The Relationship between Hypnotizability, Working Memory, and the Process of Automatization

Mahmoud Khodaverdi-Khani

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By: Mahmoud Khodaverdi-Khani

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Signed by the final examining committee:

______________________________________ Chair
Dr. Joanne Turnbull

______________________________________ External Examiner
Dr. Pierre Rainville

______________________________________ External to Program
Dr. Thanh Dang-Vu

______________________________________ Examiner
Dr. Norman Segalowitz

______________________________________ Examiner
Dr. Aaron Johnson

______________________________________ Thesis Supervisor
Dr. Jean-Roch Laurence

Approved by: ______________________________________

Chair of Department or Graduate Program Director

____

Dean of Faculty

Abstract

The Relationship between Hypnotizability, Working Memory, and the Process of Automatization

Mahmoud Khodaverdi-Khani
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The literature on hypnosis indicates that high hypnotizable (HH) people tend to follow suggestions more attentively and be less distracted by peripheral information than low hypnotizable (LH) people. Neuro-psychological measures of attention, however, seem to indicate that HHs may demonstrate less efficient executive functions. To compensate this limitation, HHs may have learned to allocate all of their attention to the task at hand and learned to automatize some aspect of information processing. In experiment one, the relationship between working memory and the degree to which participants react to hypnotic suggestions was investigated. Thirty-eight participants who underwent the Harvard Group Scale of Hypnotizability Form A (HGSHS: A) in small group sessions were assessed on a forward and backward digit span, and a reading span tests. The results showed that hypnotizability correlated negatively with the digit span backward and the digit span total tests. In experiment 1b, ten HH and ten LH participants underwent the same procedure as in experiment one with the exception that the reading span was replaced by the N-back test. The results of this experiment replicated the magnitude, direction, and significance of the relationship between hypnotizability and measures of working memory (WM). The analysis of N-back data further revealed a distinction between storage and processing involved in WM, pointing to a dynamic interaction with the automatization of attentional processes. To further investigate the role of WM in the process of automatization, in experiment two, participants' WM was loaded with zero, three, or five digits while they were performing a visual search task over five sessions. It was hypothesized that if the process of automatization is due to the limited resources available to participants then participants in the high load condition would reach automaticity over the 5 sessions regardless of their hypnotizability level. In addition, it was expected that the HH group would reach automaticity in fewer sessions than the LH or the MH groups regardless of the load condition they were in. Support for the two hypotheses was obtained when the coefficients of variability were analyzed. Across sessions, HHs significantly decreased their coefficients of variability, indicating that more than a simple improvement in speed of processing was at play in their responses. Experiment 2b, following the same methodology, replicated the key findings of experiment 2. These results are discussed in the context of two-process theory and their applicability to the study of hypnotizability and automatization. The current results suggest that individual differences in hypnotizability may be in part linked to variations in WM resources and a more efficient automatization process of information.

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Concordia University

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CONTRIBUTIONS OF AUTHORS

This dissertation consists of an introduction, four experiments and a concluding discussion. The dissertation was written by myself and was edited by my supervisor Dr. Laurence and the committee members Dr. Segalowitz and Dr. Johnson.

The four experiments were conceptualized and designed by me with guidance from Dr. Laurence. I was responsible for all the testing sessions.

For experiment 1 and experiment 2, Iliana Lilova did the screening for the Harvard testing, recruiting the participants, and managing the schedule. The software program to run the visual search experiment was developed with the help of Peter April in C++.

For experiment 1 and experiment 2b Simon Houle managed the participant pools and did the recruiting and the scheduling. The software program to run experiment four was developed by myself with technical support from F. Feraidoony in Visual Basic.

The general screening of participants using the Harvard Group Scale of Hypnotic Susceptibility was performed by myself and members of the hypnosis lab.

Chapter 1

Introduction

A bystander who observes a group hypnosis session for the first time would be surprised by the diverse display of behaviors in response to suggestions given by the hypnotist. This variability of responses has intrigued researchers since the early beginnings of hypnosis as it would indicate that some individuals are more susceptible to hypnosis than others. Although a comprehensive explanation still evades contemporary theorists, the current dissertation, follows in a long tradition of the investigation of individual differences in hypnotic responding, and proposes that a closer investigation of cognitive processes, specifically the interplay of working memory, attention and the process of automatization may bring us closer to an understanding of individual differences observed in hypnosis.

1.1 Brief historical overview of individual differences in hypnotizability

The observation of individual differences in hypnotic responses goes back to the early days of Animal Magnetism. From Mesmer at the end of the 18th century to Bernheim at the turn of the 20th century, hypnosis practitioners reported that between 10 to -15% of patients they were treating responded positively to hypnotic interventions (high hypnotizables, or HHs), whereas about 10 to15% did not respond to suggestions at all, or did so minimally (low hypnotizables, or LHs). This left the remaining 70% to respond up to a certain degree, meaning that they tended to respond to easier suggestions, such as ideo-motor and challenge items, but not to the more difficult ones, such as auditory hallucinations (Laurence & Perry, 1988; Laurence, Beaulieu-Prévost, & du Chéné, 2008). The development of standardized scales to measure hypnotizability in the mid-1960s, such as the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS: A; Shor & Orne, 1962), and the Stanford Hypnotic Susceptibility Scale, Form C (Weitzenhoffer & Hilgard, 1962), allowed researchers to confirm these earlier observations. Additionally, responsiveness to suggestions has been shown to be a relatively stable individual characteristic (Hilgard, 1965) with a test-retest reliability of 0.71 over a 25-year period (Piccione, Hilgard, & Zimbardo, 1989).

To identify the source of these individual differences, researchers have studied a wide range of variables, from personality traits, to socio-cognitive abilities, and physiological indices (Barber & Calverly, 1965; Barnier, Cox, & McConkey, 2014; de Groh, 1989; Deckert & West, 1963; Dermen & London, 1965; Hilgard, 1965; Kirsch & Braffman, 2001; Weitzenhoffer, 1953). Investigators began by looking at personality types as an indicator of hypnotic susceptibility. For example, Hull (1933) examined the association between hypnotizability and personality characteristics that were commonly being investigated at the time, such as hysteria, neuroticism, and acquiescence, but did not find any connection. The attempt to find a hypnotic personality type continued with the creation of personality scales such as the Minnesota Multiphasic Personality Inventory and the California Personality Inventory (Hathaway, & McKinley, 1943; Gough, 1957). A look at this literature reveals that most personality variables such as extroversion-introversion, neuroticism, agreeableness, conscientiousness, or openness, showed either no correlation or only a negligible correlation with hypnotizability (Green, 2004; Milling, Miller, Newsome, & Necrason, 2013; Nordenstrom, Council, & Meier, 2002). The paucity of results with classic personality traits led to the investigation of other variables thought to index different personality styles, such as absorption (de Groh, 1989; Tellegen & Atkinson, 1974), fantasy proneness (Lynn & Rhue, 1988), imaginative suggestibility (Bowers, 1978; Lynn & Rhue, 1986), self-directedness and schizotypy (Laidlaw, Dwivedi, Naito, & Gruzelier, 2005). Although the studies of personality styles revealed some degree of association with hypnotizability, these associations often proved evanescent, i.e., sometimes they materialized, and sometimes they did not. The most commonly used of these paper-and-pencil questionnaires, the Tellegen and Atkinson's (1974) absorption scale, measures the "full commitment of available perceptual, motoric, imaginative and ideational resources to a unified representation of the attentional object" (p. 274). The range of correlations for absorption and hypnotic susceptibility scales reported in the literature varies widely from r =.13 (Hilgard, Sheehan, Monteiro, & Macdonald, 1981) to r = .57 (Crawford, 1982), and the correlations are most often significant only if the scale is administered concurrently with the hypnosis testing session (Kirsch & Braffman, 1999) leading researchers to conclude that the questionnaire approach is vulnerable to a contextual effect (Lynn, Kirsch, & Hallquist, 2008; Spanos, 1986). Nonetheless, Tellegen and Atkinson's notion of absorption seemed to identify attention processes as a promising lead in the investigation of individual differences in hypnotizability. As we will see in the next section, this approach proved to be quite successful in identifying factors at play in one's response to hypnotic suggestions.

1.2 Hypnotizability, Attention and Working Memory

1.2.1 Hypnotizability and attention tasks

One of the main components of the cognitive system that has been repeatedly shown to contribute to hypnotic susceptibility is the ability to focus attention on the targeted task and to ignore extraneous stimuli (Cojan, Piguet, & Vuilleumier, 2015; Crawford, 1994; Karlin, 1979; Mitchell, 1970; Priebe & Wallace, 1986; Van Nuys, 1973; Wallace, Knight, & Garret, 1979). HH participants have demonstrated greater flexibility in their allocation of attentional resources (Cikurel & Gruzelier, 1990; Gruzelier & Warren, 1993) and shown to be superior in information processing (Ingram, Saccuzzo, McNeill & McDonald, 1979). For example, Mitchell (1970) asked subjects to perform a test where participants were required to perform a tracking task while maintaining the indicator on a reference point. During such performance, auditory distracting stimuli were presented in the testing room. The subjects had to do six sessions of five-minute tracking. The researcher indicated that HH participants were better able to ignore any distraction and performed the tracking task more accurately in comparison to the LHs. Another study also found this link between high hypnotizability and fewer distractions during a task in which participants were asked to meditate by concentrating on their own breathing or to stare at the flame of a candle (Van Nuys, 1973). Participants had to press a button when their meditation was interrupted by an intrusive thought. The researcher reported that the HH group had fewer intrusive thoughts during the meditation exercise than the LH group. Furthermore, Karlin (1979) tested the ability of HH and LH groups in a selective attention task. In this task, subjects had to listen to a target story that was recorded over a non-target story. Subsequently, they were asked to rate the difficulty of the target story and they were tested on what they could remember of the target. The experimenter concluded that the HH group performed better than the control group at attending selectively to information. Therefore, one can see multiple studies using various tasks and modalities, indicating that those high in hypnotizability have a cognitive advantage in being able to better ignore distracting stimuli and focus their attention on the target. However, the ability to ignore distractors is not the only cognitive difference between LH and HH individuals. Several groups of researchers have found indications that HH are able to process information faster than LH participants. One such group, (Ingram, Saccuzzo, McNeill, & McDonald, 1979), showed that HH subjects detected stimuli presented through a tachistoscope more accurately than the LH group. They concluded that the HH group process information more quickly than the LH group. Several years later, Wallace and Patterson (1984) conducted two experiments to investigate the speed of information processing of groups of people of varying hypnotizability. In their visual experiment, the participants had to detect the target letter imbedded among distractor letters arranged either in a straight line or in a round form. The HH group showed faster detection times in finding the target. In the second experiment the researchers tested participants on an arithmetic problem, and found that the HH group solved more of the two-digit problems and did so faster than the LH group. These earlier studies are indicative of the link between hypnotizability and cognitive processing, specifically that HHs seem to process information faster than their LH counterparts.

There are more recent examples of studies that have linked hypnotizability to attentional processes. For instance Castellani, D'Alessandro, and Sebastiani (2007) attempted to study the attentional characteristics of HHs and LHs using the Attentional Network Task (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002). The ANT is a short behavioural measure that provides quantitative indices for the executive, orienting and alerting attentional networks. They presented participants with a cue or a warning signal that told them where to look for the target on the screen. By using this task, the researchers were able to test the three networks of attention proposed by Posner (1980): alerting, orienting, and executive control systems. The effects of the alerting network were examined by changes in reaction time (RT) resulting from a warning signal. The effects of the orienting network were examined by changes in the RT that accompany cues indicating where the target will occur. And finally, the effects of the executive network were examined by analyzing the performance of participants in the congruent, incongruent, and neutral conditions. Castellani et al. (2007) showed that there were no differences between highs and lows on executive control functions. However, highs were faster than lows in the alerting condition. They were also faster in the central and 'no cue' conditions, the two conditions that assess baseline attentional responses. Castellani et al. (2007) concluded that "these findings suggest that highs would be endowed with a basal higher efficiency in achieving and maintaining their readiness to respond to incoming stimuli (p. 35)".

The same group of researchers (Castellani, D'Alessandro, & Sebastiani, 2009) went on to take a different approach and looked at hypnotizability differences in temporal dynamics of attention using an iconic version of the Attentional Blink Task. The Attentional Blinks Task employs rapid serial visual presentation method (Potter, 1976) in which stimuli such as letters, digits, or pictures are presented successively in one location. Participants were required to identify a target stimulus in the 10-item per second rapid serial visual presentation stream of distractor stimuli, then to report whether the second target stimulus occurred in the subsequent letter stream. The second target was presented on only 50% of the trials and when presented, occurred with an interval, separating the two targets of between 100 to 800 ms. Attentional blink occurs when participants report the first target correctly but fail to report the second target. It has been shown that attentional blink occurs at short intervals (100–450 ms.) but recovers to a baseline level of accuracy at longer intervals (Raymond, Shapiro & Arnell, 1992). Using an attentional blink task, Castellani et al. (2009) asked their HH and LH participants to find a black and white probe butterfly and a colored animal target picture among rapid streams of distractors. No differences in attention time dynamics were found between high and low hypnotizable individuals. However, two potentially important findings emerged. Firstly, at short intervals, probe detection was better for the HH group than for the LH group. This finding might point to a more automatic capturing of the probe by HHs. Secondly, they reported that highs performed poorer on target identification, suggesting that performance may be compromised in these participants when attention is divided between concomitant tasks.

When taken together, the above studies that looked at attention deployment in simple tasks, indicate that HHs may be processing information faster (Castellani et al., 2007), and be better able to ignore extraneous stimuli (Van Nuys, 1973) compared to

LHs. However, they also seem to show that HHs may not perform as well if the test context requires that attention be divided between tasks (Castellani et al., 2009).

1.2.2 Hypnotizability and neuro-psychological tests of attention

As one can see, there is support in the literature that attentional differences exist between those who respond highly to hypnosis, and those who do not respond to hypnotic suggestions. Neurocognitive researchers wanted to better understand the reason for these differences by observing brain differences in HHs and LHs. Research on the physiological correlates of hypnotizability has yielded many contradictory results, some supporting the role of the attentional system in hypnotizability (Aikins and Ray, 2001; Farvolden and Woody, 2004), and some not finding any evidence for such connection (Varga, Németh, & Szekely, 2011). The reason why results are contradictory may be explained by De Pascalis (1999), who pointed out that "the findings span across a host of sampling, measurement, and instrumentation methodologies, thus rendering cross-study comparisons difficult and sometimes impossible" (p. 135). Nonetheless, some general findings are worth reviewing as they may orient research onto the importance of better understanding the attentional network and executive function related to hypnotizability. For instance, Aikins and Ray (2001) tested participants on four tests of frontal lobe functioning that previously have been demonstrated to assess executive functioning (Milner, 1963). They reported that HH participants performed better than LH participants on the Wisconsin Card Sorting Test (Grant & Berg, 1948). In this test the participant is given 128 cards with various shape, color, number, and design and is asked to sort them according to a rule set by the experimenter. Once the participant has achieved ten consecutive correct responses, the experimenter changes the sorting rule without warning the participant. The faster the participant learns the sorting rule, the higher score he/she will achieve on this test. This test is considered to measure cognitive flexibility, the ability to adapt cognitive processing strategies to face new and unexpected conditions (Cañas, Quesada, Antolí and Fajardo, 2003). HH participants did not differ from controls on any of the remaining tests, such as the controlled oral word association test (verbal fluency test), the Stroop color naming test (cognitive inhibition) and the Towers of Hanoi (problem solving).

