaction times (in ms) are in boldface type; standard deviations are in standard type.

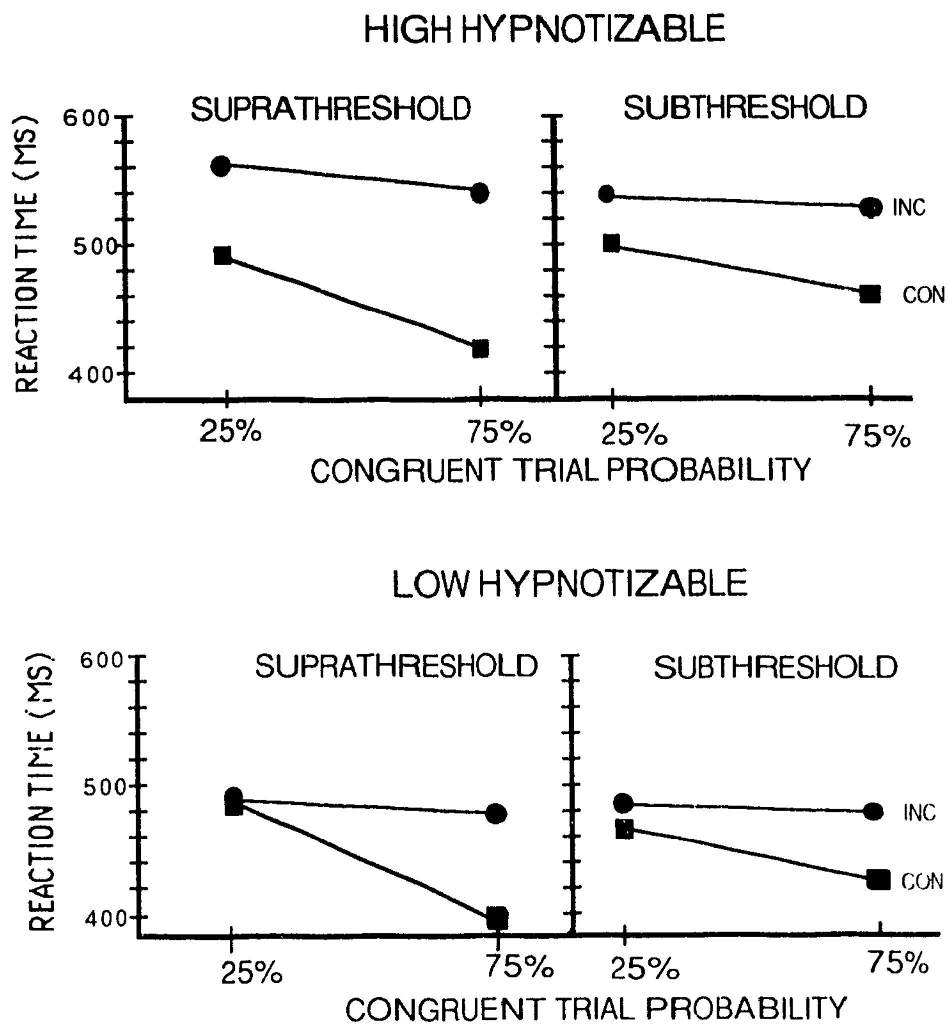

Figure 6. Reaction times for high and low hypnotizables as a function of word-colour relation, congruent trial probability and stimulus visibility.

involving both hypnotizability and congruent trial probability) indicated that highs did not differ from lows in terms of the strategies that they adopted in attempting to maximize their colour naming performance.

The failure to find a positive slope in incongruent trials when congruent trial probability was increased from 25% to 75% in the suprathreshold condition, however, calls into question whether subjects actually made use of the performance optimization strategies in the 75% suprathreshold condition. To reiterate, along with congruent trial facilitation when moving from the 25% to the 75% conditions, the increase in incongruent trial naming in the suprathreshold 75% condition would be a clear indicator that subjects have consciously adopted a strategy designed to improve their overall reaction time performance. It can be argued, therefore, that because of the absence of such strategy effects (at least for incongruent trials) the current investigation failed to provide an adequate test of the hypothesis that highs are more likely to adopt performance optimization strategies than their low hypnotizable counterparts.

Differences in the current study and that of Cheesman and Merikle may account for the failure of subjects to uniformly adopt such performance optimization strategies. Before undertaking the colour naming task in Cheesman and Merikle's experiment, subjects were told the congruent trial probability associated with that particular session. In the current study this information was intentionally omitted to see if subjects would consciously adopt the appropriate strategy based on encountering these probabilities in the practice sessions presented prior to the actual experimental trials. The suprathreshold results of the present study indicate that when left to decide their own strategies, subjects failed to consciously adopt strategies appropriate to the particular congruent trial probability. Such a finding may have occurred because, following Cheesman and Merikle's methodology, suprathreshold and subthreshold trials were intermixed after the second practice block. It is, therefore, difficult to establish whether the participants in this study subjectively interpreted the congruent trial probability as being 75%. The problem is that subjects are required to maintain a strategy based on the fact that three times out of four the word predicts the colour, yet on half of the trials in each block (the subthreshold trials) subjects were not supposed to be aware of the identity of the prime word. Thus, the current study's failure to obtain Cheesman and Merikle's positive slope for incongruent suprathreshold trials indicates that not specifically telling subjects the congruent trial probability, and presenting a mixture of subthreshold and suprathreshold stimuli, may have prevented some subjects from adopting a predictive strategy based on congruent trial probability. Such a finding suggests that in subsequent studies, suprathreshold and subthreshold trials should be presented separately and subjects should be told what congruent trial probability to expect prior to testing.

Although the failure of highs to outperform lows in terms of correct identifications of words and non-words in the forced choice procedure would seem to run contrary to the hypothesis that high hypnotizables can process more information below awareness, there is some question as to whether the stimuli used in both the forced choice decision task and in the subthreshold condition of the Stroop task were actually below awareness.

In the eight-alternative, forced-choice decision task the performance of some subjects was surprisingly high (one subject correctly identified 95% of the words and non-words). Upon questioning subjects about whether they could confidently identify stimuli that were purported to be below awareness, it was clear that at least for some subjects these subthreshold trials could be confidently identified. Thus, the staircase determined thresholds obtained at the beginning of the experiment did not correspond to the subject's subjective thresholds at the end of the experiment. This inconsistency can probably be attributed to the practice effect inherent in presenting over 288 experimental trials. In PDP terms, the large number of exposures to colour words may be viewed as training (Cohen, et al., 1988), which would serve to increase connection strengths along verbal and colour naming pathways. Increasing verbal connection strengths through multiple exposures to colour words results in a situation where more severe masking would be required to disrupt confident identifications at the end of the experiment relative to the masking required prior to such training (at the beginning of the experiment).

In addition to the practice effect contributing to inadequate subthreshold presentations in the forced choice procedure, it can be postulated that the inclusion of non-word stimuli in the original staircases may have allowed subjects to confidently identify subthreshold colour words in the Stroop task. While non-words were presented in the threshold setting task (in order to avoid subjects basing their decision on single letters), non-words were not presented in the actual Stroop task. Thus, if a subject saw the letter B in the Stroop task they could be sure the colour word was blue, and possibly use this information to implement the strategy appropriate to the 75% congruent trial probability condition. Such a situation could account for the relative decrease in subthreshold congruent trial colour naming performance as congruent trial probability was increased from 25% to 75%.

Thus, while Cheesman and Merikle's findings are difficult to interpret because of a liberal criterion setting procedure, the subthreshold findings of the present study are difficult to interpret because of the combination of the practice effect and the inclusion of non-words in the staircase procedure. In a subsequent study presented below, this problem was rectified by lengthening the staircase procedure to include 20 instead of 10 reversals, omitting non-words, and by administering the staircase procedure prior to Stroop trials on the second as well as the first day's testing.

While highs did not differ from lows in terms of strategy use or subthreshold processing, the significant difference between high and low hypnotizables in the magnitude of the Stroop effect when colour words were clearly visible indicates that highs and lows did differ in terms of automaticity. Figure 6 indicates that while incongruent trial reaction times were similar for highs and lows when the words were severely degraded (i.e. subthreshold), for suprathreshold trials, these reaction times were much longer for the high hypnotizable subjects. Such automaticity differences between highs and lows are most salient in the suprathreshold 25% "pure automaticity" condition, where highs show relatively large differences between congruent and incongruent reaction times while lows show no discernible differences between these conditions.

Figure 6 reveals that the discrepancies between congruent and incongruent trials for 25% suprathreshold trials in the present study are smaller than the Stroop effects that were obtained in both Cheesman and Merikle's experiment, or in Experiment 1 of the current series of investigations. This reduction in the Stroop effect is most likely attributable to the presence of the forward mask, and the masking properties of the energy equating vertical bars surrounding the colour words. Thus, although lows in the present experiment, showed no discernible differences between congruent and incongruent trials in the suprathreshold condition, this does not mean that they do not process words automatically. Rather, the absence of significant suprathreshold Stroop effects was probably due to the combination of a relatively weak signal at input (due to the aforementioned masking), and relatively low connection strengths along verbal pathways. It can be postulated that for highs this weak input signal was offset by the presence of strong verbal connection strengths, resulting in significant Stroop effects[8].