Furthermore, researchers like Farvolden and Woody (2004) took a different approach and proposed that there is a reasonable fit between the evidence from the hypnosis literature and the frontal lobe damage literature, suggesting a link between differences in the brain and hypnotizability. One interesting aspect of patients with damage to their frontal lobes is that, while they display severe problems in the control and regulation of their behavior, they demonstrate intact performance on other cognitive tasks such as intelligence tests (Shallice & Burgess, 1991). The poor performance of frontal lobe patients is thought to be related to the weakening of the executive function, a system that is responsible for the control and coordination of cognitive processes during the performance of complex cognitive tasks. Farvolden and Woody (2004) posited that highly susceptible individuals may appear functionally similar to people with frontal lobe damage. For this reason they postulated that HH participants would perform more poorly than control participants on a battery of frontal lobe tests. To find support for this hypothesis, they tested participants of varying hypnotizability levels on the following tests: Proactive Interference test (Perret, 1974), measuring the interference of newly learned information with the recall of previous information ; Free Recall test (Gershberg & Shimamura, 1991), measuring the ability of individuals in remembering immediately learned information; Word Fluency test (Shimamura, 1995), measuring the cognitive ability of participants in producing words with the letters A, F, and S in 60 seconds; Source Amnesia test (Moscovitch, 1994), distinguishing the source of learned information; Meta-memory test (Shimamura, 1995), measuring the ability of participants to answer questions where the solution to the question is not immediately apparent, such as, “how tall is the average Canadian women?”; Cognitive Estimation test (Shallice and Evans,1978); measuring the abilities of selecting an appropriate cognitive plan and of checking any putative answer obtained as much as the ability of carrying out the selected plan, and Temporal Organization test (Milner, 1971), measuring the ability of participants to plan and organize their everyday activities. All these tests are thought to be sensitive to the diminished frontal lobe functioning in frontal lobe patients (Shimamura, 1995). The authors postulated that HH would show many of the deficiencies in memory performance that have been observed in patients with frontal lobe damage. Their results showed that HH participants performed more poorly than LH participants on the free recall test, on the source amnesia test, on the proactive interference test, and on parts of the meta-memory test in which the participants were required to rate the confidence of their ability to recognize a word. HH tended to rate their confidence higher than the LH on meta-memory errors. There were no differences between the two groups on the cognitive estimation test and on the word fluency test. However, HH participants performed better than the LH group on the word sequencing test. The differences found seemed independent of the hypnotic context, as highs performed similarly both during and out of hypnosis. The authors were troubled by this finding and suggested that hypnotizability may be related to a less efficient performing executive function whether or not participants are hypnotized. A closer inspection of their results reveals that the two groups were different from each other on the tests that were sensitive to WM variation such as free recall test, source amnesia test and proactive interference test. They were not different on the tests that relied on other cognitive abilities such as word fluency test and cognitive estimation test. These tests may rely on general world knowledge rather than WM capacity or processes. Counter to the researchers' prediction, the better performance of HH on word sequencing test may point to the greater automatization in the HH group (Dixon & Laurence, 1992).

Nevertheless, not all research supports the idea that there is a difference in cognitive processes between those who respond strongly to hypnosis and those who do not. For example, Dienes, Brown, Hutton, Kirsch, and Mazzoni (2009) administered three tasks indexing cognitive inhibition; a memory priming task, a spatial negative priming task, and a latent inhibition task. The inhibitory test measures an individual's ability to prevent his or her natural behavioral response to a stimulus in order to implement more context behaviors (Anderson, 1995). No differences were found between HH and LH individuals. Similarly, another group of researchers (Varga, Németh, & Szekely, 2011) reported no significant correlation between HH and LH participants on a battery of attentional tasks indexing selective attention, sustained attention and divided attention, concluding that there is no consistent relationship between hypnotic susceptibility and waking attentional performance. A closer look at their results, however, reveals some interesting differences between HH and LH participants. In the sustained, divided and task switching attention tasks, the reaction times of HHs were significantly slower than those of the other participants, indicating that HHs may have to slow down when they have to resolve conflict in working memory (Varga, Németh, & Szekely, 2011). What this appears to indicate is that there are additional processes occurring that cannot be attributed solely to attention, and that working memory may also play a role in the differences found between individuals of varying hypnotic responsiveness.

Therefore, one can see, at first glance, that the reported findings on attention tests and hypnotizability seem to be inconsistent and contradictory. Some findings indicate that HHs are better at focusing their attention (Aikins & Ray, 2001), while other findings show that HHs perform more poorly on some of the frontal lobe tasks indexing executive functions (Dienes et al., 2009; Varga, Németh, & Szekely,2011). The reason for this discrepancy might be due to the fact that the tasks used to assess attentional processes do not take into consideration the diversity of processing involved, in particular attentional control, processing speed, and working memory storage capacity that may differ in individuals of varying hypnotizability levels. These points will be explored further in the following sections.

1.2.3 Hypnotizability and the process of automatization

In response to hypnosis, HH participants report the execution of suggested behaviours as highly involuntary or automatic (Hilgard, 1986; Spanos, 1986). The concept of automaticity has been studied extensively in cognitive psychology, especially the type of process that starts as a controlled process and through extensive practice becomes automatic (Schneider & Shiffrin, 1977). According to this view, the nature of the underlying cognitive processes undergoes qualitative changes from controlled processing to one with some degree of automatization (Logan, 1988; Schneider & Shiffrin, 1977). At the onset of learning a new task, performance relies on controlled processing, however, with extensive practice, the task can become automatic given that it receives sufficient amount of practice in a consistent environment. For a process to be considered automatic, some features, such as being unintentional, uncontrollable, goal independent, stimulus driven, unconscious, efficient, and fast must be present. These features are shared among many theories (LaBerg & Samuels, 1974; Moors & De Houwer, 2006; Neely, 1977; Posner & Snyder, 1975; Schneider & Shiffrin, 1977). In contrast, a conscious or controlled process is defined as being slow, effortful, under subject control, and the subject is usually aware of its occurrence. Recently, however, the core assumption of automaticity has been questioned (Pashler, 1988; Segalowitz, 2010; Wolfe, 1988). As Segalowitz pointed out, “the main difficulty facing a theory of automaticity is that the features in the “automaticity bundle” do not always co-occur as they should according to the original conception of automaticity” (p. 79). Despite this criticism, research on automaticity points to the fact that due to extensive practice during learning, certain changes happen in people’s performance, that make their performance more efficient. As Zbrodoff and Logan (1986) argued, automaticity might be a useful concept in investigating the effects of practice on individual’s performance even if its different features are not acquired simultaneously.

But how is automaticity associated with differences in hypnotic responsiveness? Several seminal studies are described below, to bridge the gap between these two concepts. Using an automaticity framework, Dixon, Brunet, and Laurence (1990) proposed that the HH and the LH individuals differ in the automaticity with which they process verbal information. Evidence that supports this idea comes from a series of studies by Dixon and his colleagues (Dixon et al., 1990; Dixon & Laurence, 1992). In their experiments, they used a version of the Stroop test (1935). The Stroop test consists of two different tasks. In one task participants have to name the color of the ink in which the word is printed while ignoring the written word, and in the second task they have to read the word aloud while ignoring the color of the ink. Some of the robust findings from the Stroop tasks are that word reading is always faster than color naming. In the word reading task, ink color does not have any effect on the process of word reading. In the color naming task, however, when the printed word is incongruent with the ink color (e.g., RED printed in green), performance is slower than in a control (e.g., XXXX printed in different colors) or a congruent condition (e.g., RED printed in red ink). The faster reaction time of color naming in the congruent condition and the slower reaction time of color naming in the incongruent condition are referred to as the facilitation and the interference effects, respectively. Stroop (1935) postulated that the observed effects were due to the relevant differences between the speed of naming the ink color and the speed of reading the word, and predicted that the faster of the two processes will interfere with the slower one. A more recent explanation of the Stroop effect relies on the distinction between automatic and controlled processes. According to this view, when the two processes work together, the well-practiced process that is automatic interferes with the less practiced, which is controlled (for an alternative explanation see Cohen, Dunbar, & McClelland, 1988; MacLeod & Dunbar, 1988).

Returning to the study that links automaticity and hypnotizability, Dixon et al. (1990) hypothesized that if HH individuals process language with greater automaticity than the LH group, then they may also show greater facilitation and inhibition effects on the Stroop task. Using a paradigm that varied cue visibility and probability, they assessed automatic and strategic effects on Stroop performance. The authors reported that HH participants showed significantly greater Stroop effects for both visible and degraded-word trials than LH and medium hypnotizable (MH) participants. They concluded that these results supported the idea that HHs demonstrate stronger verbal connection strengths, and thus process verbal information more automatically.

In a follow-up experiment, Dixon and Laurence (1992) again used a variation of the Stroop color test in which participants were presented with one of two words, either BLUE or *RED* followed by a color patch. The participants had to name the physical color of the patch as quickly as possible. They were informed that 75% of the times the word presented predicted the color patch and that the best strategy was to use the word to predict what color patch would follow. By manipulating the Inter Stimulus Interval (ISI) (16.7, 50, 100, 200, 400, 800, or 1,600 ms) and the congruence probability (75 and 25%), the researchers were able to separate the effects of strategy from the effects of automaticity. They argued that if participants rely on strategic processing, they should name the color patch in incongruent trials faster than in congruent trials at long ISIs (over 400 ms). However, at shortest ISIs (16.5 ms), where there is no time to implement strategies, the congruent trials should be faster. Their results showed that both HH and LH participants showed significant strategic effects (faster incongruent-trial, color-naming reaction times than congruent-trial reaction times at ISIs over 400 ms), but only HH participants showed significant automaticity. Because strategic processing cannot happen at such speed, the authors concluded that HHs do show greater automaticity than LHs.

In a third experiment, Laurence, Blatt, Maestri, and Khodaverdi-Khani (1997) examined whether HHs were faster than LHs in acquiring automatization of shape names. They used MacLeod and Dunbar's (1988) procedure to test for individual differences in speed of automatization. This procedure is an analog to the Stroop color-word task in which participants were trained to name four novel polygon shapes as green, pink, orange, and blue. The rationale for this experiment was that as participants begin to learn the new task of shape naming their reaction times (RT) would be slower than their RT in the color-naming task, and the shape would not interfere with color naming. With practice, however, the shape naming would become faster and it would start to interfere with color naming. This is exactly what happened in the experiment. After 20 hours of practice, shapes interfered with color naming, reversing the original asymmetry. The authors concluded that automatization is a continuous process that is achieved through practice. Using this procedure, Laurence et al. (1999) provided HH and LH groups with extensive practice trials naming four novel shapes labeled RED, BLUE, GREEN, and YELLOW. Interference and facilitation effects from both colors and shapes were assessed following 288 and 2,304 shape-naming trials. The results indicated that HH participants were not only more automatized in their responses, but that they also appeared to progress faster in the automatization of shape-naming, than did the LH group. Once again we have support for the idea that automaticity is associated with differences in hypnotic responsiveness.

While these findings (Dixon, Brunet, & Laurence, 1990; Dixon & Laurence, 1992; Laurence et al., 1997) demonstrate that the HH group seems to differ from the LH group in the process of automatization, they do not mention why there would be individual differences in automaticity to begin with. It seems that the relationship between automaticity and hypnotizability is not causal. One reason for this assertion is that the time course of the development of hypnotizability and automaticity is different. Hall (1933) mentioned that the general nature of the relationship of direct verbal suggestibility to age has long been known. It is summed up in the common observation that children are more susceptible than adults (p. 83). Moor and Lauer (1963) showed that their sample of children scored higher on the scale of hypnotic susceptibility than did their adult sample. More specifically Morgan and Hilgard (1973) compared hypnotic susceptibility scores of 1,232 subjects, ranging in ages from 5 to 78 years. They reported that the peak of hypnotizability was in the age interval of 9 to 12 years, and that it remained relatively stable during the life span. Piccione, Hilgard, and Zimbardo (1989) demonstrated that hypnotizability is a stable trait and that people show the same level of hypnotizability over the span of 25 years. The time course of the development of reading automatization begins as children begin to learn to read and progressively acquire more automaticity with more practice (Stanovich & West, 1978, 1979, 1983; MacLeod & Dunbar, 1988). Additionally, not all hypnotic inductions are carried through verbal communication. For example, Mesmer used only signs to hypnotize his subjects (Laurence & Perry, 1988). As a result, it seems that the relationship between automaticity and hypnotizability might be due to an intervening factor. As Varga et al. (2011) and Farvolden and Woody (2004) suggested, HHs may have less efficient executive functions or have more difficulty in resolving conflict in working memory. In the next section, research literature is reviewed in light of findings that might point to the construct of working memory as the intervening factor.

1.2.4 Hypnotizability and working memory

The working memory system is generally described as the system responsible for active maintenance and manipulation of transitory information (Baddeley & Hitch, 1994). Working memory plays a central role in all domains of higher cognition, such as, intelligence, reading comprehension, skill learning, and complex problem solving (Ackerman, Beier, & Boyle, 2005; Barrett, Tugade, & Engle, 2004; Daneman & Carpenter, 1980). Since Miller's article in 1956, a large number of researchers have studied the effects of working memory on a wide range of cognitive tasks and have proposed different models to explain it (Baddeley, & Hitch, 1994; Baddeley, 1986; Cowan, 2005; Engle, 2001; Oberauer, 2009). Regardless of their view on the underlying mechanisms, all these models share the notion of limited capacity.

As one group of researchers (McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010) has pointed out, attentional control has been conceptualized as executive functioning by neuropsychologists and as working memory capacity by experimental psychologists. Kiyanoaga and Egner (2013) recently described working memory as internally directed attention and suggested that these two constructs, formerly deemed distinct, are in fact intimately linked. Indeed, some recent theories of cognition describe working memory as attention directed at internal representations (Awh & Jonides, 2001; Chun, Golomb, & Turk-Browne, 2011; Kiyonaga & Egner, 2013; Oberauer & Hein, 2012). McCabe et al. (2010), using factor analysis, examined multiple measures of working memory and executive function and reported that the correlation between these two constructs was very high (r = .97). They concluded that these two constructs share a common underlying executive attentional component. Given this close relationship between WM and attention, it seems to be fruitful to examine the role of WM in hypnotizability.

Baddeley's multicomponent model of working memory (1986, 2012) has been used successfully for the study of executive functions. At the heart of this model, there is a central executive component that regulates the flow of information and implements the task goals. This component is similar to the "supervisory attention system" proposed by Norman and Shallice (1986). The model also has three subsystems; one is specialized in the maintenance of speech information (the phonological loop), the second one is specialized in visual and spatial information (the visuo-spatial sketchpad), and the third component is an episodic buffer capable of integrating information from a variety of sources.

The reported individual differences in working memory capacity and processes may be useful for our understanding of hypnotizability. When comparing participants with high and low working memory capacity, a number of findings appear to mirror the differences found between HH and LH participants. For example, on simple tasks, the low working memory span group performs equally well and sometimes even better than the high working memory span group (Kane, Bleckley, Conway, & Engle, 2001; Kane & Engle, 2003), but on complex tasks, the low working memory span group performs poorer than the high working memory span group. In simple tasks, participants are required to perform one single operation at a time, but in complex tasks they have to perform a secondary task concurrently with the primary task (Daneman & Carpenter, 1980). The same pattern of results has been reported for low versus high hypnotizable participants, namely that the HH group performs better than the LH group on simple attentional tasks (Crawford, 1994; Mitchell, 1970; Karlin, 1979; Van Nuys, 1973; Wallace, Knight, & Garret, 1976;). As the task becomes more complex, the performance of the low working memory span group and the performance of HH participants deteriorates compared to the performance of the high memory span group and the performance of LH participants, respectively (Castellani et al., 2009). However, there is an exception to this pattern: HH participants perform better than the LH group on complex tasks that have become automatized through practice (Dixon et al., 1990; Dixon & Laurence, 1992). The possibility that the variations in the process of automatization could be due to variations in WM will be argued in the discussion.

Kane and Engle (2003) showed that the capacity of working memory, as measured by an operation task, is related to the Stroop interference effect. In their experiments, they presented subject with either many congruent (75%) or many incongruent trials (100%). They argued that with many congruent trials word reading allowed correct responses on most trials. However, with many incongruent trials, the context reinforced the color-naming goal and demanded one to ignore the words. When large numbers of congruent trials were presented, low working memory span individuals committed more errors than did high working memory span individuals on the rare incongruent trials. In contrast, in tasks with no congruent trials, the low span memory group showed more interference effects than the high working memory span group when the incongruent trials were followed by congruent trials. These findings are reminiscent of the interference effects observed in the hypnotizability literature where the HH group show more interference than the LH group (Blum & Graef, 1971), indicating that the low span memory group and the HHs might rely on more automatic or habitual responses.

In spite of evidence suggesting that executive control functioning impacts hypnotizability, and the close relationship between this system and working memory, only one study (Terhune, Cardena, & Lindgren, 2011) has partially examined the role of working memory in hypnotizability. In this study looking at dissociative tendencies in HH and LH participants, high dissociative high hypnotizable individuals were found to perform less well on a counting span test (C-span) than LH and low dissociative HH participants. Although indicative of a potential difference in working memory capacity or processes between HH and LH participants, the inclusion of dissociation as a selection variable precludes any strong conclusion about the role of working memory. The reported impaired working memory among a subset of HH individuals may have been linked to dissociation rather than hypnotizability.

Present Studies

The close theoretical relationship between attention and working memory as well as the results of studies on attention and hypnotizability invite the question of how working memory relates to hypnotizability. The above studies clearly show that differences in the capacity of working memory interact with various aspects of attention and could also be at play in the attentional differences found between HH and LH individuals.

In the first study, it was hypothesized that there is a negative correlation between working memory capacity and measures of hypnotizability. The main goal of this study was to provide an empirical basis demonstrating how individual differences in hypnotizability are related to working memory and attentional processes. As discussed previously, hypnosis research suggests that the HH group tends to follow hypnotic suggestions more attentively than the LH group and that they are less distracted by peripheral information. These abilities might have been developed as a consequence of limited resources available to the members of HH group. HHs might have learned to allocate all of their attention to the task at hand and to automatize tasks that might draw on the same limited resources. In the next section, two correlational studies designed to test this hypothesis are presented.

Experiment 1

Method

Participants

Thirty-eight individuals (12 males and 26 females) ranging in age from 19 to 50 years (*M* = 27.7 years, *SD* = 8.82 years) participated in the present study. They were recruited through an advertisement placed at the university. All participants underwent the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS: A) of Shor and Orne (1962) in small group sessions. The mean score of hypnotizability was 5.07 out of

12, with a standard deviation of 3.07. Participants were introduced to the screening procedure through the consent form, which they signed if they agreed to follow the procedure. Fourteen participants with a Harvard score of 3 or lower (*M* = 1.9, *SD* = 0.99), fourteen participants with scores of between 4 and 7 (*M* = 5.2, *SD*= 0.89), and ten participants with a Harvard score of 8 or higher (*M* = 9.3, *SD* = 0.94) were identified as low, medium, and high hypnotizable, respectively. Participants were not made aware of the connection between hypnotizability and WM tests.

Materials

To test participants' working memory, two measures of working memory were employed: a digit span test, consisting of two tasks (the digit span forward [DSF] and the digit span backward [DSB] tasks), and a reading span test (RS). These two tests were chosen to examine the potential contribution of the two components of WM, capacity and processes, to hypnotizability.

Digit Span

The digit span is a subset of the Wechsler Adult intelligence test (WAIS). This test is composed of two tasks: the digit forward and the digit backward tasks (Wechsler, 1997). In the digit span forward task, participants were read number sequences of increasing length (e.g., '3, 5, 2') and their task was to recall them in the correct order ('3, 5, 2'). In the backward digit span task, participants were read similar number sequences (e.g., '4, 8, 1') and after each sequence their task was to recall back the digits in reverse order ('1, 8, 4'). The participants' scores were calculated based on the total number of correct sequences they recalled. The digit span test consisted of 8 sets of different digit sizes. In each set, there were two digit sequences. In each test condition (e.g., the digit span forward), the trials began with the set of two digits and progressed to a larger set until the participant failed to recall both sets of the same length. The maximum total score for each condition was 16. For each subject, the forward digit span score, the backward digit span score and the total digit span score were calculated. The total digit span is the sum of the digit forward span and the digit backward span scores.

Reading Span

Sentences from Daneman and Carpenter (1980) were used in the reading span test. In this test, participants were presented with one hundred unrelated sentences that had to be read out aloud. At the end of each sentence, participants had to report 'yes' if the sentence was meaningful or 'no' if the sentence did not make sense. For example, at the end of sentence 1 and 2 below they would say NO, and at the end of sentence 3 they would say YES.

1-"When he reached the top of the heart, his mountain was pounding."
2- "The barn raged through the abandoned old fire."
3- "With a frown of pain, the old ranger hung up his hat forever."

Each sentence was written on a single card; participants kept reading from the pile of cards until they reached a blank card. The blank card signified that the trial was over and that they had to recall the last word in each of the sentences in the trial (e.g. 'pounding, fire, forever'). The 100 sentences were divided into five sets of 2, 3, 4, 5, and 6 sentences. As a result, participants read 5 sets of 2 sentences, 5 sets of 3 sentences, 5 sets of 4 sentences, 5 sets of 5 sentences and 5 sets of 6 sentences.

For each set, the total number of correct responses was calculated and transformed into the proportion of total for that set. For example, if a subject had a total score of 10 out of 15 for a set of three sentences, his proportion score would be (10/15) * 3 = 2. The sum of the proportion scores for all the sets was the total reading span score.

The University Human Research Ethics Committee at Concordia University approved all experiments reported in this chapter (certificates 10000016 and 30002144), and all observers provided written consent.

Results and discussion

For each subject, the reading span score, the forward digit span score, the backward digit span score, and the total digit span score were calculated as it was described in the materials section. The total digit span score is the sum of the digit forward span and the digit backward span scores. Before analyzing the data, all variables were screened for missing data, outliers, and statistical assumption violations with SPSS (22) Frequencies, Explore, Plot procedures. Using a variety of techniques, no missing data and no univariate outliers were detected. The inspection of the distributions of hypnotizability data and digit span scores for skewness and kurtosis revealed that these statistics were also in the expected ranges (Table 1).

To estimate the correlation between the measures of working memory and hypnotizability, a correlation analysis was performed on the data using SPSS (version 22). The results from these analyses are presented in Table 2.

Although, the trend of correlations between hypnotizability and all the measures of working memory was in negative direction, only the digit span backward task and the digit span total score were correlated significantly with hypnotizability (DSB: *r* [36] = -.35, *p* <.05, R^2 = 0.12; DST: *r* [36] = -.35, *p* <.05, R^2 = 0.12). These correlations indicate that HH participants had smaller WM capacity in comparison to MH and HH participants.

The relationship between WM memory and hypnotizability has not been explored directly in previous research. Moghrabi (2005) who was studying the correlates of hypnotizability and imaginativity reported a negative correlation between imagery measures and WM measures in participants who passed the cognitive suggestions. When we re-examined her data in regards to hypnotizability, a significant negative correlation emerged between hypnotizability and WM. Terhune, Cardena, and Sweden (2011) studied the relationship between hypnosis and dissociation and demonstrated that dissociative tendencies modulated individual differences among HH participants. In their study, a sub group of HHs who were also high dissociative were more responsive to hallucination suggestions, experienced greater involuntariness during hypnotic responding, and exhibited impaired working memory capacity. The negative correlations found here add to what Terhune et al. (2011) and Moghrabi (2005) reported previously.

As mentioned before, the DSB reached significance. It might be that these two measures (DSF and DSB) are indexes of different cognitive processes. Specifically, the DSF may be an index of WM capacity, whereas the DSB may index both capacity and process. If HHs have a less efficient WM, this deficit may play a role when participants with low capacity WM are confronted with attentional tasks that may tax WM capacity or processing speed.

Table 1

Mean Scores, Standard Deviations and Statistics for Skewness and Kurtosis for Hypnotizability, Reading Span, Digit Span Forward, Digit Span Backward and Digit Span Total in Experiment 1

	N	*M*	*Min*	*Max*	*SD*	*Skewness*	*Kurtosis*
Hypnotizability	38	5.07	0.00	11.00	3.07	.29	.89
Reading Span	38	5.42	2.70	8.40	1.29	-.15	-.05
Digit Forward	38	9.05	4.00	12.00	2.09	-.37	-.56
Digit Backward	38	7.44	3.00	12.00	2.15	.18	-.54
Digit Total	38	16.50	7.00	24.00	3.63	.40	.42

Table 2

Correlations for Hypnotizability, Reading Span, Digit Span Forward and Digit Span Backward

	Hypn.	RS	DSF	DSB	DST
Hypnotizability	1	-.18	-.25	-.35*	-.35*
Reading Span		1	.49**	.25	.43*
Digit Forward			1	.47**	.85**
Digit Backward				1	.86**

Note. Hypn = hypnotizability; RS = reading span; DSF = digit span forward; DSB = digit span backward; DST = digit span total. $*p < .05$; $**p < .01$

Experiment 1b

To test whether the negative correlation between hypnotizability and the measures of working memory obtained in the first experiment would be replicated with extreme groups on the hypnotizability scale, the next experiment focused on very HH and very LH participants. The selection of these extreme groups should allow any real difference between them to be teased apart. A new cognitive task also indexing working memory, the N-back task, was administered in an attempt to examine the contribution of speed of processing and the capacity of WM to hypnotizability.

Method

Participants

Ten HHs (with a Harvard score ≥ 10) and ten LHs (with a Harvard score ≤ 2) Concordia university students who previously have been tested on the Harvard Group Scale of Hypnotizability Form A (HGSHS: A) of Shor and Orne (1962) were recruited for this study in exchange for course credit. Participants were introduced to the screening procedure through the consent form, which they signed if they agreed to follow the procedure. The main experimenter was blind to the participants' hypnotizability group. The groups were comprised of 15 females (eight HHs, and seven LHs) and five males (two HHs and, three LHs), with a mean age of 25.7 ($SD = 9.52$) and 27.60 ($SD = 12.9$) years, respectively.

Materials and Procedure

The reading span test used in experiment one was not a suitable measure of working memory for our mostly bilingual population, because this test may predict other cognitive abilities such as reading skills (Daneman & Carpenter, 1983). We tested if participants who selected English as their first language performed differently on the reading span test than those who marked English as second or third language on the participant's form. A significant difference emerged (t (29) = 2.12, p .04, $d = .79$). Native speakers performed better than the second language group. For this reason, we replaced the reading test with a more language neutral test called the N-back test (Cohen et al., 1997; Schmiedek, Hildebrandt, & Wilhelm, 2009). In this test, participants were presented with a sequence of letters one at a time on a computer screen. Their task was to evaluate each letter as to whether it matched another stimulus presented two steps prior in the sequence. Whenever the participants identified a matched letter, they rendered their response by pressing a key on the keyboard. In order to familiarize the participants with the task, a set of practice trials were presented. To evaluate potential changes in the automatization of responses to the N-back tasks as a function of practice, three successive blocks of 99 trials were presented with a break of 2 minutes between the blocks. Thirty-three of the trials per block were target letters (i.e., 33%). Letters were presented on the screen for 1.5 seconds, with a 2-second interval between letters. Participants sat 43 cm away from the computer screen (Dell precision computer and PWS 390 and Dell monitor M992 with resolution of 1600 X 1200 at 75 Hz refresh rate). Letters were presented in the center of the screen in a Times New Roman font, size 75.

The same digit span test used in experiment 1 was administered with an additional component "called digit span sequencing" (Young, Sawyer, Roper, & Baughman, 2012). In this task, participants were orally presented a series of digits and their task was to verbally repeat the numbers back in ascending order. For example, if the presented numbers were '3, 7, 5, 2,' the correct response would be '2, 3, 5, 7'. The digit sequencing task measures the capacity of working memory and the processes necessary for the manipulation of information. There were 8 sets of digit sequences and 2 sequences per set. The sequences were comprised of 2 to 9 digits. The maximum score one could achieve was 16.

Statistics

The digit span scores were transformed in percentages of correct responses for clarity. For the N-back test, number of hits and mean response time for hits were analyzed. The coefficient of variability (CV) was calculated for the hits. CV is defined as the standard deviation divided by the mean (CV = SD / M). The CV provides an index of RT variability that takes into account the mean RT which can vary from individual to individual. This measure provides an index of the efficiency (automatization) and stability of the responses (Segalowitz & Segalowitz, 1993; Howell, 2013). SPSS (version 22) was used for all statistical analyses.

Results

As can be seen from Table 3, the magnitude, direction and significance of the relations between hypnotizability and measures of working memory were replicated. Table 4 presents the mean and standard deviations of HH and LH participants on the digit span task.

To evaluate if participants' performance on the N-back task changed with practice, the number of hits per block of trials was analyzed using a 2 (LH and HH) by 3 (blocks) repeated measure ANOVA (Appendix A, Table 1). The analyses indicated that the block by hypnotizability interaction was statistically significant (*F* (2, 36) = 4.55, $p <$ .01, η_p^2 = .20). Figure 1 illustrates this interaction. Post hoc comparison with a Bonferroni t-test revealed that LHs' performance decreased from B1 to B2 (p = .08, d= 0.62) and did not change from B2 to B3, whereas HHs' performance significantly improved from B1 to B3 (p = .03, d = 0.91). As can be seen from Figure 1, LHs and HHs did not differ during the first block. However, from there on, HHs improved their performance, while LHs' performance decreased. There were no main effects of blocks (*F* [2, 36] = 0.741, $p >$ .05, η_p^2 = .04) nor of hypnotizability (*F* [1, 18] = 0.09, $p >$ .05, η_p^2= .01), To test if the number of false alarms was similar for the HH and the LH groups, the number of false alarms per block were analyzed using a 2 (LH and HH) by 3 (blocks) repeated measures ANOVA. There were no main effect of blocks (*F* [2, 36] = 2.60, $p >$ .05, η_p^2 = .126) nor of hypnotizability (*F* [1, 18] = 0.06, $p >$ .05, η_p^2 = .003). The interaction between block and hypnotizability was not statistically significant either (*F* [1, 18] = 0.09, $p >$ .05, η_p^2 = .01). Thus, the analysis of false alarms indicated that the improved performance of HHs was not due to a trade-off between speed and accuracy.

To better understand the effects of training on the performance of the groups, we calculated the coefficient of variability (SD/mean) for the RT data (Segalowitz & Segalowitz, 1993). Although the repeated measures ANOVA did not reveal any significant difference between blocks (*F* (2, 17) = 1.16, $p >$ .05, η_p^2 .12), or any significant interaction (*F* (2, 17) = 0.04, $p >$ .05, $p >$ .05, η_p^2 = .01), HHs displayed a CV that was consistently lower than that of the LHs (see Table 5). The lower CV of HHs may indicate that their performance became more efficient and stable.