Thus, while Experiment 2 partially supports the findings of Experiment 1, at least in terms of automaticity, it failed to eliminate below awareness strategy effects, despite using a superior, (albeit imperfect) threshold setting procedure. It also failed to evoke the positive slope for incongruent suprathreshold trials indicative of subjects adopting performance optimization strategies. Before making extensive interpretations of these findings, however, it must be remembered that these data were based on only five high and five low susceptible subjects. Because of such small numbers, and because of the potential importance of these findings, an attempt to replicate this study with a larger sample should be made before drawing firm conclusions based on this data. The purpose of the third experiment was to replicate Cheesman and Merikle's 1986 paradigm using the improvements suggested by Experiment 1. In doing so it was hoped that the hypnotizability and automaticity relation found both in this pilot study and in Experiment 1 could be replicated, the hypothesis that highs can process more information

[8] Such discrepancies in the automaticity with which subjects of differing hypnotizability process information causes problems when the hypnotizability dimension is temporarily ignored and Experiment 2 is evaluated as a replication of Cheesman and Merikle. When subjects are collapsed across hypnotizability groups the present study fails to obtain significant differences between congruent and incongruent trials in the 25% congruent trial probability conditions. This finding is most likely attributable to the combining of high hypnotizables with lows who fail to show automaticity effects when strategy dictated that the prime should be ignored. That is, when lows are combined with highs who show a great deal of automaticity, a large amount of within cell variance results, precluding significant differences between congruent and incongruent trials. Such a finding suggests that in order to adequately replicate the work of Cheesman and Merikle, a group of medium hypnotizables must be included in the study to offset the lack of automaticity displayed by lows.

below awareness could be tested, and a better test of the hypothesis that highs and lows differ in terms of strategy could be provided.

Experiment 3

Method

Subjects

Twenty - seven subjects were categorized into three hypnosis categories. The subjects were initially screened on the HGSHS:A, and all but one were subsequently classified for hypnotic susceptibility using the SHSS:C. This one subject did not wish to be tested on the SHSS:C, but having scored 10 with amnesia on the HGSHS:A was included among the highs. The majority of these subjects had undergone hypnotizability screening for other experiments directly involving hypnosis that were previously conducted in this laboratory. Subjects scoring between 8 with amnesia[9] and 12 were considered highly susceptible (n = 9), subjects between 5 and 8 without amnesia were considered medium susceptible, and those who scored between 0 and 4 were considered to be subjects of low susceptibility. All subjects were undergraduate or graduate students attending Concordia University. These subjects were contacted by phone and asked to participate in a study conducted by the Concordia Cognition Laboratory. In describing the purpose of the reaction time study, no mention was made of possible links with hypnosis.

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[9] Since many researchers consider hynotically induced amnesia as being the hallmark of high hypnotizability, (Wallace, 1990) the presence or absence of amnesia was used to assign those subjects (four) who passed a total of eight items as being highly or only moderately susceptible subjects.

Stimuli.

Stimuli were identical to the first experiment, with the following exceptions. The four non-words YOLLEW, ERD, BUEL and GENER were not used in this second experiment. Also, letters of the prime words, and symbols comprising the masking stimuli, were presented as black letters on a white background. This alteration circumvented possible ceiling effects due to the limitations of the masking abilities of the colour monitor. Using a standard raster monitor such as the one employed in this study, ISI durations could only be varied in steps of 16.67 ms. In the first experiment one subject with exceptional temporal resolution had to be eliminated because he indicated that he could confidently detect the prime, even when masking (ISI = 16.67 ms) was most severe. By presenting black stimuli on a white background temporal resolution was reduced, thereby making masking at a given ISI more effective. In order to informally test the efficacy of this alteration the subject with the above average temporal resolving capabilities was retested, and as predicted, could not confidently identify any of the primes when they were presented at the smallest possible ISI.

Procedure.

To minimize the possibility of demand characteristics systematically influencing the performance of subjects, the experimenter responsible for administering the Stroop test and related tasks was blind to the hypnotic susceptibility level of subjects. Upon entering the laboratory subjects underwent a practice session designed to familiarize them with the prime words and masking stimuli, and to ensure that there were no ocular problems that prevented them from seeing the stimuli. In this session, subjects initiated trials via a button press. After a 250 ms delay a 250 ms forward mask was presented followed by blank field for 33.4 ms. Next, one of the four randomly selected prime words were presented for 16.7 msec. Following a 250 ms ISI, the pattern mask appeared for 50 msec. These temporal parameters allowed the stimuli to be clearly visible. Subjects were required to indicate by pushing an appropriately labelled button which of the words had been presented. Two practice blocks of 32 such trials (eight presentations of each word) were administered followed by a third, 32 trial, block where correct identification performance was recorded by the computer. In order to qualify for further testing subjects had to obtain at least 75% accuracy on this task.

The threshold setting procedure was similar to the staircase procedure used in Experiment 1, except that the number of reversals for each word was increased to 20, and the non-words were omitted.

25% Congruent Trial Probability Trials. Following the staircase procedure, subjects were explicitly told that in the ensuing Stroop presentations, the word, although difficult to see, would predict the colour only one time out of four, and that the best strategy was therefore to ignore the word and to concentrate on naming the color as quickly as possible. Subjects were then presented with the five blocks of 32 trials. Each of these 32 trial blocks contained 8 congruent trials (two presentations of each congruent word - colour pairs) and 24 incongruent trials (two presentations of each unique incongruent word - colour pairing). All stimuli were presented in random order, with the constraint that no two successive physical colours followed one another. All stimuli were presented using the staircase determined ISI's, which corresponded with the subjective threshold (the lowest ISI obtained for each word that corresponded only to guessing and never to confident responses). As before the second blank field (shown in Figure 4) was adjusted so that for all subthreshold trials a constant 300 ms delay occured between the offset of the word and the onset of the colour patch. The first of these five blocks served as a practice session to familiarize the subject with the procedure. The computer recorded reaction times for each trial of the remaining four, 32 trial blocks. Throughout the colour naming test, trials on which errors were made were recorded and presented again at the end of each block. Reaction times below 150 ms were immediately considered errors.

Upon completing these subthreshold trials, subjects were given the same instructions as above, except that subjects were now told that the prime words would be clearly visible. All trials in this condition were presented using a 250 ms ISI between the offset of the prime word and onset of the colour word. Subjects were then informed that this completed the first day's testing and that they could not receive feedback until completing the second session.

75% Congruent Trial Probability Trials. The following day, or later that week, subjects returned to the laboratory, whereupon their subjective thresholds for the four colour words were reassessed using the staircase procedure. Immediately following the staircase procedure, subjects were given the same set of instructions as the 25% subthreshold condition, except that they were informed that the word would now match the colour three times out of four, and that the best strategy was to use the word (if they could) to predict the colour and thereby improve their reaction time performance. Subjects were presented with five, 32 trial blocks, each block consisting of 24 congruent trials (six repetitions of each colour word pair) and 8 incongruent trials. Since there were 12 possible word colour combinations making up an incongruent trial, the 4 combinations that were not used in a particular block were programmed to appear in the subsequent block. Once again the first block was used as practice, and all presentations were random with the constraint that no two identical colour patches followed one another.

Upon completion of the subthreshold trials, subjects were told that now the prime words would be visible, and once again the best strategy was to use the word to predict the colour and thereby improve reaction time performance. This set of blocks was similar to the below threshold trials, with the exception that all trials used a 200 msec ISI between word and mask, rendering all prime words clearly visible.

Forced choice decision task. After completing the 75% suprathreshold trials, subjects were required to complete a four-alternative, forced-choice decision task. Subjects were required to press an appropriately labelled button which matched the word presented. This procedure was designed to ascertain the percentage of correct responses associated with words presented below the subjective level of awareness. Five blocks of 24 trials were presented, with each word presented six times per block. Twelve of these trials contained words presented below the staircase determined subjective threshold, the other twelve presented words with ISIs that were 16.67 ms longer than that subjects most degraded trial. Presenting half of the trials slightly above threshold provided subjects with a more interesting task than one in which they felt they were consistently guessing. The computer randomized the order of presentation prior to each block. Upon completion of the four alternative forced choice procedure subjects were debriefed as to the purpose of the experiment and paid $12.00 for their time and effort. (A verbatim transcript of the instructions to subjects appears in Appendix F).

Results

On the initial screening and familiarization procedure subjects correctly identified a mean of 94.31 % of the stimuli. No significant differences among hypnotizability groups were noted on this variable ($F(2,24) = 1.33$ $p > .1$). Members of different hypnotic susceptibility categories did not differ in terms of their subjective thresholds ($F(2,24) = .48$ $p > .1$), nor was there a significant difference between the first days threshold assessments and the second day's threshold assessments ($F(1,24) = .07$ $p > .1$).