Given that the N-back task may not have been a sufficiently difficult working memory task to differentiate HHs from LHs, we analysed the CVs using WM measure as covariate in an analysis of covariance (ANCOVA). This would statistically equate participants on WM capacity and assess the effect of practice on participants' performance in the N-back task. (Appendix A, Table 2). Table 5 presents the CV data per group and per block, taking WM performance (DSF) into account. The analyses revealed an interaction trending towards statistical significance between WM performance with blocks (F (2, 16) = 3.14, p = .056, η_p^2=.156). This analysis also revealed a statistically significant effect for blocks (F (1, 17) = 3.69, p = .038, η_p^2 = .175). Table 5 reports the means and standard errors by blocks of the CVs with and without WM as a covariate for HH and LH participants. Figure 2 illustrates the pattern of CV responses across the three blocks of trials with WM as a covariate. As can be seen from Figure 2, the mean coefficient of variability decreased from B1 to B3 for HHs, whereas the mean CV of LHs increased from B1 to B3 (Appendix B, Table 6).

Table 3

Spearman Correlations between Digit Span Forward, Digit Span Backward, Digit Sequence and Hypnotizability (N = 20)

	Digit Forward	Digit Backward	Digit Sequence	Digit Total
Hypnotizability	-.41	-.63**	-.37	-.70**
Digit forward		.53*	.13	.73**
DigitBackward			.36	.84**
Digit Sequence				.64**

*. Correlation is significant at the $p < 0.05$ level (2-tailed).

**. Correlation is significant at the $p < 0.01$ level (2-tailed).

Table 4

*Means and Standard Deviations (in parentheses) for the Digit Span Task for High and Low Hypnotizable Participants**

Group	Hypnotizability	Digit Forward	Digit Backward	Digit Sequence	Digit Total
Highs	10.20_a	60.62_a	50.62_a	58.75_a	56.66_a
	(0.42)	(11.80)	(8.56)	(9.40)	(6.57)
Lows	1.10_b	72.5_b	69.37_b	67.50_a	69.80_b
	(0.73)	(9.86)	(13.32)	(11.71)	(8.00)

* Column wise, means with different subscripts differ at the $p < .05$.

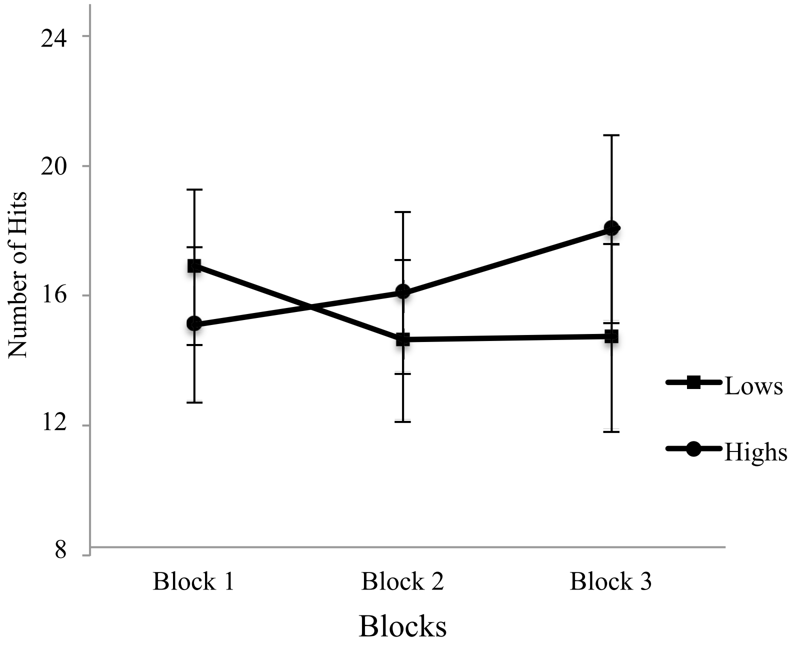

Figure 1. Numbers of hits per block on the N-back task. Error bars represent the standard error of the mean.

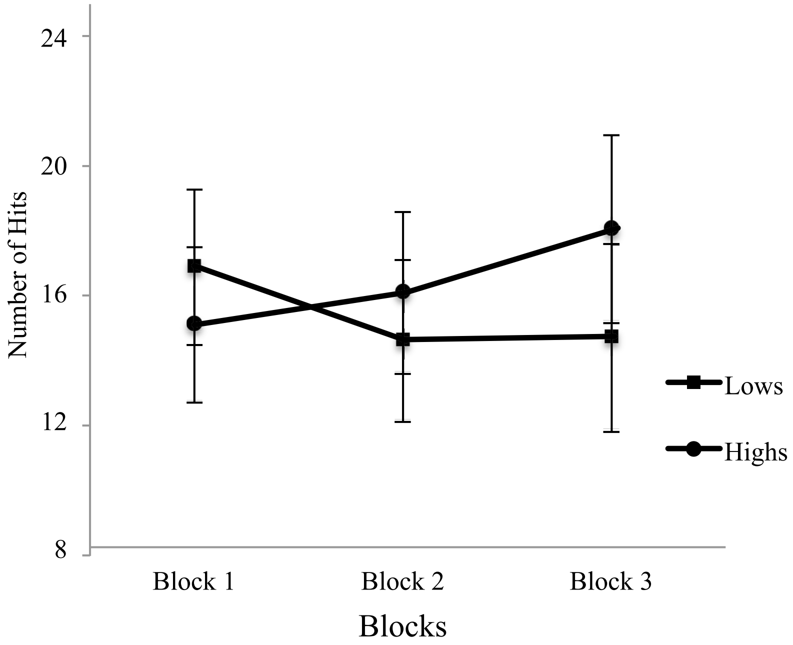

Figure 1. Numbers of hits per block on the N-back task. Error bars represent the standard error of the mean.

Table 5

Mean CV and Standard Error per Block for High and Low Hypnotizable Participants with DSF Performance as a Covariate (CVs without co-varying DST are shown in parentheses)

	High Hypnotizable		Low Hypnotizable	
	M	*SE*	*M*	*SE*
Block 1	0.21 (0.20)	0.03 (0.02)	0.21 (0.22)	0.03 (0.03)
Block 2	0.21 (0.24)	0.04 (0.03)	0.29 (0.27)	0.04 (0.04)
Block 3	0.17 (0.22)	0.03 (0.02)	0.28 (0.24)	0.03 (0.03)

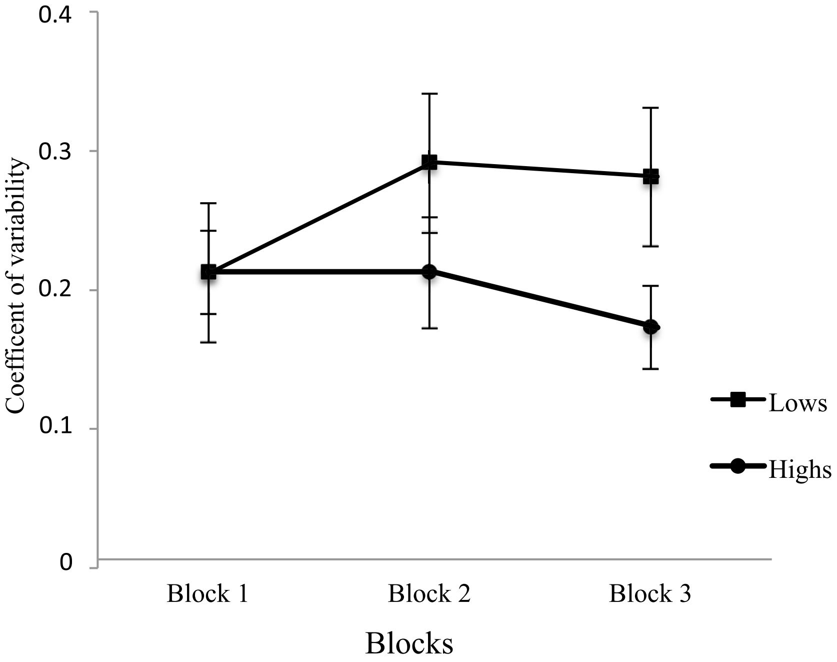

Figure 2. The interaction between coefficients of variability (CV) and blocks. Error bars represent the standard error of the mean.

Discussion

For the first time in hypnosis research the results from the above correlational studies showed that there is a negative correlation between measures of hypnotizability and measures of working memory. This study helps to clarify the relationship between hypnosis and WM by demonstrating that HH participants exhibited impaired working memory capacity. Working memory is considered to be central in different aspects of human cognition. Many models have hypothesized that WM span measures some limited resource sharing capacity within a central executive system. It has been shown that the variation in WM contributes to the differential performance of people on many mental and motor tasks (Barrouillet, 1996; Daneman & Carpenter, 1983; Kyllonen & Christal, 1990; Miyake, Just, & Carpenter, 1994) mostly through a dynamic interaction between memory maintenance and attentional control (Baddeley, 1993). Consistent with the above studies, the results of the present experiments revealed differences between HH and LH participants in WM capacity and speed of processing as well as attentional control and the process of automatization. Furthermore, the correlation between digit span and hypnotizability indicates that the storage of working memory is a crucial component in this relation.

A close inspection of the components of the digit span task reveals that it is not a pure measure of storage. The digit span forward is the most direct measure of maintenance as participants simply must recall the numbers as they were presented to them. On the other hand, both the digit span backward and the digit span sequencing are indices of working memory processes, as they require participants to maintain the numbers in their mind, while manipulating the sequence in which they were presented (e.g., to sort the digits in temporal order for digit backward and to sort them in ascending order for digit sequencing). Thus, the digit span task measures two functions of working memory: maintenance and process.

The performance of HH and LH participants on the N-back task provides additional support for the assertion that HH may have superior attentional capability. As Figure 1 shows, the two groups performed similarly at the beginning of the session, with slightly more number of hits for the LH group. As the session progressed, however, the number of hits for the HH group increased but the performance of the LH group dropped.

To perform the N-back task, at any moment in the course of the experiment, participants need to maintain two letters in their working memory. Holding two letters in WM is well below the capacity of all participants' WM and does not tax memory unduly. A defining characteristic of the N-back test is that it requires a continuous focus of attention on the task and the person should not be distracted by external or internal stimuli. This characteristic may separate the performance of the HH from the LH group. Upon review of the analysis of the coefficient of variability, one could observe a difference in attentional processing between HHs and LHs. When CV data were analyzed with ANOVA, there was no main effect for hypnotizability, thus no difference in participants' speed of response. However, as Figure 2 shows, by partitioning out the effect of working memory in an ANCOVA analysis, it became clear that the HH group had a more stable and efficient performance than the LH group, most likely indexing a more automatized response as the three experimental blocks of trials unfolded.

Chapter 2

Introduction

Visual search task

Based on the results from experiments 1 and 1b, one can posit that HHs and LHs differ on executive control and processing with regards to working memory. Given the association between individual differences in hypnotizability and automaticity, if these individual differences are in part a by-product of variation in WM resources, the question that needs to be empirically addressed is: Is the process of automatization influenced by working memory capacity? Following Laurence et al. (1999) it may be interesting to see if HHs could develop the process of automatization with fewer sessions, as compared to LH, given enough practice performing a task that taxes WM capacity. To test this, we used a visual search paradigm which is one of the most successful paradigms employed in research on selective attention because of its versatility (see Wolfe, 2010 for a recent review). It offers many possible ways in which search tasks can be adapted to investigate the various aspects of selective visual processing (Krummenacher, Müller, Deubel, Wolfe, & Humphreys, 2010). In the case of our mostly bilingual participants, the visual search paradigm is particularly appropriate because all participants would equally benefit from practicing it as it is neutral in regard to verbal information.

In a typical visual search experiment, participants are presented with a target item to remember, followed by a visual display containing characters. The subject has to decide as quickly and as accurately as possible whether or not the target is present among the visual display. On about half of the trials, the target is present among the distractors.

To explain the process of target detection, Treisman and Gelade (1980) developed the Feature-Integration Theory (FIT), which has greatly influenced the study of visual search. This theory assumes that in the early stages of visual processing, the visual display is decomposed into a number of elementary features. For instance, color, luminance, and orientation are regarded as simple features (Treisman & Sato, 1990). If the target item contains a unique feature, for example the color red and the target is surrounded by green distractors, then the target will be detected quickly, and the RT will be independent of the number of distractors. This type of visual search stimuli, where the unique feature can be detected rapidly irrespective of the set size, is known as a parallel search (or "pop-out" search). That is, the information is processed simultaneously across the feature maps, such as color and orientation maps, without effort or the need for the involvement of the spotlight of attention, also known as focused attention (Treisman & Gelade, 1980). However, the detection of a target amongst distractors becomes more complicated when the target is defined by the presence of a conjunction of two different features, and each half of the distractors shares one of the features with the target. For instance, when the target is red and vertical, and the distractors are either red and horizontal, or green and vertical. According to the FIT, search stimuli that contain a conjunction require a serial search which is slower than the parallel search. (Wolfe, Cave, & Franzel, 1989). Feature-Integration Theory assumes that in a conjunction search, each stimulus must be attended to in sequence. Only when a location is encountered where there is activity in both feature maps (e.g., in the example above, when the target orientation is vertical and the target colour is red) can the participant signal that the target has been found.

The serial-parallel dichotomy proposed in the FIT has been incorporated into other search models. For instance, the Guided Search model (Wolfe, 1994) adopts a two-stage architecture. The first stage detects all simple features in parallel. During the first stage, the information activated by simple features is added and registered in a global map of activation in which each location represents the probability of containing a target. Then the processed information from the first stage is used to guide a second stage that is serial in nature, and that takes place within limited areas of the visual field. In the second stage, attention is directed to the location with the highest activation level. However, according to McElree and Carrasco (1999), the RT logic that motivates models such as the FIT and the Guided Search Model (GSM) provides less than satisfactory grounds for drawing a sharp dichotomy between parallel and serial processing. As a consequence, another search model has been proposed to account for the differential impact of set size on mean RT. Duncan and Humphreys (1989) argued against the FIT. They believed that the similarities of the target and distractors were more important, as opposed to the number of features that was stressed in the FIT. When the distractors are similar to the target, the RT is longer than when the distractors are dissimilar. This suggests that more attention, and a longer search, will be required in order to identify a target among similar distractors. In the real world, it is very rare to have a true feature search for the only green item among homogeneous distractors. In the latest model of the guides search Version 4.00 (Wolfe, 2007), the process of object recognition is considered as an asynchronous diffusion process. In this version of the model information begins accumulating for a selected item. Then, if that information reaches a target threshold, a target-present response is generated. Otherwise, if that information does not reach a target threshold, the item is rejected as a possible target. The distinction between serial and parallel models of visual search is blurred in this version of the model. If the system can handle only one item at a time, you have a strict serial model. However, if all items can be handled at the same time, the model is a parallel one.

It has been shown that the detection of a target among similar distractors becomes more efficient when there is a consistent stimulus-to-response mapping (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). In an environment where the target set and the distractor set are chosen from two different pools of stimuli, the mapping is considered to be consistent (CM). In the varied mapping (VM) procedure, the targets and the distractors are chosen from one pool of stimuli. In the CM procedure, participants are expected to develop a learned attentional response to the targets as they search for basic features. In this sense, the well-practiced search no longer imposes capacity demands and runs effortlessly, and participants do not need to search serially for it, because the target pops out of the display.