Before analyzing the reaction time data the means and standard deviations were calculated for each subject for each condition. In order to eliminate outliers that could disproportionably influence these means, reaction times that were three standard deviations away from the subject's mean for that condition were discarded, and new means were recalculated. These data were analyzed using a 3 X 2 X 2 X 2 analysis of variance with hypnotizability as the between subjects factor, and word-colour relation, congruent trial probability, and threshold as within subjects factors. The relevant means for this analysis are presented in Table 3, and the source table for this analysis is presented in Appendix G. In terms of the specific hypotheses previously mentioned, this analysis revealed the same significant threshold by word-colour relation by congruent trial probability interaction ($F(1,24) = 39.831$, $p < 001$) as was obtained in Experiment 2 and in the experiment of Cheesman and Merikle. Theoretically important differences between cell means were evaluated using simple simple main effects analyses (Howell, 1982). These analyses revealed a significant difference between congruent and incongruent trials for suprathreshold ($F(1,26) = 8.78$, $p < .01$), but not for subthreshold ($F(1, 26) = 1.43$, $p > 1$) trials in the 25% congruent trial probability condition. At 75%, however, these effects were significant for subthreshold stimuli ($F(1,26) = 12.25$, $p <.01$). The simple-simple main effects of congruent trial probability revealed significantly slower reaction times for suprathreshold incongruent trials at 75% compared to 25% ($F(1,26) = 8.22$, $p <.01$), while for subthreshold incongruent trials, 75% trials were significantly faster than 25% trials ($F(1,26) = 8.77$, $p < .01$). For congruent trials, both subthreshold and suprathreshold conditions benefited significantly from the 75% compared to the 25% condition (smallest $F=34.99$, $p < .01$).

Table 3.

Mean Reaction times (in ms) for high, medium and low hypnotizable subjects as a function of word - colour relation, congruent trial probability, and stimulus visibility.

	Highs			
	Suprathreshold		Subthreshold	
congruent trial probability	25%	75%	25%	75%
Incongruent	**505.77**	**532.11**	**497.44**	**484.22**
	(39.40)	(56.77)	(40.23)	(44 7)
Congruent	**465.77**	**383.33**	**479.77**	**444.22**
	(44.34)	(34.48)	(45.69)	(44 78)
	Mediums			
	Suprathreshold		Subthreshold	
congruent trial probability	25%	75%	25%	75%
Incongruent	**548.22**	**556.33**	**526.55**	**508.77**
	(63.13)	(59.19)	(55.07)	(42.60)
Congruent	**527.77**	**445.55**	**523.33**	**483.00**
	(64.26)	(56.53)	(46.36)	(48.95)
	Lows			
	Suprathreshold		Subthreshold	
congruent trial probability	25%	75%	25%	75%
Incongruent	**489.55**	**506.11**	**479.00**	**461.77**
	(72.94)	(68.73)	(65.96)	(62.56)
Congruent	**482.44**	**420.11**	**477.33**	**447.77**
	(68.74)	(70.09)	(62.54)	(68.00)

Note. Mean reaction times (in ms) are in boldface; standard deviations are in standard type.

This analysis also revealed a significant interaction involving hypnotizability and word - colour relation ($F(2,24) = 4.765$, $p < .02$). By looking at the reaction times of the three hypnotizability groups depicted in Figure 7, it is evident that this interaction is caused by highs showing greater discrepancies between congruent and incongruent trials than either their medium or low hypnotizable counterparts. In order to see if the 25% suprathreshold findings of Experiment 2 would replicate, simple simple main effects analyses were conducted to compare the performance of highs, mediums and lows on congruent and incongruent trials. These analyses revealed significant differences between congruent and incongruent means ($F(1,24) = 10.24$, $p < .01$) for highs but not for mediums ($F(1,24) = 2.67$, $p > .05$) or lows ($F(1,24) =.32$, $p>.1$). Interestingly, for subthreshold trials, only the highs in the 75% condition showed significant differences between congruent and incongruent trials.

In terms of the strategy hypothesis the four way interaction involving hypnotizability, congruent trial probability, word-colour relation and threshold was not significant [$F(2,24) = .304$, n.s), nor were any of the interactions involving both hypnotizability and congruent trial probability (highest $F=1.059$, n.s).

Finally, no differences were found between highs, mediums and lows on the four alternative forced choice procedure. All three groups performed well in excess of chance (25%), but there were no differences between highs (61%), mediums (60%) and lows (56%).

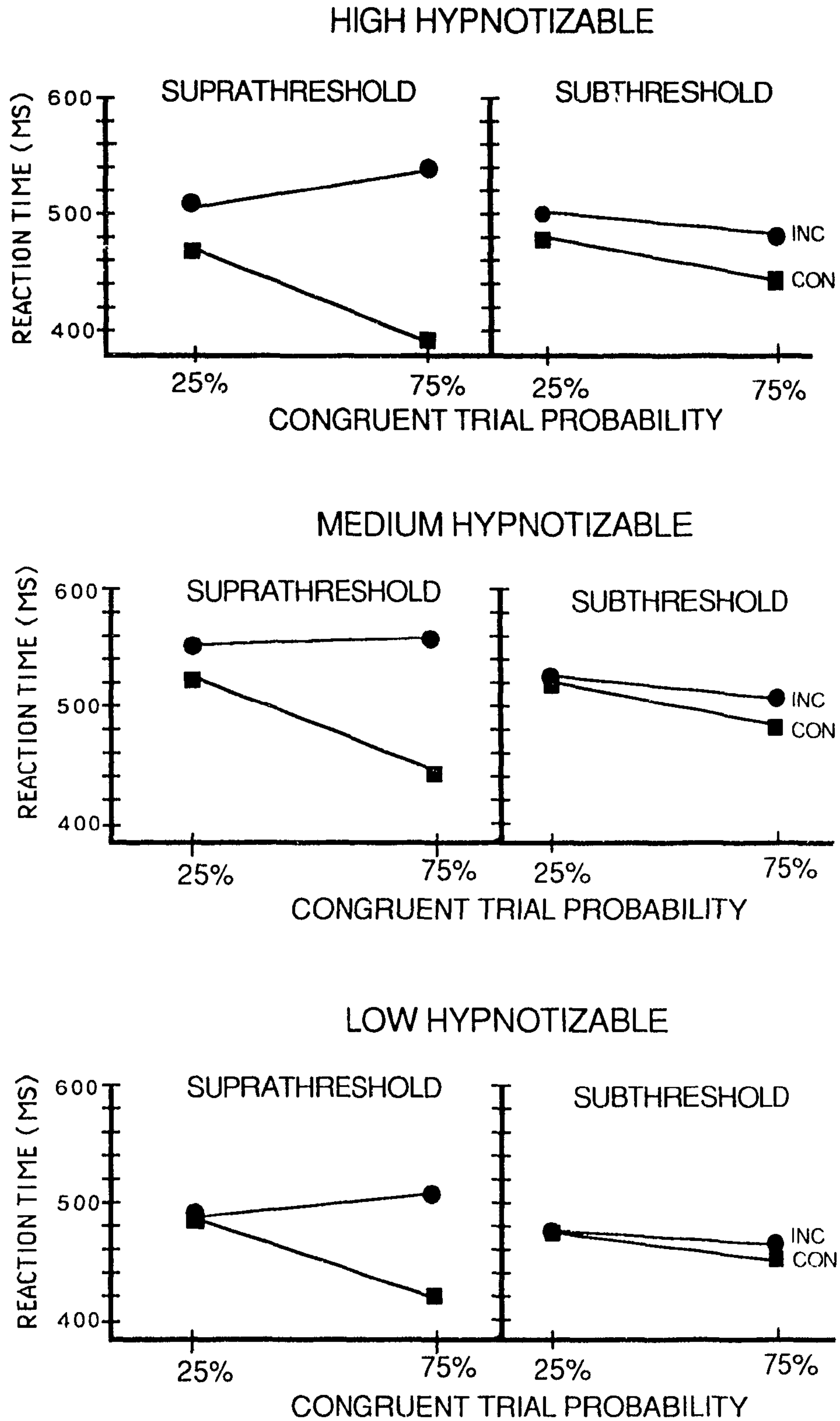

Figure 7. Reaction time as a function of hypnotizability, threshold, congruent trial probability and word-colour relation

Discussion

The primary purpose of this experiment was to expand the work of Cheesman and Merikle (1986) by including a hypnotizability dimension so that three specific hypotheses could be tested. One hypothesis stated that relative to lows, subjects of high hypnotic susceptibility would make greater use of strategies designed to optimize performance within a Stroop type task. A second hypothesis predicted that relative to their low hypnotizable counterparts, highs would be able to process more information presented below the subjective threshold of awareness. The third hypothesis stated that people who differ in hypnotic susceptibility also differ in the automaticity with which they perform the Stroop colour naming task. Specifically, it was predicted that highs, because of greater verbal connection strengths, would show more verbal automaticity (as reflected by larger differences between congruent and incongruent trials) than low hypnotizable subjects.

Consider first the strategy hypothesis. If, as the results of Sheehan et al., (1988) suggest, high hypnotizables were better able to make use of performance optimization strategies than low hypnotizables then, relative to lows, highs should show greater discrepancies between congruent and incongruent trials in the 75% suprathreshold trials (See appendix A simulation 5). The most rigourous statistical test of this hypothesis would be a four-way interaction involving hypnotizability, threshold level, word-colour relation and congruent trial probability. The failure of Experiment 3 to show this interaction, or indeed any significant interactions involving hypnotizability and congruent trial probability, indicates that subjects of differing hypnotizability levels did not show differences involving the implementation of performance optimization strategies.