Several studies have focused on the possibility of a relationship between hypnotizability and visual search performances. For example, in a series of experiments, Wallace (1984, 1990, 1994) presented HH and LH participants with pictures and asked them to find embedded objects in the pictorial scene. The list of embedded objects was presented to the participants before they saw the pictorial scene, thus, they knew what objects to look for. One group of participants received instructions about how to find the objects and the other group searched for the objects without any instructions. The participants were instructed to spend around twenty seconds to familiarize themselves with the list of objects to be searched for and to try to form an image of them. The results indicated that the HH group did equally well in both the instruction and no instruction condition, whereas the LH group did worse than the HH group in the no instruction condition but performed equally well in the instruction condition. Wallace concluded that the HH group used search strategies and these strategies could be thought to improve their performance on a cognitive search task. This assertion is supported by two additional studies conducted by Wallace, Allen, and Weber (1994) where they investigated the role of hypnotic susceptibility level and imaging ability in the performance of a visual search. In this version of the visual search, participants were presented with a matrix of 15 X 15 letters and their task was to find words in horizontal, vertical, or diagonal orientations embedded in such matrices. His results showed that subjects who were high in hypnotic susceptibility and vivid in imaging ability found a greater percentage of target words and performed the task the fastest. He concluded that "such superior performance of subjects with high in hypnotic susceptibility and vivid imaging ability can be attributed to the greater ability of these subjects to use their attentional skills and imagery in the performance of the visual search (p. 34)". Specifically, those who performed the visual search most expediently appeared to be using a holistic search strategy (Crawford & Allen, 1983), whereas those who performed more slowly appeared to be using a detail search strategy.

Visual search has also been studied in relation to working memory in several studies. For example, Kane, Poole, Tuholski, and Engle (2006) correlated individual differences in working memory capacity (WMC), as measured by complex span tasks, with subjects' performance on visual search. They reported that in feature-absence search, conjunction search, and spatial configuration search, WMC was unrelated to subjects' performance on visual search.

In another experiment, however, Poole and Kane (2005) showed that the capacity of working memory would predict latencies in visual search. In their experiment, subjects were cued about the location of the target when it was presented alone or among distractors. Participants had to fixate on the cued location until the target appeared at either a short (300 ms) or long delay (1500 ms). The authors reported subjects with greater WMC identified targets faster compared to subjects with low WMC only when distractors were present and the fixation delay was long. It is possible that the results from the Poole and Kane (2005) study indicate that working memory is related to executive functioning, whereby participants high in working memory have greater executive control in a cued search task when given enough time to prepare for the visual search. Evidently, the task needs to be somewhat difficult for WM to need to recruit executive functioning thus it would make sense that subjects high in WM only performed better when distractors are present. Further evidence for the link between WM and executive functioning comes from a study by Han and Kim (2004), who asked their participants to search for a target among distractors while performing a secondary task which manipulated information held in WM (counting backwards from a target digit and remembering the outcome). They reported that WM resources related to executive functions may be required in visual search.

Experiment 2

While the aforementioned studies devoted their attention toward uncovering the principles of human visual search and its relationship with WM, in the following experiment we use the visual search paradigm to examine the effects of WM on the process of automatization. Using the consistent mapping (CM) procedure, the present study attempted to manipulate the capacity of working memory and explore the effects of this manipulation on the process of automatization in different groups of hypnotizable participants. Based on the results of the N-back study (Chapter 2, Experiment 2b), and the findings from Laurence et al. (1999), it was expected that HHs would attain an automaticity level in fewer sessions compared to the LH or MH groups, regardless of the load condition. The second hypothesis this study investigated was that if the process of automatization was due to the limited resources available to participants, then it would be expected that participants in the high load condition would reach automaticity in fewer sessions regardless of their hypnotizability level.

Method

Participants

Thirty-eight individuals (12 male and 26 female) ranging in age from 19 to 50 years (*M* = 27.7 years, *SD* = 8.82 years) participated in the present study. They were recruited through an advertisement placed at the university. All participants underwent the Harvard Group Scale of Hypnotic Susceptibility in small group sessions. The mean score of hypnotizability was 5.07 out of 12, with a standard deviation of 3.07. Participants were paid 25$ for their participation in five sessions. Fourteen participants with a Harvard score of 3 or lower (*M* = 1.9, *SD* = 0.99) were identified as LHs, fourteen participants with Harvard scores between 4 and 7 (*M* = 9.3, *SD* = 0.94) were identified as medium hypnotizable (MHs), and ten participants with a Harvard score of 8 or higher (Mean = 9.3, *SD* = 0.94) were identified as HHs participants.

Materials and Procedure

Participants were introduced to the screening procedure through a consent form, which they signed if they agreed to follow the procedure. After the initial screening test of hypnotizability, a research assistant helped with the selection and scheduling of participants to ensure that the experimenter was blind to each participant's hypnotic level. Participants were randomly assigned to one of three experimental conditions ("no load", "medium load" and "high load"). The load was a sequence of 0, 3, or 5 digits presented to participants on the computer screen prior to each trial. Participants were required to remember these digits and to type them in after each trial. They sat 43 cm away from the screen with their head placed on a chin rest to reduce head movements. To familiarize participants with the task, they were presented with sixteen practice trials. During the practice trials, they were given feedback on their performance.

Participants underwent 5 identical sessions where they had to perform a computer task called "Visual Search". In this task, subjects were presented with a red dot in the middle of the screen. By clicking the 'start trial' button, the red dot disappeared and a memory load was displayed for 200 ms. Memory loads were a sequence of three or five digits that needed to be remembered. After the presentation of the memory load, a target letter was presented for 120 ms, and it was followed by the display of a set of letters called distractors. The letters A, B, C, and D were designated as target letters and the remaining letters of the alphabet were designated as the distractors. The subjects' task was to determine as quickly and as accurately as possible whether the target letter was present among the distractor letters. On fifty percent of the trials, the target was present. After giving the Yes-No response using the number key pad, participants were asked to type in the memory load. In the "No load" condition only the target letter was presented and the subjects' task was to decide whether the target was present or not. Depending on the condition to which the participant was assigned, a session lasted from 25 to 50 minutes. Each session consisted of 320 trials with half of the trials (160) containing a target letter. The trials were presented randomly with the constraint that no more than five targets of the same type could follow each other. No more than five trials of target present or target absent followed each other, and no more than five trials of the same distractor trials followed each other. The target and distractors were randomly presented in an invisible matrix of 5 by 5 cells for a total of 25 possible locations. The letters were presented in New Century Schoolbook font, size 14. At the beginning of each new session, participants were encouraged to perform as fast and as accurately as they could.

Results

Before analyzing the data for each subject in each session the outliers were identified. Reaction times larger than three standard deviations above or below the mean of the respective condition were identified as outliers and replaced by the score that was one unit smaller or larger than the next most extreme score in the distribution, as suggested by Tabachnick and Fidell (2000). These processes were repeated, a maximum of three times, if it was necessary. On average less than 1.7% of the scores were detected as outliers (Appendix C, Table 1 [A, B, C] displays the descriptive statistics for different groups of hypnotizability).

Instead of reporting the results for the mean RT and the SD separately, the results from the analyses of the coefficients of variability (CV) will be reported, as this measure combines the information of the mean and SD into a single value. A CV was calculated for each participant by dividing the standard deviation of each condition (five sessions by four distractors) by the mean response time for each condition. In using the CV, we are scaling the SDs by the magnitude of the mean. This combined measure provides a more informative index of participants' performance (Howell, 2013). The complete analysis of mean RT for target present and target absent can be found in Appendix D.

A 3 x 3 x 5 x 4 (Hypnotizability by Load by Session by Distractors) between-within analysis of variance (ANOVA) was performed on the CVs. In this analysis, hypnotizability (high, medium and low) and load (0, 3, 5) served as between subject factors, and the within subject factors consisted of session with five levels (1, 2, 3, 4, 5) and distractor with four levels (1, 3, 7, 15). It was expected that with practice the mean RT and the mean SD of all participants' performance would decrease. However, for HHs the SD should decrease more than the decrease in RT compared to the MHs and the LHs, resulting in lower CVs. Furthermore, it was expected that participants in the high load condition group would have lower CVs by the end of the fifth session of the experiment.

The interaction between session and hypnotizability was significant (F [8, 116] = 2.31, $p < .02$, $\eta_p^2 = .13$). The source of the interaction, as Figure 3 shows, is due to the fact that the CV of the HH group in the first session was higher than the CVs of the LH and MH groups. However, by the fourth session, the CV of the HH group dropped to the lowest level in comparison to the CVs of the LH and the MH groups. This conclusion was supported by a test of simple effects using Bonferroni corrected t-test (Appendix B, Table 1). The presence of this interaction indicates that the performance of HHs became more stable (or automatized) with practice.

The interaction between session and load was also significant (F (8, 116) = 2.5, $p < .01$, $\eta_p^2 = .147$). The source of the interaction, as Figure 4 displays, is due to the fact that in the first session the CV of the high load group was slightly (but not significantly) higher than the CVs of the medium load and the no load groups. By the fourth session, the difference between the CV of the high load group was significantly lower than the CVs of the medium load and no load groups. This assertion was supported by a test of simple effects using Bonferroni-corrected t-test (Appendix B, Table 2). Taxing memory of participants had greater effects for high load group in comparison with the medium or no load group.

The main effect of session was significant (F (4, 116) = 12.7, $p < .001$, $\eta_p^2 = .30$) with means and 95% CIs of 0.238 [0.221, 0.255], 0.220 [0.202, 0.238], 0.207 [0.195, 0.220], 0.198 [0.187, 0.210], 0.194 [0.181, 0.208] for session 1, 2, 3, 4, and 5, respectively (the complete ANOVA tables can be found in Appendix A, Table 3). The Bonferroni pairwise comparison test indicated that all means were significantly different from each other (Appendix B, Table 3). All participants benefited from practice in finding the targets

The main effect of distractor was significant as well (*F* (3, 87) = 154, *p* < .001, η_p^2 = .84) with means and 95% CIs of 0.169 [0.159, 0.182], 0.179 [0.165, 0.192], 0.225 [.213, 0.238], 0.273 [0.259, 0.288] for distractor 1, 3, 7 and 15, respectively (Appendix B, Table 4). Participants had more difficulty in finding targets as the number of distractors increased.

To compare the results of the target present condition with the results of the target absent condition, the CVs for the target absent condition were calculated. The analyses revealed that the interaction between session and hypnotizability (F (8, 116) = 0.885, p = .531, =η_p^2 = 0.058) and the interaction between load and session (F (8, 116) = 0.842, p = .5681, =η_p^2 = 0.055) were not significant. These results indicate that the nature of processes in the target present and target absent conditions were different. Specifically, it seems that only in the target present condition the process of automatization happened.

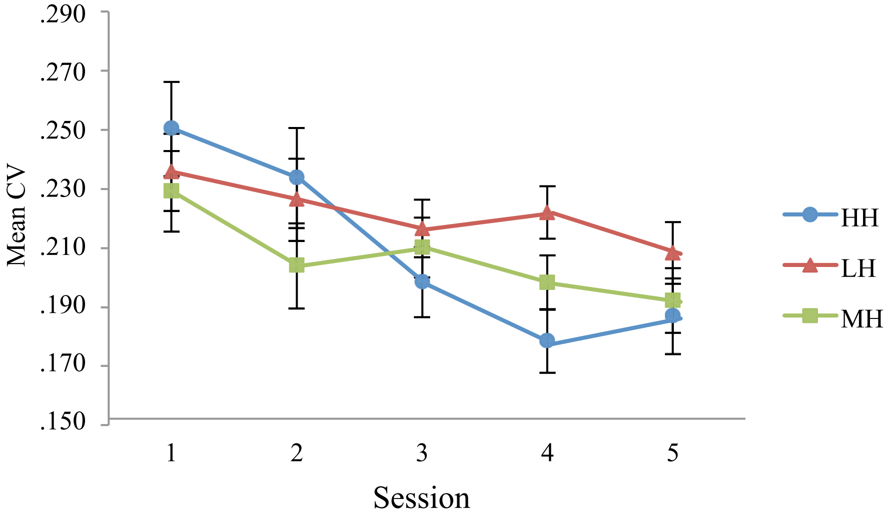

*Figure 3***.** The interaction between session and hypnotizability for CVs in experiment 2. HH (high hypnotizable), LH (low hypnotizable), MH (medium hypnotizable). CV is the coefficient of variability. Error bars represent the standard error of the mean.

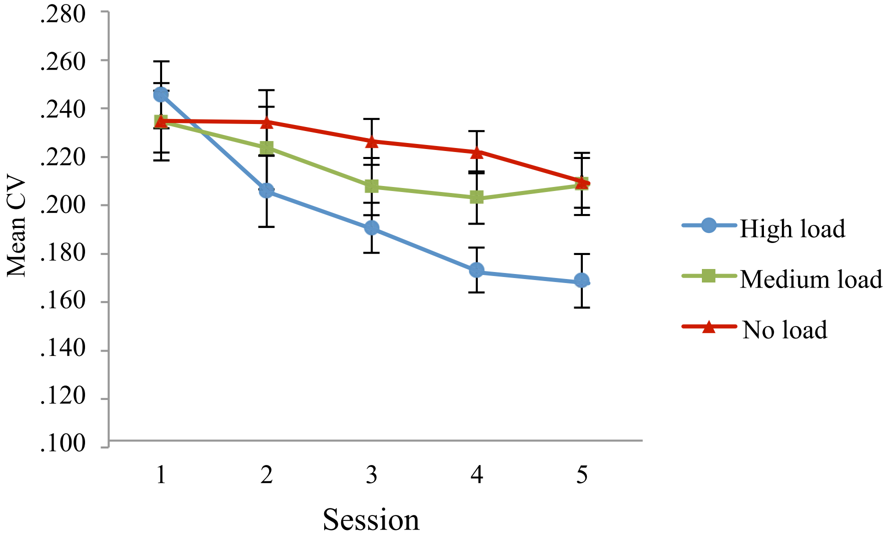

Figure 4. The interaction between session and load for CVs in experiment 2. HH (high hypnotizable), LH (low hypnotizable), MH (medium hypnotizable). CV is the coefficient of variability. Error bars represent the standard error of the mean..

Discussion

In the present study, two hypotheses were tested with regards to automatization. First, following Laurence et al.'s (1999) article, it was postulated that HHs would attain an automaticity level in fewer sessions compared to the LH or the MH groups regardless of the load condition. Second, it was expected that participants in the high load condition would reach automaticity in fewer sessions than the no-load and medium load groups, regardless of their hypnotizability level. This hypothesis was based on the idea that the High load condition would tax all participants' working memory, leading to a greater need to automatize.

The results from the CV analyses showed some support for both hypotheses. The HH group had a higher CV than the MH and the LH groups in the first session; by the fourth session, however, their CVs were significantly lower than the MH and the LH groups. A very similar interaction was observed for the load condition. The CVs for the low load condition did not change over sessions and the CVs of the medium load changed slightly from session one to session four. However, the CVs of the high load group clearly decreased from session one to session five. Since there were no other higher order interactions, these two-way interactions may provide direct support for the two hypotheses. The analyses of the CVs revealed that the performance of the HH participants and the high load group became more efficient over sessions in the visual search experiment.