In reconciling the failure to show hypnotizability related strategic differences in the present study with the positive findings of Sheehan, et al.

(1988), it is useful to look at the differences between the types of strategies that were offered to subjects in the two studies. In the present task the instructions to use the word to predict the colour involved a relatively complex strategy in which lexical information was processed. As previously mentioned, in parallel distributed processing terms, such a strategy would involve two task demand units operating in parallel – one sensitizing the colour naming pathway, and the other sensitizing (to a lesser degree) the word naming pathway.

In the study of Sheehan et al., subjects were instructed to focus on the bottom corner of the last letter of the word – a situation which would merely make word reading more difficult. In parallel distributed processing terms, looking at one corner of the last letter of the word would serve to reduce the activation value of input units along the verbal pathway without affecting the units of color naming pathways. Thus, the two strategies differ in both complexity, and the direction of their predicted effects – with the parafoveal viewing strategy reducing interference, and the lexical strategy actually serving to increase interference effects. When such differences are combined with the effects of automaticity, a possible explanation emerges concerning why significant differences in strategy use were noted in the Sheehan et al. study, but not in the current investigation. In the former study, highs in hypnosis were shown to be extremely prone to interference effects; a situation which can be attributed to relatively greater connection strengths along the verbal pathways. As such, a strategy which would serve to weaken verbal signals at the level of input would have greater ramifications for the data of high hypnotizable subjects, who displayed greater interference effects That is, highs would have much more room to show improvements in their performance than their low hypnotizable counterparts.

In the current study, however, highs are asked to employ a strategy which they are in effect already using because of the automatic reading of the verbal inputs. Thus, it can be argued that, because highs can't help paying attention to the word anyway, specifically telling them to pay attention to the word will not have as profound an effect on their performance as offering them a strategy which will allow them to circumvent such automaticity effects.

An alternative hypothesis pertaining to why strategy effects were found in the Sheehan et al. study, but not in the current study, is that while every effort was made to conceal the relationship between the Stroop task and hypnosis in the current investigation, the parafoveal viewing strategy (focusing on the bottom corner of the last letter) used in the Sheehan et al., study was actually given as an hypnotic suggestion. Thus, it could be postulated that highs were better able to filter out the effects of the colour words because they were in hypnosis. Whether this hypnotizability by hypnosis interaction is due to highs in hypnosis being better able to mobilize certain cognitive resources required to implement and maintain this parafoveal strategy, or whether this interaction is due to social psychological factors such as lows seeing themselves "as unable or unwilling to respond maximally to the types of suggestion associated with hypnosis" (Spanos, 1986, p. 460) is a question that would need to be empirically addressed.

Consider now the second hypothesis concerning below awareness processing. The statistical equivalence among the three hypnotizability groups in the four-alternative, forced-choice procedure fails to support the hypothesis that high hypnotizable subjects can process more information presented below awareness than mediums or lows. As was previously mentioned, however, the whole awareness-nonawareness distinction depends on the utility of the subjective threshold in defining the border between conscious and unconscious processing. This, in turn, depends on whether the subjective threshold can be empircally validated (Cheesman and Merikle, 1986). In order to evaluate the degree to which the subjective threshold was validated, the hypnotizability dimension of Experiment 3 must be temporarily ignored, and the results considered simply as a replication of Cheesman and Merikle's study with certain methodological improvements.

Cheesman and Merikle proposed that if perceptual information presented above and below the subjective threshold had a qualitatively different effects then "strong support would be provided for the claim that the subjective threshold defines the transition between two different perceptual states which may be equated with conscious and unconscious perceptual processing" (Cheesman and Merikle, 1986, p. 347). In order to fulfil this "qualitative difference criterion" Cheesman and Merikle made use of the automatic and strategic components inherent in the Stroop task. They assumed, as others had before them (Posner and Snyder, 1975; Underwood, 1982), that controlled processes involving strategy would fall within the domain of consciousness, while automaticity would be under the jurisdiction of unconscious processing. In order to validate this hypothesis and establish the subjective threshold as the boundary separating consciousness from the unconscious, they attempted to show that strategy effects in the Stroop task could only be elicited when subjects were fully aware of the verbal primes that served as Stroop stimuli. Specifically, they attempted to show that increasing the congruent trial probability would only elicit increases in the Stroop effects (indicative of the adoption of performance optimization strategies) when words were presented above the subjective threshold. In contrast to such suprathreshold presentations, they predicted that "no evidence for strategy effects should be found when primes are presented below the awareness threshold" (p. 50).

Their claim was supported in two separate experiments in which subjects showed increases in Stroop effects (faster congruent reaction times and slower incongruent reaction times) when congruent trial probability was increased from 33% to 66% for suprathreshold trials, but not for subthreshold trials. In a third experiment that used more extreme congruent trial probabilities, however, a planned comparison indicated that subthreshold reaction times for congruent trials were significantly faster in the 75% congruent trial probability condition than in the 25% congruent trial probability condition. Thus, contrary to their theoretical position, significant strategy effects were obtained, at least for congruent trials

It was postulated prior to experiments two and three of the current series of investigations that this finding might be attributable to Cheesman and Merikle's use of a somewhat liberal threshold setting procedure for in their third experiment, a possible eight percent of the stimuli that were supposed to be below awareness could be confidently identified by subjects Thus, in both Experiment 2 and Experiment 3 of the current series, an attempt was made to see if these strategy effects could be eliminated by improving Cheesman and Merikle's methodology. One such methodological improvement involved using the staircase procedure rather than the method of limits to assess the subjective thresholds of subjects. Such a psychophysical procedure also had the advantage of removing the previously discussed memory confound inherent in Cheesman and Merikle's study. Other improvements concerned equating the stimulus energy of the prime words by having sets of vertical bars surrounding each of the prime words. This manipulation ensured that confidence/guessing decisions were made on the basis of semantic rather than physical properties such as word length

Despite all of these alterations, a significant simple interaction effect for subthreshold trials was obtained in Experiment 3 The subthreshold trials depicted in Figure 7, indicate that this interaction was caused by relatively greater improvements in reaction time for congruent as opposed to incongruent trials when probabilities are increased from 25% to 75%. This finding replicates the planned comparison of Cheesman and Merikle and leads to the conclusion that contrary to their theory (yet consistent with their actual data), subjects show strategy effects for subthreshold congruent trials.

Such a finding has important ramifications concerning Cheesman and Merikle's approach to distinguishing conscious from unconscious processing. According to their qualitative difference criterion, presenting words above and below the subjective threshold should affect behaviour in qualitatively different ways; yet the congruent trial facilitation noted in both Cheesman and Merikle's study and in the present investigation indicates that strategic effects can be elicited in both suprathreshold and subthreshold presentations. In attempting to account for their unpredicted subthreshold congruent trial facilitation, Cheesman and Merikle chose to de-emphasize such strategic benefits, and focused on the performance of subjects on incongruent trials. They noted that while suprathreshold trials evoke a positive slope for incongruent trials when going from 25% to 75% conditions, this slope was absent in the subthreshold trials. For Cheesman and Merikle, this "benefit without cost" (Cheesman and Merikle, 1986, p. 366) for subthreshold trials was enough to fulfil their qualitative difference criterion.

Although a more conservative interpretation of this qualitative difference criterion would suggest that **any** evidence of strategic effects would violate the qualitative difference criterion, the subthreshold results of Experiment 3 suggest that Cheesman and Merikle's subthreshold data show strategic effects for both congruent **and** incongruent trials. Such a postulate is confirmed by the presence of a significant practice effect in the current investigation, and the absence of such an effect in the Cheesman and Merikle study. In the present study, such a practice effect was attested to by the decrease in subthreshold incongruent trials as congruent trial probability was increased from 25% to 75%. This decrease in subthreshold incongruent reaction time is illustrated in the subthreshold trials of Figure 7.

In the present study, the first day's testing involved assessing subject's reaction times for suprathreshold and subthreshold trials presented using a 25% congruent trial probability. Reaction times for the 75% condition were recorded on the second day. What is interesting is not the presence of a practice effect over testing days in the present study, but rather the absence of a practice effect in the study of Cheesman and Merikle, who also tested all the 25% condition trials on day one and all the 75% condition trials on day two This absence of a practice effect is illustrated by the flat line joining the 25% and 75% incongruent conditions noted in panel B of Figure 3.

One possible explanation for this absence of a practice effect is the somewhat liberal threshold setting procedure employed by Cheesman and Merikle. By considering a possible eight percent of trials that could confidently be identified subthreshold, Cheesman and Merikle may have introduced strategic effects into their subthreshold incongruent trial naming task. Since, for incongruent trials the effect of strategy is to induce a positive slope when congruent trial probability is increased from 25% to 75%, and the practice effect serves to induce a negative slope from day 1 (25%) to day 2 (75%), it can be postulated that these two opposing processes cancelled each other out, resulting in the flat line for incongruent trials In the present study, however, since the ISI's used for subthreshold stimuli were associated only with guessing responses and never with confident identifications, incongruent strategic effects were minimized, leaving the negative slope indicative of the practice effect intact.

Thus, the data of the current experiment and the data of Cheesman and Merikle may be thought of as lying along a continuum from complete awareness to non-awareness. Cheesman and Merikle's suprathreshold presentations would be placed in the upper extreme, and the present study's suprathreshold presentations placed at a lower level (because of the masking properties of the energy equating bars bounding the colour words). At the next level would appear Cheesman and Merikle's subthreshold stimuli which, in light of the practice effect findings of the current study, can be interpreted as displaying strategy effects for both congruent and incongruent trials. Appearing at the bottom level would be the present studies subthreshold data which, by using a more conservative threshold setting procedure, minimized incongruent trial strategy effects, leaving only strategic facilitation for congruent trials.

By looking at the trend towards decreasing strategy effects as one moves down this continuum, it would seem that there might be a point at which strategy effects could be eliminated altogether, leaving only the resident automaticity effects intact. It could be argued that the relatively large step sizes of 16.67 ms used in determining masking severity in both the current study and that of Cheesman and Merikle may not have been sensitive enough to finda point on the continuum where subthreshold strategy effects could be completely partialled from automaticity differences. Initially this argument may appear unrealistic, because in the current investigation congruent subthreshold strategy effects were noted in the 75% condition despite the fact that masking was so extreme that it eliminated significant automaticity effects in the 25% condition[10].

It should be noted, however, that the power of finding subtle differences between subthreshold congruent and incongruent trials is dramatically reduced by pooling subjects who differ significantly in the degree of automaticity with which they process language. That is, pooling subjects of high, medium and low hypnotizability may cause undue increases in within

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[10] Since only ISIs associated with guessing responses were used in Stroop procedure, in this paradigm using more sensitive step sizes would result in using ISIs that would be larger than those used in the present study (but still smaller than ISIs associated with confident responses). As such using more sensitive step sizes would serve to increase subthreshold automaticity effects but also would cause concomitant increases in the already significant subthreshold strategy effects.

cell variability, and thereby make it increasingly difficult to find a point where significant 25% and 75% automaticity differences emerge without finding significant 75% strategy effects. In sum, although neither Cheesman and Merikle's study nor the present work provides empirical validation of the subjective threshold, it is possible that future studies that combine sensitive threshold assessments with large numbers of subjects who show equivalent amounts of automatic processing, may be able to fulfil the qualitative difference criterion using the strategic and automatic components of the Stroop phenomenon

Alternatively, it can be argued that Cheesman and Merikle made a fundamental mistake in assuming that strategic processes must invariably be aligned with awareness. One study that suggests that this may not be the case was conducted by Lewicki, Czyzewska and Hoffman (1987). These authors presented subjects thousands of presentations of numbers that could appear in one of 24 locations of a computer screen These numbers were presented in blocks consisting of seven trials. The first six trials involved displaying individual numbers in the various spatial locations. On the seventh trial a complex series of numbers appeared in which a target (the number 6) was embedded. The reaction time required to detect the target on trial 7 provided the dependent measure. In this experiment the spatial location of the target could be predicted by the pattern of spatial locations of the individually presented number stimuli which preceded the appearance of the target. The thousands of 7 trial blocks were presented over a period of 48 sessions. On the 43rd session the experimenters manipulated the pattern of the six preceding stimuli so that it predicted an incorrect spatial location of the target. This manipulation led to reaction times that were significantly longer than those recorded on the preceding day. Despite showing robust changes in behaviour (increases in reaction time), subjects were unaware of the predictive information contained in the series of number locations that preceded the target. This was verified by showing subjects the six preceding number stimuli and asking them to predict the location of the target. Despite showing reaction time evidence that suggested they were adopting a strategy to maximize performance, subject's were unable to predict the location of the target at levels above chance.

Such a finding is of interest to Cheesman and Merikle's assumption that strategic processes are invariably associated with awareness, for it shows that in certain circumstances just the opposite is true -- that strategic processes can be exclusively aligned with unconscious processing and inaccessible to conscious processing. This finding is in some ways analogous to the fact that most people are capable of forming grammatically correct sentences without being aware of the actual grammatical rules that govern the structure of such sentences (Lewicki, 1986; see also Bowers, 1981 for a review of situations in which people are implicitly informed).

Such evidence suggests that while Cheesman and Merikle are to be commended for their attempt to validate the subjective threshold using the qualitative difference criterion, they may have erred in their implicit assumption that strategic processes must invariably fall within the exclusive jurisdiction of conscious awareness. As such, Cheesman and Merikle may have been correct in their postulate that the subjective threshold is the true border between conscious and the unconscious, but their attempts to validate this concept may have been thwarted by the fact that the implementation of a performance optimization strategy can occur both above and below awareness.

Whether the failure to eliminate subthreshold strategy effects is attributable to mistakingly aligning strategic effects exclusively with awareness, or is attributable to not using equipment that was adequately sensitive, the subthreshold conditions of both Cheesman and Merikle and the current series of investigations fail to empirically validate the subjective threshold as a useful concept in delineating conscious from unconscious processing. As such, these subthreshold conditions must merely be considered as degraded versions of the clearly visible suprathreshold stimuli. This important theoretical distinction precludes making definitive statements about whether high hypnotizable subjects can process more information below awareness than their low hypnotizable counterparts.

Finally consider the last of the three hypotheses addressed by this third experiment. The hypothesis that high hypnotizable subjects would process verbal information more automatically than low hypnotizable subjects was fully substantiated. It will be recalled that because automaticity effects contribute to the differences between congruent and incongruent trials in all conditions, the statistical test of this hypothesis was a significant interaction involving hypnotizability and word-colour relation. As Figure 7 indicates, the significant interaction that was obtained was due to the fact that, as predicted, highly susceptible subjects showed greater discrepancies between congruent and incongruent trials in all conditions. As in Experiment 2, these automaticity differences were most striking in the 25% suprathreshold "pure automaticity" condition where, once again, highs show significant amounts of automatic processing, while lows show minimal differences between congruent and incongruent reaction times.

General Discussion

The differences between high and low hypnotizable subjects in naming incongruent Stroop stimuli obtained in Experiment 2 and replicated in Experiment 3 can best be understood in terms of connection strength differences between input and output along the verbal pathways of high and low susceptible subjects. Specifically, it can be postulated that while the color naming pathways of highs and lows are roughly equivalent, highs show greater differences between congruent and incongruent reaction times because of greater connection strengths than lows along verbal pathways.

This contention was selected from a number of competing alternatives that can be derived from inserting different values into the connection strengths of the pathways in Figure 1. For example, it could be proposed that the obtained automaticity differences could be caused by highs and lows having equivalent verbal connection strengths but lows having higher connection strengths along the colour naming pathways than highs. Such a situation would tend to reduce the discrepancies between the verbal and colour naming connection strengths in low hypnotizables and account for their minimal discrepancies between congruent and incongruent trials. If such was the case, however, then relative to highs, lows should have shown significantly faster colour naming performance on the control trials of Experiment 1. That is, if lows have higher connection strengths along colour naming pathways, the appropriate response node should achieve its response activation threshold quite quickly, resulting in faster reaction times for lows compared to highs (see simulation 6 Appendix A) The results of Experiment 1 fail to indicate any significant differences between highs and lows on control trials Further evidence against this hypothesis comes from Blatt (1990), who showed no reaction time differences between highs and lows in naming coloured squares.

A second, and more competitive hypothesis that accounts for some, but not all of the data observed in Experiments 1 through 3 is that relative to highs, lows make superior use of the task demand units depicted in Figure 1. As was previously mentioned, in the PDP model of the Stroop phenomenon, intermediate units calculate activation values using a logistic function that ranges from zero to unity. The function of the task demand unit is to sensitize a given pathway by setting the logistic function to the most dynamic portion of its range. One scenario that could account for some of the data in the current series of investigations is that lows were able to fully activate the task demand unit responsible for sensitizing the colour naming pathway, whereas highs could only partially activate this unit. Simulation 7 in Appendix A indicates that if this were the case, then relative to highs, lows should have faster congruent, control and incongruent reaction times. Experiment 1 reveals data that adequately fit this pattern. It must be noted, however, that while lows show significantly faster incongruent reaction times, differences in the reaction times of highs and lows failed to achieve statistical significance for both congruent and control trials

While the outcome of this simulation yields surface similarities to the data obtained in experiment 1, there is little in the way of theoretical backing for such an hypothesis. Given that the task demand simulates selective attention, the hypothesis that lows are better than highs at selectively attending to specific stimuli runs contrary to the findings of Mitchell (1970), who showed that highs were more resistant to distractions in a tracking task Perhaps a more serious threat to this hypothesis can be derived from looking at the simulated outcomes of highs and lows in the Cheesman and Merikle paradigm if lows had more control over task demand units Simulation 7 in Appendix A reveals that a main effect of hypnotizability should have been noted in this experiments. The absence of this main effect in either Experiment 2 or 3 argues against the postulate that observed differences in incongruent trial naming are due to hypnotizability differences in the task demand units.

Thus, of the several available alternatives, the best explanation of the findings of the current series of investigations is that high hypnotizables show statistically longer incongruent reaction times than lows (Experiment 1) and statistically larger differences between congruent and incongruent trials (Experiment 3) because, relative to lows, they have greater connection strengths along verbal pathways.