The literature on visual search argues that in the target present condition, the search for the target would terminate as soon as the target is detected (Schneider & Shiffrin, 1977; Wolfe, 2010), however, in the target absent condition, the search continues until all the elements of the display are checked (Schneider & Shiffrin, 1977; Wolfe, 2010). As a result, the RTs in the target absent condition would be longer than the RTs in the target present condition. Another difference between the search in the target present and in the target absent conditions is that in the target present condition participants reported that the target would pop out and they would not need to search all the elements in the display. However, in the target absent condition, the pop-out effect would not happen. Comparing the results for these two conditions is informative about the nature of practice effects. If practice has the same effect on both conditions, one reasonable conclusion would be that the same processes underlie the two types of search. On the other hand, different pattern of results might indicate that searching for a target in the two conditions relies on different processes. By comparing the results from the CV analyses in the target present and in the target absent conditions, support was found for the theory that HHs are able to develop automatization progressively. In the target absent condition, the only significant effects were the main effect of session and the main effect of distractor. However, in the target present condition, the analyses revealed that HHs had a larger CV in session one but by session five their CVs were the smallest among the groups.

Similarly, the CVs for the high load condition were more reduced than the CVs of the medium load and no load conditions. The presence of these two interactions (session by hypnotizability and session by load) may provide support for the automatization of the visual search by HH and by participants in the high load condition.

Consistent with the findings of MacLeod and Dunbar (1988), the present results revealed that the automatization of a task performance develops gradually. In the present study, the main effect of session for all participants may indicate that a gradual development of efficient performance began from the second session and continued until the fifth session. Furthermore, while MacLeod and Dunbar (1988) did not address the question of individual differences in their study, our results point to the potential difference between the development of automaticity in the HH and the LH groups. In this regard, our results are consistent with Dixon et al. (1990), who demonstrated that the HH group differs from the LH group in the process of automatization, their conclusion being mainly based on reaction time data. Speed of processing alone could not be totally eliminated as one potential explanation for these results. Our results based on CVs provide a more reliable measure of the efficiency of performance and provide further support for Dixon et al.'s (1990) automaticity hypothesis.

Dixon and his colleagues did not discuss why there would be individual differences in automaticity to begin with. In the present study, we hypothesised that the link between hypnotizability and automaticity might be due to variation in the capacity of WM. Participants with lower WM capacity may use automatization as a compensatory mechanism. The findings from the load condition might establish a link between the capacity of WM, and the process of automatization. The results showed that loading participants' memory with five digits (high load condition) interfered with their visual search in the first session. The findings from the first session are consistent with Han and Kim's (2004) findings. Similar to their study, participants in the high load condition had difficulty to do the search task while holding the 5 digits in their WM. However, by the fifth session, a new pattern of results emerged.. The high load group's performance improved more than that of the medium and no load groups. The results from the fifth session may be explained by the fact that the high load group benefited more from practice than the medium or no load groups.

Experiment 2b

Experiment 2b was designed to replicate and to extend the findings of experiment 2 while avoiding some of the potential inherent problems associated with unequal sample sizes.

Method

Participants

Twenty participants (ten HH participants with a Harvard score of 10 or greater with a mean score of 10.2 and *SD* = 0.73, and ten LH participants with a Harvard score of two or lower with a mean score of 1.1 and *SD* = 0.42) from a pool of Concordia university students who previously had been tested on the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS: A) of Shor and Orne (1962) were recruited for this study in exchange for course credit and a bonus of 25$.

Procedure

The method and procedure for this experiment were similar to those of experiment 2 with the exceptions of: 1) Instead of three groups of hypnotizability, only two extreme groups of HH and LH were selected for this experiment; 2) Instead of four levels of distractor conditions (1, 3, 7, and 15), only distractor 1, and distractor 15 were used in this experiment; 3) Instead of 3 load conditions (no load, medium load and high load) only no load and high load conditions were used in this experiment. By reducing the number of levels in these factors, participants will be exposed more often to each unique condition of the experiment, and as a result, they will have more practice with the stimuli. This will allow to inspect more closely the effects of practice on the development of automaticity.

Results and Discussion

Before analyzing the data for each subject in each session the outliers were identified. Reaction times 2.5 standard deviations above the mean and reaction times of less than 100 ms were identified as outliers and were replaced by the mean of a particular condition.

To assess the effects of hypnotizability, loads, sessions, and distractors, a separate 2 x 2 x 5 x 2 (hypnotizability x load x session x distractors) between-within analysis of variance (ANOVA) was performed on the mean CVs. In all analyses, hypnotizability (high and low) and load (0, 5) served as between subject factors, and session (1, 2, 3, 4, 5) and distractor (1, 15) were the within-subject factors.

The interaction between session and hypnotizability was significant (F [4, 64] = 3.81, $p < .008$, $\eta_p^2 = .19$). The source of this interaction, displayed in Figure 5, was confirmed by a test of simple effects using Bonferroni t-test. It was due to the larger decrease of the mean CV of the HH group over sessions in comparison to the mean decrease of the LH group. This decrease might indicate that HH's performance became more efficient over the sessions.

The analysis of the mean CV revealed that there was a main effect of session (F [4, 64] = 13.5, $p < .001$, $\eta_p^2 = .46$) with mean CV and CI of .244 [.223, .264], .214 [.192, .237], .198 [.181, 215], .189 [.177, .201], .193 [.174, .213] for session 1, 2, 3, 4, and 5, respectively (the complete ANOVA tables can be found in Appendix A, Table 4). With more practice the performance of all participants became more efficient.

The main effect of distractor was significant as well (F [3, 87] = 154, $p < .001$, $\eta_p^2 = .84$), with means of .24 [.223, .257], and .175 [.160, .190] for the mean CV of distractor 15 and distractor 1, respectively. It took longer for participants to find the target among 15 distractors in comparison to two distractors.

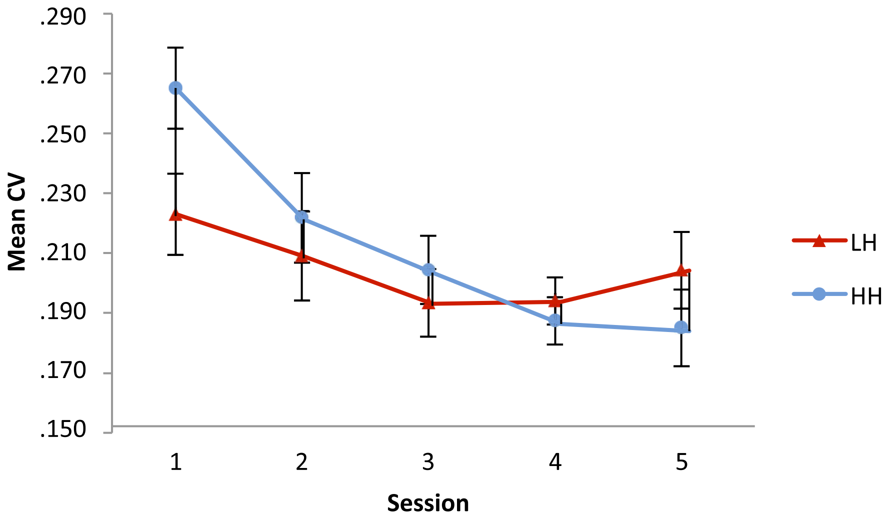

Figure 5. The interaction between session and hypnotizability. HH (high hypnotizables), LH (low hypnotizables). CV is the coefficient of variability. Error bars represent the standard error of the mean.

The major findings from experiment 2 were replicated, namely the main effect of session, the main effect of distractor for the means in both target present and target absent conditions. With only two levels of hypnotizability and two load conditions, a simpler and cleaner pattern of results emerged. As in experiment 2, the strong support for the hypotheses outlined earlier came from the analyses of the CVs. As in experiment 2, the analyses indicated that over sessions, participants' performance became more efficient regardless of their hypnotizability and more importantly, the performance of the HHs became more efficient than the performance of the LHs. The analysis of the mean CV in the target present condition failed to replicate the interaction between load and session that was present in experiment 2. The fact that the interaction between session and hypnotizability for the CV in the target present condition was significant in experiment 2 and these interactions were replicated in experiment 2b, may lend stronger support for the hypothesis that the HH group tends to become more automatic or more efficient in its performance over the sessions. The interaction between load and session, however, was significant only for the target absent condition and was not replicated in experiment 2b. Therefore, the conclusion about the role of load in the development of automaticity cannot be deduced from the data.

Chapter 3

General Discussion

In order to be a HH, a person must possess certain abilities that distinguish him or her from a LH. Our results indicate that the capacity of working memory could be the starting point. It seems that the capacity limitation of WM, as it has been shown in the cognitive literature, has certain consequences. The present studies suggest that the individual differences in hypnotizability may also be a by-product of variation in WM resources. The relationship between hypnotizability and working memory was examined in two correlational studies and the results of these experiments revealed some interesting differences between HH and LH participants in terms of variation in WM capacity, attentional control, and the speed of processing in WM. The correlation between digit span and hypnotizability indicates that the storage of working memory is a crucial component in this relation. Perhaps the most reliable correlate of hypnotizability reported in the literature by Tellegen and Atkinson (1974) is absorption. Tellegen and Atkinson reported a correlation of .42, which accounted for about 17.6% of the variance in hypnotizability. Dixon, Labelle, and Laurence (1996) performed a multivariate study, where they simultaneously analyzed many of the covariates of hypnotizability, such as the TAS (Tellegen Absorption Scale), the PICS (Preference for an Imagic Cognitive Style questionnaire; Issac, 1982), and the PEQ (Paranormal Experience Questionnaire; Nadon & Kihlstrom, 1987), and found that only 17% of the variance in hypnotizability could be explained by the combination of these variables. The results from the present studies show that a measure of WM (digit span total, in experiment 2b with a Spearman correlation of 0.70) accounts for 49% of the variability in hypnotic responding.

The literature on hypnosis indicates that HH people tend to follow suggestions more attentively than LH people. In addition, HH people are less distracted by peripheral information. These abilities might have been developed by HH people as a consequence of limited resources available to them. To compensate for this limitation, they might have learned to allocate all of their attention to the task at hand or to use other strategies, as Dixon et al. (1990) had already demonstrated. Dixon and his colleagues found that HHs were more prone to implement a strategy when this optimization strategy was made available to them. Simultaneously, another plan to alleviate the effects of this limitation is to automatize tasks that might draw on the same resources. By automatizing a task, the individual frees his/her resources to process more information. In the present experiments, the highs rapidly automatized their responses, making them more efficient and constant. This automatization of responses may in certain circumstances compensate for a less efficient working memory.

Working memory might be the thread that links different variables modulating hypnotizability. The limitation of working memory may force the individual to be more attentive to the task, automatize tasks which are repetitive, devise strategies whenever the task allows for such an implementation.

The relationship between WM memory and hypnotizability has not been explored directly in previous research. However, there is some indirect evidence that may point to this relationship. Recently, some studies have revealed a correlation between the capacity of working memory and some variables which have been known to be related to hypnotizability. For example, Peters, Jelicic, and Verbeek (2007) have reported that poor working memory predicts false memories. Freedman, Larouche-Wilson, and Laurence (in preparation) report that HHs are more prone to incorporate lure words in a DRM paradigm. Simple phobia is another phenomenon that has been shown to be related to hypnotizability. People with phobias have been shown to display higher hypnotic susceptibility (Frankel, 1976; Frankel and Orne, 1976; Foenander, Burrows, Gerschman, Home, (1980)., 1983; Rodney, Hollander, & Perry, 1983). In a recent study, Nader and Bomyea (2011) have compared the WM capacity of individuals with a generalized social phobia to the WM capacity of a control group. They used two types of words as stimuli; threatening and neutral words. They reported that the control group displayed better working memory capacity than the individuals with a generalized social phobia for neutral words only. However, the phobia group demonstrated better working memory performance for threat words relative to neutral words. The better performance of the control group on the neutral words is due to the fact that neutral words measure the capacity of working memory such as in a regular working memory test, but the better performance of the phobia group on threatening words could be due to their familiarity with these words and the stronger associations in their semantic network for these words. It seems that the phobia group has a greater degree of automatization for the threatening words.

Further indirect support for the presence of a connection between hypnotizability and WM may come from studies utilizing structural and functional magnetic resonance imaging (fMRI). For example, in a study by Hoeft et al. (2012), the brains of 12 HH and 12 LH participants were examined as they rested in the scanner. Their results indicated that while there were no significant differences between the two groups with regard to brain structure, HH exhibited greater functional communication between the executive and salience networks of the brain. Considering the role of the executive control network in WM and attention, these results may shed new light on what may differentiate HH from LH: a component of the executive network that was differently activated depending on the hypnotizability of the subject.

Similar findings have been reported by Cojan, Piguet, and Vuilleumier (2015). Using a modified flanker test, they demonstrated that susceptibility to hypnosis is associated with particular executive control capabilities allowing efficient attentional focusing, and point to specific neural substrates associated with executive networks.

Hereditary studies indicate that hypnotizability might have a genetic component. The earliest attempt to study the genetic basis of hypnotizability was made by Morgan (1973), who examined the hypnotizability of monozygotic and dizygotic twins and reported a correlation of .52 for monozygotic and a correlation of .17 for dizygotic twins. Furthermore, Lichtenberg, Bachner-Melman, Gritsenko, & Ebstein (2000) studied the involvement of an enzyme called catechol-O-methyltransferase (COMT) in relation to hypnotizability and reported evidence to support this involvement. Interestingly, the results from Rominger, Weiss, Nagl, Niederstätter, and Papousek (2014) suggest that sub-types of the COMT gene can predict hypnotizability only if the carrier of the COMT subtypes had a high attentional ability. This finding is similar to the results from the N-back experiment in which HH showed greater attentional abilities.

Researchers studying WM usually distinguish between two components of working memory. First, the amount of information that people can maintain in WM at any point in time, and second, the individual differences in the processing or the ability to actively control attention. For example, Baddeley's model emphasizes the dynamic interaction of memory maintenance and attention control in the executive system. His model assumes that the limitations of working memory result from the limitation of the capacities for supervising and coordinating multiple-system functioning. Barrouillet and Comos (2001) proposed that in concurrent tasks, individuals switch their attention between storage and processing. The combination of these factors is depicted in Table 6. Our results indicate that people with low WM span and higher processing speed are ideal candidates for being HH. If the speed of processing is a main component of hypnotizability, people with slow speed of processing may not qualify for HH. From our data, however, we cannot infer if individuals with a large memory span and fast processing system could be HH or not.

Many hypnosis theorists have noticed that the HH group may rely on one type of processes more often than the LH group, and based on this distinction offered a model to explain the phenomenon of hypnotizability (Brown & Oakley, 1997; Dixon et al., 1990; Kirsch & Lynn, 1997). The notion of two processing systems has been present in psychology and many psychologists have come up with a number of different names for the two contrasting types of thinking, such as automatic versus controlled (Schneider & Schiffrin, 1977), experiential vs rational (Epstein, 1994), implicit vs explicit, (Reber, 1993), heuristic vs systematic (Chaiken, 1980), heuristic vs analytic (Evans, 1989, 2006), associative vs rule-based (Sloman, 1996), intuitive vs analytic (Hammond, 1996), system 1 vs system 2 (Stanovich, 1999, 2004), holistic vs analytic (Nisbett et al., 2001), adaptive unconscious vs conscious (Wilson, 2002), reflexive vs reflective (Lieberman, 2003), stimulus-bound vs higher order (Toates, 2006), and impulsive vs reflective (Strack & Deustch, 2004). What all these dual processes theories have in common is that there is a distinction between processes that are rapid, automatic, running in parallel, and unconscious, and those that are slow, effortful, deliberate and limited by mental resources.