Such a postulate can account for much of the data in previous studies involving hypnotizability differences in Stroop performance. In the study of Blum and Graef's (1971), high hypnotizable subjects showed a greater amount of interference than lows across five levels of post-hypnotically manipulated arousal. Although arousal levels were not manipulated in the current series of investigations, similar patterns of interference among highs and lows were obtained in Experiments 1 through 3. All of these findings are consistent with the notion that highs have greater connection strengths along verbal pathways than their low hypnotizable counterparts.

In Blum and Graef's study, high hypnotizable subjects showed a monotonic increase in interference as arousal level was post-hypnotically reduced from "very aroused to stuporous." Such a finding is in some ways comparable to the results of Sheehan et al. (1988), where highs showed dramatic increases in incongruent trial naming when Stroop stimuli were performed in hypnosis. It can be argued that reducing arousal levels either post-hypnotically, or merely by inducing hypnosis, is likely to decrease the diligence with which subjects attempt to ignore the colour word in Stroop trials. Such reductions in vigilance would likely exacerbate the automaticity with which the verbal stimuli are processed. In such a situation, it can be predicted that the largest effects will be found for subjects who have the largest verbal connection strengths, and who are capable of experiencing hypnosis. This combination of relatively large connection strengths and good hypnotic abilities would account for the dramatic increases in interference among the high hypnotizable subjects relative to low hypnotizables.

The verbal connection strength hypothesis also may account for the findings of the masking studies of Ingram et al. (1979), Saccuzo et al. (1982) and Acosta and Crawford (1985). Whenever single letters were used as stimuli in these studies, highs required smaller ISI values to disrupt letter identification than lows. In PDP terms, if highs have stronger verbal connection strengths than lows, then response units corresponding to these letters will reach their threshold activation levels faster than those of lows and therefore require more severe masking to disrupt this process.

Initially this hypothesis would seem at odds with the failure to obtain hypnotizability differences in the forced choice procedures of experiments 2 and 3. Such differences may be attributable to the temporal resolution capabilities of the devices that were being used to display word and masking stimuli. In the present study the severity of masking was increased or decreased in step sizes of 16.67 ms (the frame rate of the monitor). In the single letter masking studies, tachistoscopes were used, and the step sizes employed (1 ms) were much more sensitive. Thus, the failure to find hypnotizability differences in the ISIs required to disrupt word recognition must be considered of relatively minor importance compared to the twice - replicated finding of hypnotizability differences in the colour naming of incongruent Stroop trials.

The proposed verbal connection strength hypothesis not only has explanatory power for specific studies involving hypnotizability and information processing, it also may have important ramifications for the area of hypnosis in general. Specifically, the finding that highs differ in the manner in which they process information may allow researchers to choose among a number of competing theories concerning the factors that underly hypnotic susceptibility. As was previously mentioned, these schools of thought include the special process view of hypnosis, the social psychological interpretation of hypnosis, and finally a synergistic model which integrates social psychological factors with the existence of reliable individual differences in interpreting hypnotic susceptibility

Traditionally, researchers interested in disproving strictly social psychological interpretations of hypnotic susceptibility have attempted to design studies showing that reliable perceptual alterations can be induced by hypnotic suggestions. In a recent review of these studies, Jones and Flynn (1989) have concluded that there is no evidence for perceptual distortion that can be attributeable exclusively to hypnosis. According to these authors, in experiments that do show reliable perceptual alterations, subjects "strategically adjust their behavior to meet the demands of an experimenter for perceptual enhancement or degradation" (p.174).

Several factors suggest that such a "strategic adjustment" hypothesis cannot adequately explain the data of the current series of investigations. First, the results of the present series of investigations represent one of the few replicated findings concerning differences between highs and lows in an experimental situation that is actually removed from the hypnotic context. Subjects were tested under the auspices of a cognition laboratory, and no mention was made of possible links to hypnosis until after the experiment was over. Furthermore, the experimenter conducting the Stroop experiments was blind to the susceptibility level of the subjects being tested. Finally even in the unlikely event that subjects were able to establish a link between hypnosis and the Stroop test, it would be unlikely that subjects would be able to anticipate the predicted outcomes of the differential connection strength hypothesis. In fact, conventional social psychological wisdom would suggest that highs would be better able to respond to the explicit demands of the situation, and show faster colour naming reaction times. In contrast to such an hypothesis, but consonant with the PDP model of hypnotic responding, "better" hypnotic subjects were shown to have "poorer" reaction time performance (at least for incongruent trials).

As such, the findings of this study are difficult to reconcile from a purely social psychological view of hypnotic phenomena that would minimize or ignore the role played by individual differences in information processing, or reduce them to artifacts of the contextual demands (Spanos & Chaves, 1989). While incompatible with the social psychological perspective, the present results could prove useful to Hilgard's conception of hypnosis and hypnotizability. Indeed the parallel distributed processing conception of cognition in some ways resembles the Hilgard's network of cognitive subsystems, and the discrepancies among connection strengths along various pathways could be used to account for concepts such as " the amnesic barrier" (Hilgard, 1977 p. 81).

Attempts to align such findings with Hilgard's system may, however, be marred by the nonspecificity of the mechanisms of such a system. Hilgard postulates highs are able to carry out certain hypnotic suggestions by dissociating certain elements of a response from awareness. Thus, in hypnotic analgesia the experience of pain is somehow dissociated from the monitoring processes of the executive ego. The major evidence that such dissociative processes take place come from investigations concerning the "hidden observer" effect, a metaphor used by Hilgard to characterize cognitive subsystems that are normally dissociated from hypnotic consciousness, but can be accessed through appropriate suggestions (Hilgard, 1977 p. 185). It is therefore somewhat problematic that only about 40 -50% of highly susceptible subjects (subjects who would be capable of experiencing hypnotic analgesia) show evidence of this hidden observer effect (Laurence & Perry, 1981). Thus, neo-dissociation theory fosters a number of questions that are as yet unanswereable. For example, if the hidden observer is considered evidence for dissociative abilities, how do the other 50% of highly susceptible subjects manage to respond to suggestions? More importantly, what are the mechanisms which differentiate these people from low susceptible subjects?

Perhaps the resolution to these problems involves looking at hypnotic responding in a more synergistic fashion. Research conduceted by Laurence and his colleagues (Laurence, Perry & Kilstrom, 1983; Laurence & Perry, 1981; Nadon, D'eon, McConkey, Laurence & Perry, 1988) indicates that the hidden observer effect is indicative of one of many styles of hypnotic responding as opposed to reflecting the mechanism which enables hypnotizable subjects to experience hypnosis. According to Laurence et al., highs in whom the hidden observer effect can be elicited, are also likely to show duality in hypnotic age regression (Nogrady, McConkey, Laurence, & Perry, 1983) and a predeliction to experience hypnotically created memories when give appropriate suggestions (Laurence, Nadon, Nogrady & Perry, 1986; Laurence & Perry, 1983).

The fact that not all highly susceptible subjects adopt any one given style of hypnotic responding is consonant with the synergistic conception of hypnosis and hypnotic susceptibility. According to this synergistic perspective the hypnotic subject is comprised of a host of beliefs, attitudes, expectations and cognitive skills, which vary from individual to individual, and from situation to situation. What determines hypnotic susceptibility is the degree to which subjects possess certain attributes and the manner in which these attributes interact with one another, in a given situation. Thus, strong verbal connection strengths can be viewed as one of many cognitive individual differences that allow highly hypnotizable subjects to experience hypnosis.

It must be stressed that strong verbal connections alone cannot guarantee successful hypnotic responding. It is unlikely for example, that a subject with poor attitudes towards hypnosis will be responsive to hypnotic suggestions regardless of how strongly units along verbal pathways are connected. The results of the present study suggest that, other attributes being equal, subjects with stronger verbal connection strengths are more likely to be susceptible to hypnosis than subjects with lower conneciton strengths.

It should be noted, however, that in the real world other attributes are seldom equal, and from a synergistic point of view, it is often the interaction of unequal attributes that determines hypnotic susceptibility. It can be proposed that verbal automaticity may figure in a large number of such interactions, for in a PDP system, interconnections are found not only within pathways, but also between different pathways. Thus, presenting verbal input to subjects with strong verbal connection strengths may serve to activate other sensory, cognitive, and/or emotional pathways to a greater degree than subjects with lower connection strengths. Thus the automatic processing of verbal input may serve to rally other skills such as absorption and imagery which seem to aid in the production of an hypnotic response. Viewed in this manner, verbal automaticity can be seen as a triggering mechanism that actuates a whole series of cognitive subsystem permitting highly hypnotizable subjects to experience hypnotic suggestions. Although hypotheses concerning the role of verbal automaticity as a triggering mechanism for non-verbal subsystems requires further experimental investigation, the automaticity with which highly susceptible subjects processed verbal material in the present series of investigations suggest that verbal connection strengths may directly relate to a subject's hypnotic susceptibility level, and that further investigations designed to test this hypothesis are warranted.

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Appendix A.

Computer simulations of the Stroop phenomenon.

Figure 1 represents the Parallel Distributed processing model of the Stroop phenomenon as conceived by Cohen, Dunbar and McClelland (1986). In this model, word reading and colour naming are divided into two discrete pathways that converge on common response units. The values of the connection strengths joining lower to upper units are those given by these authors. In the model of the Stroop phenomenon proposed by Cohen et al. (1986), information is processed from input units to response units in a continuous bottom up fashion in the following manner. Stimulus combinations are registered by the input units (which can be simulated by having a value of one to indicate the presence of a word or colour, and zero to indicate the absence of the word or colour. Thus for the word RED painted in red the input codes would be 1,0,1, 0 respectively). Next, the activation values of the hidden units are updated using a weighted sum of the input they receive from units at the previous level in the network. Specifically, the net input at time (t) for $unit_j$ (at $level_n$) is calculated as:

$netj(t) = \Sigma\, a_i(t)wij$ (Equation 1)

where $a_i(t)$ is the activation of each $unit_i$ (at the input level) and wij is the connection strength bridging $unit_i$ to $unit_j$. The activation of a given unit is given by :

$aj(t) = \overline{net}\, j(t) = t\, netj(t) + (1-t)\overline{net}\, j(t-1)$ (Equation 2)

where $\overline{net}\, j(t)$ is the time-average of the net input to unit j, net j(t) is the net input to unitj at time (t) and t is a constant specifying the rate of processing.

This temporary value is then run through a logistic function with the resulting value determining the total activation value of that particular unit for that particular cycle.

$$a_j(t) = \text{logistic}(net_j(t)) = \frac{1}{1 + e^{-net_j(t)}} \quad \text{(Equation 3)}$$

Giving the following activation rule:

$a_j(t) = \text{logistic}(\overline{net}_j(t))$ where $\overline{net}_j(t)$ is defined above.

In this system the resting activation level of hidden units has a strong negative bias, indicated by the values of negative 4. The purpose of the task demand unit is to sensitize the colour naming pathway by counteracting this negative bias. Thus when a value of 1 is put in the task demand unit, it will be multiplied by the connection strength (4) in the link between the task demand unit and the hidden unit. This would serve to set the activation value of the hidden unit to zero. This value of zero serves to set the logistic function to .5, the most active part of its range. This is the point at which the input unit activation values will have the greatest ramifications in determining the updated activation value for the hidden unit. The inherent non-linearity of the logistic function is necessary to simulate the relatively smaller amount of congruent trial facilitation compared to incongruent trial inhibition.

Once activation values for hidden units have been calculated, these values used by response units to calculate their activation values. In Cohen's, et al. (1986) model, a response selection mechanism was used in which a given response unit would reach it's threshold activation when the ratio of the two competing response units activation values exceeded .6.

In this model of the Stroop phenomenon, zeros and ones are placed in the input units (simulating the presence and absence or word and colour stimuli) and letting the circuit cycle through until one of the response units holds a 60% 40% relation with the other response units. Reaction times are simulated by the number of cycles required by the circuit to achieve this threshold activation.

Appendix A.

Simulation 1.

The Basic Stroop effect.

In order to simulate the basic Stroop instructions to pay attention to the colour of the stimuli and ignore basic colour naming task, task demand units in the colour naming and word naming pathway were set at one, and zero respectively. The rate constant was set at .1 for all simulations. In order to simulate the three different types of trials, zeros and ones were inserted in the appropriate input units. For example to simulate the word RED painted in red, a one was placed in the red word unit, a zero in the blue word unit, a one in the red colour input unit and a zero in the blue colour input unit. Similarly an input array containing 1, 0,0,0 would simulate a control trial, and an input array containing 1,0,0,1 was used to simulate incongruent trials Using the equations presented above and the connection strengths of Cohen et al. presented in Figure 1, the following simulated reaction times were noted.

Congruent	Control	Incongruent
16	23	35

The discrepancy between facilitation 23-16= 7 and inhibition 35-23=12 mimics the discrepancy between facilitation and inhibition in human subjects, and is in the simulations attributable to using logistic functions.

Appendix A

Simulation 2.

In order to simulate what would happen if high hypnotizable subjects had stronger connection strengths than low hypnotizables, a value of .5 was added to all positive connection strengths and a value of -.5 was added to negative connection strengths in the word naming pathways for highs. The colour naming pathways were assumed to be similar for highs and lows. The simulated reaction time values were obtained.

	Congruent	Control	Incongruent
lows	16	23	35
highs	14	20	38

Note the dissimilarity between facilitation increases and interference increases. While increasing the verbal connection strengths serves to increase facilitation by 2 cycles, it increases inhibition by 3 cycles. The decrease in control reaction times is an anomaly of using the logistic function at output levels.

Appendix A

Simulation 3.

In the 25% condition of Cheesman and Merikle, the fact that the best strategy was just to ignore the colour words and concentrate on naming the colours can be simulated by placing a zero in the task demand unit of the word reading pathway, and a one in the task demand unit of the colour naming pathway of figure 1. For the 75% congruent trial probability condition where 3 out of 4 times the word predicts the upcoming colour, the best strategy is to pay a small amount of attention to the word, while still remembering that the task is to name the colour of the stimuli. Such a situation can be simulated by placing a value of .02 in the task demand unit of the word reading pathways. Simulated reaction times for Cheesman and Merikle's task are given below.

	25%	75%
inc	35	37
con	16	16

Appendix A

Simulation 4.

This simulation combines the effect of simulations 2 and 3 showing the expected increases in the Stroop effect due to strategy when high and low hypnotizable subjects are assumed to have different verbal connection strengths. In this simulation the absolute value of verbal connection strengths are .5 units greater for highs than lows. As in Simulation 3, the strategy of paying attention to the word is simulated by placing .02 in the task demand unit of the word reading pathway.

	Lows		Highs	
	25%	75%	25%	75%
inc	35	37	38	42
con	16	16	14	13

Appendix A.
Simulation 5.

The effect of highs being better at implementing performance optimization strategies than lows can be simulated by adding .04 instead of .02 to their verbal task demand unit. Such a manipulation would not change congruent naming times, but would rather dramatically increase incongruent colour naming times .

	Lows		Highs	
	25%	75%	25%	75%
inc	35	37	38	57
con	16	16	14	13

The dramatic increase in incongruent trial naming for clearly visible stimuli for highs in this situation indicates why an interaction involving word colour relation, congruent trial probability, and hypnotizability would be expected if highs showed increased strategy use, as well as automaticity.

Appendix A

Simulation 6.

This simulation shows the effect of increasing the absolute value of connection strengths in the colour naming pathways of low hypnotizables. All positive colour connection strengths were increased by .5 and all negative connections strengths were decreased by .5. In this simulation high and low hypnotizables were assumed to have similar verbal connection strengths. The resulting values for highs and lows were

	Congruent	Control	Incongruent
lows	13	17	23
highs	16	23	35

Appendix A

Simulation 7.

This simulation shows the effect on reaction times of highs and lows if no differences were noted for verbal connection strengths, but lows had more control over the task demand units. In this simulation, lows were assumed to be better at selectively attending to relevant stimuli than highs. Thus, for the colour naming task demand unit, lows could input a value of 1 (maximally sensitizing the colour naming pathway) while highs could only input a value of .8 (less than maximum sensitivity). If lows are assumed to have greater control over task demand units, then in terms of strategy, they should be able to sensitize the word naming pathway more than high hypnotizables when congruent trial probability is high. Thus, for this simulation it was assumed that lows could input .04 in the word-reading task demand unit for 75% congruent probability trials, while highs could only input .02 into these units. The simulated results for Cheesman and Merikle's paradigm are presented below.

	Lows		Highs	
	25%	75%	25%	75%
inc	35	40	41	45
con	16	16	17	17

If this were the case, a main effect of hypnotizability would ensue, as lows are faster than highs in every condition. Such a finding is inconsistent with the actual data obtained for highs and lows.

Appendix B.

No Feedback Condition.

"O.K. can you see the white dot in the middle of the screen? That dot means that a trial is ready to begin. Now what is going to happen is that when you push this red button a word will appear on the screen. This word will be either BLUE, RED, GREEN or YELLOW, or a series of 5 Xs". These words are going to be painted in one of four different colours, blue red, green or yellow. All you have to do is ignore the word or the X's and just concentrate on naming the physical colour of the stimulus, out loud, as fast as you can. What will happen is the speaker behind you will pick up your voice and record your reaction time to naming the colour, and this information will be stored in the computer. So for each trial, the white dot will come up, you press the red button to start the trial, and just name the physical colour of the paint as fast as you can without making any errors".

After practice block subjects are told that: *"In this task it is tempting to use certain strategies to make things easier – like blurring your eyes so that you can't read the word, or focusing on the last letter of the word. These kinds of strategies are cheating, so I am asking that you not use them. I just want you to focus your vision on the dot before each trial, and just concentrate on naming the colour as fast as you can without making any errors".*

Feedback Condition.

"O.K now this is going to be a little bit more fun. You are going to do the exact same task as the last time only this time the computer is going to print out your reaction times at the end of each block so that you will know how you are doing. This task is sort of like a video game where you try and beat your own score each time. Just like before, however, you always have to focus on the dot before each trial and just concentrate on naming the colour as fast as you can without making errors.

Appendix C.

Source Table for Experiment 1.