Kahneman (2012) proposed a two processing model that might be useful in understanding hypnotic behavior. In his model the mind has two modes of thinking: one which is slow, deliberate, and with a limited capacity but capable of performing complicated tasks (System 2). The other mode is fast, automatic, unconscious and is not affected by mental capacity (System 1). At the heart of Kahneman’s model, there is an association machine. Most of the effects observed in the model are due to the operation of this machine.

Table 6

Hypothesized Classification of High and LHs Based on the Interaction of WM Capacity and Speed of Processing.

		Processing	
		Slow	Fast
WM Span	High	LH	?
	Low	LH	HH

According to him, when an event occurs, it does not activate a single node, it activates an entire network of associations. We are not conscious of the activation but it prepares us to interpret what comes next in a particular way and produces an interpretation of the current situation. Every time the mind faces a question, either from the outside or from the inside, it automatically activates System 1 and searches through the associative machine to come up with a solution based on the available information. Afterwards, it passes the solution to System 2. If System 2 finds the solution wrong or biased, it will correct it, but if System 2 is not responsive because it is overwhelmed by fatigue, or because it finds the solution offered by System 1 acceptable, it will let it go through. Because System 2 is economical and sluggish, and as long as most of the solutions offered by System 1 are reliable, the solutions from System 1 are likely to be accepted. Kahneman (2012) suggests that people use the two systems on different occasions, but some people may tend to rely more often on one system than on the other. However, he does not explain which person's characteristic makes him or her more prone to use one mode of processing over the other one. The description of System 1 makes it a suitable candidate for the type of processing the HH group may utilize as a cognitive tendency.

Given the high correlation of WM with hypnotizability in our experiments, it is possible that relying on System 1 might be a consequence of the capacity limitation of working memory. Kahneman (2012) reported an experiment by Gilbert that shows the role of working memory in switching from System 2 to System 1 processing. Subjects in this experiment were presented with a series of nonsensical sentences. The sentences were followed by a single word; either by "true" or "false". In one condition of the experiment, during the task, the researchers loaded the subjects' memory with a single digit to remember. When the subjects were tested for their memory of sentences, they found that the subjects with loaded memory picked more of the "false" sentences than of the "true" ones. This experiment shows that loading the WM of participants interfered with their System 2 and forced them to rely on their default system, System 1.

In experiments 3 and 4, we loaded the working memory of participants with different number of digits and studied the effects of this manipulation on the performance of three hypnotizable groups in a visual search task. The results from the analysis of the mean coefficient of variability (CV) are straightforward. This statistical measure provides an index of the efficiency (automatization) and stability of the responses. The CVs for the low load did not change over sessions and the CVs of the medium load changed slightly from session one to session four. However, the CVs of the high load group clearly decreased from session one to session five. By loading the participants' memory, it appears that this limitation imposed a certain method of processing to them and forced them to process the incoming information as fast as they can before the information fades, or is interfered with by new information.

The interaction between session and hypnotizability revealed that the HH group had a higher mean CV than the MH and the LH groups in the first session. By the fourth session, however, their CVs were significantly lower than those of the MH and the LH groups. The analysis of the CVs revealed that the performance of the HH participants and the high load group became more stable across sessions in the visual search experiment.

The findings of the current studies are important for many reasons. Firstly, the present studies introduce the concept of WM into hypnosis research and show that individual differences in the capacity and storage component of WM may be linked to the degree to which people react to hypnotic suggestions.

Secondly, the individual differences observed in the WM literature are similar to individual differences in hypnotizability. There are, however, certain occasions when the findings are different (Kane et al., 2005). The difference might be due to two factors. In WM research there is a wider range of individual differences in the samples of working memory studies compared to our samples. The low-span participants consist of the lowest 10 to 15 percentile of the population. Our samples were chosen from university students and the range of individual differences is narrower. Another reason that might explain the differences between our findings and findings from WM research as it was discussed earlier, might be due to that fact that the HH group in our studies may possess a faster processing component of working memory.

Thirdly, the comparison of the results from the current studies with the results of complex tasks in cognitive psychology is informative and interesting. In this study, the HH participants perform equally well (in experiment 2b) or worse than the LH group (in experiment 2, N-back task, and in experiment 2) in the first segment of the experiment. With practice over five sessions, however, performance of the HH became as fast as the performance of LHs, or on certain occasions better than the performance of the LH group. The results from session one in the current studies (experiments 2 and 2b) are similar to what has been reported in the cognition literature with complex tasks. Namely, the low memory span and the HH group perform worse than the high memory span and the LH group on complex tasks, but the differences decrease when they train in a consistent environment. The low memory span and HH group reach the same level of performance as the high memory span and HH group. This finding should guide future experimentation for a better understanding of individual differences in hypnotizability and automatization.

Finally, these findings suggest that the study of individual differences in hypnosis opens a window for researchers to explore fascinating aspects of the mind, and findings from these investigations may go beyond hypnosis and elucidate some central questions in cognitive psychology.

Limitations and Future Directions

There were several limitations to this research that should be addressed in future studies. First, the completion of five sessions of target detection in visual search can be tiring and difficult for the participants. Future studies could overcome this limitation by making the task more interesting. One possibility is to design the task as a computer game in which the improvement of participants' performance can be monitored and they could receive a reward for their performance.

An additional limitation relates to the nature of the samples used in our studies. Our samples consisted mostly of university students with a restricted range of WM capacity. Results from samples with a wider range of WM might be more desirable. Another limitation was the sample sizes used in our studies as this may have reduced statistical power of our analyses.

In the current studies, only three types of working memory tests were used: the digit span, the N-back test and the reading span. One of the main criticisms of working memory tests is that they often show low to medium inter-correlations (Redick and Lindsey, 2013). It may not be surprising given the complexity of the working memory system in its interaction with executive functions. Many other complex tests of working memory could be administered to better understand the basic differences that were found between the HH and the LH groups. If, for example, Unsworth and Engle's (2007) dual-component model of working memory is correct, working memory capacity would be comprised of two systems: primary memory (PM) and secondary memory (SM). Whereas PM actively maintains a fixed number of representations, SM is driven by cue-dependent search for retrieval. Using free call tasks paired to complex span tasks may shed further light on the links between hypnotizability and WM.

Despite these limitations, the major strength of the present study is the replication of the results across two correlational studies (studies 1 and 1b) and two experimental studies (studies 2 and 2b), highlighting the robust nature of our findings.

Many questions about the nature of the relation between working memory and hypnotizability remain to be addressed. Our study demonstrated that both the speed of processing and the capacity of working memory might contribute to this relation. Future studies should employ tasks that differentially quantify the contribution of these components. In our studies we measured participants' susceptibility to hypnosis through the Harvard Group Scale of Hypnotic Susceptibility. This scale relies mostly on ideomotor and challenge items. We are currently extending this study by testing participants with the Stanford Hypnotic Susceptibility Scale, Form C (Weitzenhoffer & Hilgard, 1962) which mostly depends on cognitive items that tend to be more difficult and usually only performed by people on the higher end of the hypnotizability scale.

In addition to the relation between working memory and hypnotizability, the present studies have important implications for sports coaches, educators and teachers who are working with people who are attempting to learn tasks that require long hours of practice to master. The findings from study 2a and 2b provide evidence for the role of working memory in the development of automaticity of a task. These findings underline the need for addressing WM capacity and its limitations in developing an ideal practice session.

Taken together, the findings from this research provide support for the relationship between WM and hypnotizability. Future studies of individual differences in hypnotizability should also look at the thinking style of participants as suggested by Kahneman (2012). There is a growing body of literature showing that individual differences in working memory capacity moderate the relative influence of automatic versus controlled processes on wide range of behaviors (Hofmann et al., 2008).

In conclusion, we believe our research to be the first to clearly link individual differences in hypnotizability to measurements of working memory. This finding is invaluable to our understanding of the nature of hypnotic responding. Moreover, we provide evidence for the role of working memory in the development of automaticity.

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Appendix A

ANOVA Source Tables

Table 1

ANOVA Source Table for the N-back Test in Experiment 1b.

Source	Sum of Squares	df	MS	F	Sig.	Partial Eta Squared
			Within-Subjects Effects			
Block	12.133	2	6.067	.741	.484	.04
Block * Hypcate	74.533	2	37.267	4.553	.017	.20
Error (block)	294.667	36	8.185			
			Between-Subjects Effects			
Hypcate	19.267	1	19.267	.099	.757	.005
Error	3506.333	18	194.796			

Table 2

ANCOVA Source Table for CVs for the N-back Test in Experiment 1b.

Source	Sum of Squares	df	MS	F	Sig.	Partial Eta Squared
			Within-Subjects Effects			
Block	.0	2	.023	3.604	.038	.175
Block * WM	.040	2	.020	3.145	.056	.156
Block * Hypnotizability	.014	2	.007	1.116	.339	.062
Error (block)	.217	34	.006			
			Between-Subjects Effects			
Intercept	.161	1	.161	16.670	.001	.495
WM	.017	1	.017	1.720	.207	.092
Hypnotizability	.020	1	.020	2.120	.164	.111
Error	.164	17	.010			

Table 3

ANOVA Source Table for the Coefficient of Variability (CV) in the Target Present Condition of Experiment 2.

Source	Sum of Squares	df	MS	F	Sig.	Partial Eta Squared
			Within-Subjects Effects			
Session	.169	4	.042	12.721	.000	.305
Session * Hypnotizability	.062	8	.008	2.315	.024	.138
Session * Load	.067	8	.008	2.502	.015	.147
Session * Hypnotizability * Load	.077	16	.005	1.447	.132	.166
Error (Session)	.386	116	.003			
Distractor	1.169	3	.390	154.62	.000	.842
Distractor * Hypnotizability	.015	6	.002	.965	.454	.062
Distractor * Load	.007	6	.001	.484	.818	.032
Distractor * Hypnotizability * Load	.040	12	.003	1.317	.224	.154
Error (Distractor)	.219	87	.003			
Session * Distractor	.018	12	.002	1.096	.363	.036
Session * Distractor * Hypnotizability	.030	24	.001	.903	.598	.059
Session * Distractor * Load	.037	24	.002	1.103	.338	.071
Session * Distractor * Hypnotizability * Load	.060	48	.001	.906	.653	.111
Error (Session*Distractor)	.481	348	.001			

Table 3 continued

Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Hypnotizability	.033	2	.017	.774	.471	.051
Load	.109	2	.054	2.523	.098	.148
Hypnotizability * Load	.004	4	.001	.050	.995	.007
Error	.626	29	.022			

Table 4

ANOVA Source Table for the Coefficient of Variability (CV) in the Target Present Condition of Experiment 2b.

Within-Subjects Effects

Source	Sum of Squares	df	MS	F	Sig.	Partial Eta Squared
session	.079	4	.020	13.560	.001	.459
session * load	.010	4	.003	1.741	.152	.098
session * Hyp	022	4	.006	3.812	.008	.192
session * load * Hyp	.005	4	.001	.809	.524	.048
Error (session)	.093	64	.001			
Distractor	.213	1	.213	116.69	.000	.879
Distractor * load	.002	1	.002	.949	.344	.056
Distractor * Hyp	.002	1	.002	1.222	.285	.071
Distractor * load * Hyp	.002	1	.002	.914	.353	.054
Error (Distractor)	.029	16	.002			
session * Distractor	.000	4	.000	.156	.960	.010
session * Distractor * load	.004	4	.001	1.377	.252	.079
session * Distractor * Hyp	.006	4	.001	2.082	.093	.115
session * Distractor * load * Hypc	.005	4	.001	1.957	.112	.109
Error (Session*Distractor)	.044	64	.001			

Table 4 continued

Between-Subjects Effects

Source	Sum of Squares	df	MS	F	Sig.	Partial Eta Squared
Load	4.881	1	4.88	.005	.943	.001
Hypcathe	.003	1	.003	.351	.562	.021
Load * Hypcathe	.007	1	.007	.759	.396	.045
Error	.150	16	.009			

Table 5

ANOVA Source Table for the mean reaction times (RTs) for target detection in the target present condition of experiment 2.

Tests of Within-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Session	3998145,281	4	999536,320	58,753	,000	,670
Session * Hypnotizability	41733,533	8	5216,692	,307	,962	,021
Session * Load	207039,220	8	25879,903	1,521	,157	,095
Session * Hypnotizability * Load	235181,336	16	14698,833	,864	,611	,106
Error (Session)	1973442,350	116	17012,434			
Distractor	13755638,774	3	4585212,925	194,897	,000	,870
Distractor * Hypnotizability	476303,606	6	79383,934	3,374	,005	,189
Distractor * Load	209701,495	6	34950,249	1,486	,193	,093
Distractor * Hypnotizability * Load	290062,590	12	24171,883	1,027	,432	,124
Error (Distractor)	2046788,183	87	23526,301			
Session * Distractor	442976,379	12	36914,698	16,696	,000	,365
Session * Distractor * Hypnotizability	106613,578	24	4442,232	2,009	,004	,122
Session * Distractor * Load	112426,063	24	4684,419	2,119	,002	,127
Session * Distractor * Hypnotizability * Load	125794,433	48	2620,717	1,185	,197	,141
Error (Session*Distractor)	769432,112	348	2211,012			

Table 5 continued

Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Hypnotizability	7117307.605	2	3558653.802	6.053	.006	.294
Load	3203579.251	2	1601789.626	2.724	.082	.158
Hypnotizability * Load	7707815.664	4	1926953.916	3.277	.025	.311
Error	17050289.105	29	587941.004			

Table 6

ANOVA Source Table for the mean reaction times (RTs) for target detection in the target present condition of experiment 2b.

Tests of Within-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Session	1146774.920	4	286693.730	34.804	.000	.685
Session * Load	28035.180	4	7008.795	.851	.498	.050
Session * Hypnotizability	23540.220	4	5885.055	.714	.585	.043
Session * Load * Hypnotizability	124593.920	4	31148.480	3.781	.008	.191
Error (Session)	527187.960	64	8237.312			
Distractor	1424672.000	1	1424672.000	97.248	.000	.859
Distractor * Load	52164.500	1	52164.500	3.561	.077	.182
Distractor * Hypnotizability	14011.380	1	14011.380	.956	.343	.056
Distractor * Load * Hypnotizability	4646.480	1	4646.480	.317	.581	.019
Error (Distractor)	234399.040	16	14649.940			
Session * Distractor	77586.900	4	19396.725	14.227	.000	.471
Session * Distractor * Load	12515.400	4	3128.850	2.295	.069	.125
Session * Distractor * Hypnotizability	22236.520	4	5559.130	4.077	.005	.203
Session * Distractor * Load * Hypnotizability	5733.820	4	1433.455	1.051	.388	.062
Error (Session*Distractor)	87257.960	64	1363.406			

Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Load	2979.920	1	2979.920	.006	.937	.000
Hypnotizability	402842.880	1	402842.880	.860	.367	.051
Load * Hypnotizability	71215.380	1	71215.380	.152	.702	.009
Error	7490537.840	16	468158.615			

Table 7

ANOVA Source Table for the Coefficient of Variability (CV) in the Target Absent Condition of Experiment 2.