Source	SS	df	MS	F	P
BETWEEN BLOCKS					
Hyp	133601.193	1	1335601.193	6.234	026
Error	257149.070	12	21429.089		
WITHIN BLOCKS					
Rel	474162.158	2	237081.079	281.886	.001
Hyp X Rel	10928.312	2	5464.156	6.496	005
Error	20185.218	24	841.05		
Feed	90948.757	1	90948.757	26 243	001
Hyp X Feed	4200.410	1	4200.410	1 212	.292
Error	41587.515	12	3465.626		
Rel X Feed	7516.195	2	3758.097	11.351	.001
Hyp X Rel X Feed	906.527	2	453 263	1.369	273
Error	7945.597	24	31.066		
Total	1049130.957	83			
Residual	69718.332	60			

Note. Hyp = Hypnotizability, Rel= Word-Colour Relationship, Feed= Feedback

Appendix D.

FAMILIARIZATION PROCEDURE.

O.K. can you see the white dot in the middle of the screen? That dot means that a trial is ready to begin. Before you start each trial, I want you to make sure you are focusing on this dot. Now what is going to happen is when you push this red button a word or a non-word will appear on the screen. This word will be either BLUE, RED, GREEN or YELLOW, or non-words using the same letters. These non-words will be BUEL, ERD, GENER or YOLLEW. When you see the word or the non-word I just want you to push the button that corresponds with what you saw. If you saw YELLOW then just push the button with the word YELLOW written above it. If you saw ERD then just press the button with ERD written above it. Now I am interested in accuracy in this task, not speed, so take your time and see how many you can get correct. O.K. remember to focus on the dot at all times.

Staircase Procedure.

"O.K. this time what is going to happen is that the words or the non-words are going to be presented so that at first they will be either easy to see or very hard to see. All you have to do is tell me whether you were confident you could tell what the word or non-word was or whether you were just guessing by pushing either the confident button or the guessing button. So if you press the start button and see the word RED, and you are sure it was the word RED then press the confident button. If you press the start button and you see something but you are not sure which of the words or non-words it was, then press the guessing button. Make sure you are focusing on the dot at all times.

Stroop Task, instructions for both 25% and 75% congruent trial probability.

O.K. This time you are going to be presented one of four words, BLUE , RED, GREEN or YELLOW, and these words will be followed by a colour patch that is blue red green or yellow. Sometimes the word will be easy to see; other times it will be hard to see. Regardless of what the word is, all I want you to do is to name the colour of the patch as quickly as possible.

At the end of each block your average reaction time will be printed on the screen so I want you to try to beat your own score each time. Once again, make sure you are focusing on the dot at all times.

Forced Choice procedure.

"O.K. this task is going to be the exact same as the very first task that you did. The computer is going to present you a word or non-word, and all you have to do is push the button that corresponds with what you saw. Unlike those first trials though, this time the words and the non-words are going to be very hard to see, so I want you to pay close attention, and try to get as many correct as you can. If you aren't sure which word or non-word you were presented I want you to make your best guess". O.K. remember to focus on the dot at all times.

Appendix E.

Source Table for Experiment 2.

Source	SS	df	MS	F	P
BETWEEN BLOCKS					
Hyp	31205.000	1	31205.000	3.739	.087
Error	66749.687	8	8343.710		
WITHIN BLOCKS					
Thresh	31.254	1	31.254	.186	
Hyp X Thresh	5.000	1	5.000	.029	
Error	1342.511	8	167.813		
Rel	72963.198	1	72963.198	17.63	.003
Hyp X Rel	6661.25	1	6661.25	1.609	.239
Error	33108.324	8	4138.540		
Thresh X Rel	3645.0	1	3645.0	23.021	.001
Hyp X ThreshX Rel	1264.052	1	1264.052	7.983	.021
Error	8502.417	8	1062.802		
Per	31680.805	1	31680.805	29.808	.001
Hyp X Per	369.054	1	369.054	.372	
Error	8502.417	8	1062.802		

Thresh X Per	1804.990	1	1804.990	4.853	.057
Hyp X Thresh X Per	451.259	1	451.259	1.213	.303
Error	2974.972	8	371.871		
Rel X Per	19406.450	1	19406.450	16.606	.003
Hyp X Rel X Per	259.204	1	259.204	.221	
Error	9348.566	8	1168.570		
Thresh X Rel X Per	1394.453	1	1394.453	12.769	.007
Hyp X Thresh X Rel X Per	115.170	1	115.170	1.054	.336
Error	873.628	8	109.203		
Total	295449.921	79			
Residual	57417.089	56			

Note. Hyp = Hypnotizability, Rel= Word-Colour Relationship, Per = Congruent Trial Percentage, Thresh= Threshold

APPENDIX F.

FAMILIARIZATION PROCEDURE.

O.K. can you see the Black dot in the middle of the white rectangle? That dot means that a trial is ready to begin. Before you start each trial, I want you to make sure you are concentrating on this dot. Now what is going to happen is when you push this red button a word will appear on the screen. This word will be either BLUE, RED, GREEN or YELLOW. When you see the word I just want you to push the button that corresponds with what you saw. So if you saw yellow then just push the button with the word YELLOW written above it. Now I am interested in accuracy in this task, not speed, so take your time and see how many you can get correct. Make sure you are focusing on the dot at all times.

Staircase Procedure.

"O.K. this time what is going to happen is that the words are going to be presented so that sometimes they will be easy to see other times they will be hard to see. All you have to do is tell me whether you were confident you could tell what the word or non-word was or whether you were just guessing. You can tell me by pushing either the confident button or the guessing button. So if you press the start button and see the word RED, and you are sure it was the word RED then press the confident button. If you press the start button and you see something but you are not sure which of the words it was, then press the guessing button. O.K. remember to focus on the dot at all times.

Stroop Task, instructions for subthreshold 25% congruent trial probability.

O.K. This time you are going to be presented one of four words, BLUE , RED, *GREEN or YELLOW, and these words will be followed by a colour patch that is blue, red, green, or yellow. In this condition the words are going to be very hard to see, but I will tell you that the word only matches the colour one time out of four, so the best strategy is just to ignore the word and concentrate on naming the colour as fast as you can. At the end of each block your average reaction time will be printed on the screen, so I want you to try to beat your own score each time. O.K. remember to focus on the dot at all times.*

Stroop Task, instructions for suprathreshold 25% congruent trial probability.

O.K. This time you are going to do the exact same thing except now the words will be easy to see. Once again however, the word only matches the colour one time out of four so the best strategy is still just to ignore the word and concentrate on naming the colour as fast as you can. At the end of each block your average reaction time will be printed on the screen so I want you to try to beat your own score each time. O.K. remember to focus on the dot at all times.

Stroop Task, 75% congruent trial probability.

"O.K. this is going to be the same colour naming task that you did yesterday. In this condition the words are going to be very hard to see, but I will tell you that the word is going to match the colour three out of four times so that the best strategy is to try to use the word, if you can, to predict what colour is going to come up, and thereby improve your reaction time. Just like before, your average reaction time is going to be given to you at the end of each block, and I want you to try to beat your own score. O.K. remember to focus on the dot at all times.

Stroop Task, 75% congruent trial probability.

O.K. This is going to be exactly the same as the task you just did except that this time the words are going to be very easy to see. Once again the words will match the colour three out of four times so I want you to use the word to predict what colour will come up and thereby improve your reaction time. O.K. remember to focus on the dot at all times.

Forced Choice procedure.
"O.K. this task is going to be the exact same as the very first task that you did. The computer is going to present you a word, and all you have to do is push the button that corresponds with what you saw. Unlike those first trials though, this time the words are going to be very hard to see, so I want you to pay close attention, and try to get as many correct as you can. If you aren't sure which word or non-word you were presented I want you to make your best guess". O.K. remember to focus on the dot at all times.

Appendix G.

Source Table for Experiment 3.

Source	SS	df	MS	F	P
BETWEEN BLOCKS					
Hyp	87754.675	2	43877.337	2.096	.143
Error	502247.375	24	20926.973		
WITHIN BLOCKS					
Thresh	933.328	1	933.328	1.402	.246
Hyp X Thresh	2110.851	2	1055.425	1.5286	.224
Error	15966.457	24	665.269		
Rel	99631.107	1	99631.107	87.224	.001
Hyp X Rel	10887.363	2	5443.681	4.765	.017
Error	27413.687	24	1142.236		
Thresh X Rel	36218.548	1	36218.548	47.797	.001
Hyp X ThreshX Rel	1623.269	2	811.634	1.071	.359
Error	18185.808	24	757.742		
Per	40755.058	1	40755.058	58.114	.001
Hyp X Per	927.246	2	463.623	.621	
Error	16830.859	24	16830.859		

Thresh X Per	186.996	1	186.996	.504	
Hyp X Thresh X Per	162.632	2	81.316	.219	
Error	8898.968	24	370.790		
Rel X Per	42140.197	1	42140.197	99.478	.001
Hyp X Rel X Per	897.257	2	448.628	1.059	
Error	10166.640	24	423.610		
Thresh X Rel X Per	18278.613	1	18278.613	39.831	.001
Hyp X Thresh X Rel X Per	279.429	2	139.746	.304	
Error	11013.5	24	458.895		
Total	953509.935	215			
Residual	108475.921	168			

Note. Hyp = Hypnotizability, Rel= Word-Colour Relationship, Per = Congruent Trial Percentage, Thresh= Threshold