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Session	.058	4	.015	5.502	.000	.159
Session * Hypnotizability	.019	8	.002	.885	.531	.058
Session * Load	.018	8	.002	.842	.568	.055
Session * Hypnotizability * Load	.070	16	.004	1.664	.064	.187
Error (Session)	.306	116	.003			
Distractor	.555	3	.185	44.054	.000	.603
Distractor * Hypnotizability	.047	6	.008	1.861	.097	.114
Distractor * Load	.021	6	.004	.844	.540	.055
Distractor * Hypnotizability * Load	.019	12	.002	.369	.971	.048
Error (Distractor)	.365	87	.004			
Session * Distractor	.031	12	.003	1.734	.058	.056
Session * Distractor * Hypnotizability	.030	24	.001	.825	.704	.054
Session * Distractor * Load	.062	24	.003	1.726	.020	.106
Session * Distra.. * Hypnotizability * Load	.072	48	.001	.993	.490	.121
Error (Session*Distractor)	.524	348	.002			

Table 7 continued

Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Hypnotizability	.077	2	.039	2.721	.083	.158
Load	.098	2	.049	3.445	.045	.192
Hypnotizability * Load	.059	4	.015	1.033	.407	.125
Error	.411	29	.014			

Table 8

ANOVA Source Table for the Coefficient of Variability (CV) in the Target Absent Condition of Experiment 2b.

Tests of Within-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Session	,046	4	,012	7,793	,000	,328
Session * Load 2	,006	4	,002	1,087	,370	,064
Session * Hypnotizability	,007	4	,002	1,249	,299	,072
Session * Load 2 * Hypnotizability	,003	4	,001	,467	,760	,028
Error (Session)	,095	64	,001			
Distractor	,205	1	,205	30,131	,000	,653
Distractor * Load 2	,000	1	.000	,009	,926	,001
Distractor * Hypnotizability	.000	1	.000	,005	,944	,000
Distractor * Load 2 * Hypnotizability	,003	1	,003	,437	,518	,027
Error (Distractor)	,109	16	,007			
Session * Distractor	,008	4	,002	1,677	,166	,095
Session * Distractor * Load 2	,005	4	,001	1,037	,395	,061
Session * Distractor * Hypnotizability	,003	4	,001	,686	,604	,041
Session * Distractor * Load 2 * Hypnotizability	,004	4	,001	,881	,481	,052
Error (Session*Distractor)	,078	64	,001			

Tests of Between-Subjects Effects

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Load 2	,028	1	,028	2,050	,171	,114
Hypnotizability	,041	1	,041	3,008	,102	,158
Load 2 * Hypnotizability	,002	1	,002	,182	,675	,011
Error	,217	16	,014			

Appendix B

Bonferroni's Pairwise Comparison Tests

Table 1

Bonferoni's Test of Simple Effects, Comparing the Mean Differences of Hypnotizability (HH, MH, LH) in Five Sessions in Experiment 2b

Session	Hypnotizability		Mean Difference	SE	Sig.	95% Confidence Interval for Difference Lower Bound	95% Confidence Interval for Difference Upper Bound
1	HH	LH	.015	.021	1.000	-.038	.067
		MH	.022	.021	.944	-.032	.075
	LH	HH	-.015	.021	1.000	-.067	.038
		MH	.007	.019	1.000	-.041	.055
	MH	HH	-.022	.021	.944	-.075	.032
		LH	-.007	.019	1.000	-.055	.041
2	HH	LH	.008	.022	1.000	-.048	.063
		MH	.030	.022	.561	-.027	.087
	LH	HH	-.008	.022	1.000	-.063	.048
		MH	.023	.020	.805	-.028	.074
	MH	HH	-.030	.022	.561	-.087	.027
		LH	-.023	.020	.805	-.074	.028
3	HH	LH	-.018	.015	.724	-.057	.021
		MH	-.012	.016	1.000	-.052	.028
	LH	HH	.018	.015	.724	-.021	.057
		MH	.007	.014	1.000	-.029	.042
	MH	HH	.012	.016	1.000	-.028	.052
		LH	-.007	.014	1.000	-.042	.029
4	HH	LH	-.044*	.014	.011	-.080	-.009
		MH	-.020	.014	.505	-.056	.016
	LH	HH	.044*	.014	.011	.009	.080
		MH	.024	.013	.209	-.008	.056
	MH	HH	.020	.014	.505	-.016	.056
		LH	-.024	.013	.209	-.056	.008
5	HH	LH	-.022	.017	.598	-.064	.020
		MH	-.005	.017	1.000	-.048	.037
	LH	HH	.022	.017	.598	-.020	.064
		MH	.016	.015	.864	-.022	.055
	MH	HH	.005	.017	1.000	-.037	.048
		LH	-.016	.015	.864	-.055	.022

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*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

The CVs of HHs are significantly different from the CVs of LHs in session 4.

Table 2

Bonferroni's Test of Simple Effects, Comparing the Mean Differences of Loads (High, Medium and No Load) in Five Sessions in Experiment 2b

Session	Load	Load	Mean Difference	SE	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	H load	Med Load	.011	.021	1.000	-.042	.065
		No load	.011	.019	1.000	-.037	.059
	Med Load	H load	-.011	.021	1.000	-.065	.042
		No load	.000	.021	1.000	-.052	.052
	No load	H load	-.011	.019	1.000	-.059	.037
		Med Load	.000	.021	1.000	-.052	.052
2	H load	Med Load	-.018	.023	1.000	-.075	.039
		No load	-.029	.020	.493	-.080	.022
	Med Load	H load	.018	.023	1.000	-.039	.075
		No load	-.011	.022	1.000	-.066	.045
	No load	H load	.029	.020	.493	-.022	.080
		Med Load	.011	.022	1.000	-.045	.066
3	H load	Med Load	-.017	.016	.832	-.057	.023
		No load	-.036*	.014	.046	-.072	.000
	Med Load	H load	.017	.016	.832	-.023	.057
		No load	-.019	.015	.687	-.057	.020
	No load	H load	.036*	.014	.046	.000	.072
		Med Load	.019	.015	.687	-.020	.057
4	H load	Med Load	-.030	.014	.127	-.067	.006
		No load	-.049*	.013	.002	-.082	-.017
	Med Load	H load	.030	.014	.127	-.006	.067
		No load	-.019	.014	.545	-.054	.016
	No load	H load	.049*	.013	.002	.017	.082
		Med Load	.019	.014	.545	-.016	.054
5	H load	Med Load	-.041	.017	.070	-.084	.002
		No load	-.041*	.015	.033	-.079	-.003
	Med Load	H load	.041	.017	.070	-.002	.084
		No load	.000	.016	1.000	-.042	.041
	No load	H load	.041*	.015	.033	.003	.079
		Med Load	.000	.016	1.000	-.041	.042

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*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

The CVs of the high load group became significantly different from the CV of the no load group from the third session onwards

Table 3

Bonferroni's Post Hoc Test Comparing the CVs of Different Sessions in Experiment 2b

					95% Confidence Interval for Difference[b]	
Session	Session	Mean Difference	SE	Sig.[b]	Lower Bound	Upper Bound
1	2	.017	.007	.129	-.003	.037
	3	.030*	.008	.011	.005	.056
	4	.039*	.009	.001	.013	.066
	5	.043*	.008	.000	.018	.069
2	1	-.017	.007	.129	-.037	.003
	3	.013	.007	.826	-.009	.035
	4	.022	.008	.085	-.002	.046
	5	.026*	.007	.008	.005	.047
3	1	-.030*	.008	.011	-.056	-.005
	2	-.013	.007	.826	-.035	.009
	4	.009	.005	.804	-.006	.024
	5	.013	.005	.098	-.001	.027
4	1	-.039*	.009	.001	-.066	-.013
	2	-.022	.008	.085	-.046	.002
	3	-.009	.005	.804	-.024	.006
	5	.004	.005	1.000	-.011	.019
5	1	-.043*	.008	.000	-.069	-.018
	2	-.026*	.007	.008	-.047	-.005
	3	-.013	.005	.098	-.027	.001
	4	-.004	.005	1.000	-.019	.011

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 4

Bonferroni's Post Hoc Test Comparing the CVs of Different Distractors in Experiment 2a

Distractor	Distractor	Mean Difference	SE	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-.010	.004	.143	-.022	.002
	3	-.057*	.005	.000	-.071	-.043
	4	-.104*	.006	.000	-.123	-.086
2	1	.010	.004	.143	-.002	.022
	3	-.047*	.004	.000	-.059	-.034
	4	-.095*	.007	.000	-.113	-.076
3	1	.057*	.005	.000	.043	.071
	2	.047*	.004	.000	.034	.059
	4	-.048*	.006	.000	-.064	-.032
4	1	.104*	.006	.000	.086	.123
	2	.095*	.007	.000	.076	.113
	3	.048*	.006	.000	.032	.064

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 5

Bonferroni's Test of Simple Effects, Comparing the Mean Differences of Hypnotizability (HH, LH) in Five Sessions in Experiment 2b

						95% Confidence Interval for Difference[b]	
Session	Hypnotize	Hypnotize	Mean Difference	SE	Sig.[b]	Lower Bound	Upper Bound
1	HH	LH	.043*	.019	.040	.002	.083
	LH	HH	-.043*	.019	.040	-.083	-.002
2	HH	LH	.013	.021	.550	-.032	.058
	LH	HH	-.013	.021	.550	-.058	.032
3	HH	LH	.011	.016	.496	-.023	.045
	LH	HH	-.011	.016	.496	-.045	.023
4	HH	LH	-.007	.011	.553	-.031	.017
	LH	HH	.007	.011	.553	-.017	.031
5	HH	LH	-.020	.018	.297	-.058	.019
	LH	HH	.020	.018	.297	-.019	.058

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

The CVs of the HH group were significantly higher than the CV of the LH group in the first session of the experiment

Appendix C

Descriptive Statistics for CVs in Experiments Two and 2b.

Table 1A

Descriptive Statistics for High Hypnotizable Participants (HH) in Experiment 2 (with the group standard error in parentheses). The skewness and kurtosis z scores were obtained by dividing the value of Skewness and Kurtosis by their respected SEs.

	N	Mean	SD	Skewness		Kurtosis		Skew z score	Kurt z score
s1d1	10.00	838.40	179.83	0.02	(0.69)	-1.01	(1.33)	0.03	-0.76
s1d3	10.00	884.30	207.50	0.24	(0.69)	-0.74	(1.33)	0.35	-0.56
s1d7	10.00	1107.2	280.50	0.12	(0.69)	-1.51	(1.33)	0.17	-1.13
s1d15	10.00	1438.1	426.15	0.69	(0.69)	-0.60	(1.33)	1.00	-0.45
s2d1	10.00	735.10	193.82	0.09	(0.69)	-1.06	(1.33)	0.13	-0.80
s2d3	10.00	787.50	232.31	0.19	(0.69)	-1.40	(1.33)	0.28	-1.05
s2d7	10.00	955.80	279.50	-0.21	(0.69)	-1.44	(1.33)	-0.30	-1.08
s2d15	10.00	1221.8	384.78	-0.19	(0.69)	-1.09	(1.33)	-0.27	-0.81
s3d1	10.00	709.50	218.37	0.82	(0.69)	0.11	(1.33)	1.19	0.09
s3d3	10.00	750.50	222.50	0.75	(0.69)	0.00	(1.33)	1.08	0.00
s3d7	10.00	903.20	266.74	0.26	(0.69)	-1.03	(1.33)	0.38	-0.77
s3d15	10.00	1140.6	340.58	-0.10	(0.69)	-1.14	(1.33)	-0.14	-0.85
s4d1	10.00	682.70	210.98	0.89	(0.69)	-0.45	(1.33)	1.29	-0.34
s4d3	10.00	721.50	229.67	0.78	(0.69)	-0.70	(1.33)	1.13	-0.52
s4d7	10.00	837.90	265.06	0.55	(0.69)	-1.05	(1.33)	0.81	-0.79
s4d15	10.00	1030.1	327.83	0.24	(0.69)	-1.49	(1.33)	0.35	-1.12
s5d1	10.00	680.70	232.52	1.25	(0.69)	0.92	(1.33)	1.82	0.69
s5d3	10.00	707.30	237.96	1.25	(0.69)	1.28	(1.33)	1.81	0.96
s5d7	10.00	826.50	277.49	0.90	(0.69)	-0.46	(1.33)	1.32	-0.34
s5d15	10.00	1008.4	338.63	0.51	(0.69)	-1.10	(1.33)	0.74	-0.82

Table 1B

Descriptive Statistics for Medium Hypnotizable Participants (MH) in Experiment 2 (with the group standard error in parentheses. The Skewness and Kurtosis z scores were obtained by dividing the value of Skewness and Kurtosis by their respected SEs.

	N	Mean	SD	Skewness		Kurtosis		Skew z score	Kurt z score
s1d1	14.00	714.00	178.44	0.33	(0.60)	-0.83	(1.15)	0.56	-0.72
s1d3	14.00	740.93	177.01	0.17	(0.60)	-0.81	(1.15)	0.28	-0.70
s1d7	14.00	863.79	233.23	-0.04	(0.60)	-1.36	(1.15)	-0.07	-1.18
s1d15	14.00	1097.8	313.85	-0.17	(0.60)	-1.42	(1.15)	-0.29	-1.23
s2d1	14.00	615.86	147.68	0.63	(0.60)	0.49	(1.15)	1.05	0.43
s2d3	14.00	655.57	148.67	0.25	(0.60)	-0.90	(1.15)	0.42	-0.78
s2d7	14.00	743.64	178.49	-0.03	(0.60)	-0.92	(1.15)	-0.06	-0.80
s2d15	14.00	926.21	277.50	-0.12	(0.60)	-1.61	(1.15)	-0.20	-1.39
s3d1	14.00	583.07	130.20	0.50	(0.60)	-0.22	(1.15)	0.83	-0.19
s3d3	14.00	609.86	129.37	0.38	(0.60)	-0.59	(1.15)	0.64	-0.51
s3d7	14.00	699.21	157.13	-0.33	(0.60)	-0.65	(1.15)	-0.55	-0.56
s3d15	14.00	884.93	265.35	-0.22	(0.60)	-1.47	(1.15)	-0.36	-1.27
s4d1	14.00	555.21	112.95	-0.17	(0.60)	-0.85	(1.15)	-0.29	-0.73
s4d3	14.00	574.86	119.95	-0.09	(0.60)	-1.16	(1.15)	-0.15	-1.01
s4d7	14.00	664.36	157.76	-0.25	(0.60)	-0.83	(1.15)	-0.41	-0.72
s4d15	14.00	834.21	243.02	-0.19	(0.60)	-1.06	(1.15)	-0.31	-0.92
s5d1	14.00	553.43	109.75	0.07	(0.60)	-0.55	(1.15)	0.12	-0.47
s5d3	14.00	576.50	125.96	0.05	(0.60)	-0.56	(1.15)	0.09	-0.48
s5d7	14.00	648.57	136.51	-0.33	(0.60)	-0.62	(1.15)	-0.55	-0.53
s5d15	14.00	789.64	213.04	-0.33	(0.60)	-0.79	(1.15)	-0.55	-0.68

Table 1C

Descriptive Statistics for LH Participants (LH) in Experiment 2 (with the group standard error in parentheses). The Skewness and Kurtosis z scores were obtained by dividing the value of Skewness and Kurtosis by their respected SEs.

	N	Mean	SD	Skewness		Kurtosis		Skew z score	Kurt z score
s1d1	14.00	708.79	177.47	0.06	(0.60)	-1.21	(1.15)	0.10	-1.05
s1d3	14.00	748.50	180.38	0.18	(0.60)	-1.23	(1.15)	0.29	-1.06
s1d7	14.00	868.14	198.07	0.22	(0.60)	-1.02	(1.15)	0.37	-0.89
s1d15	14.00	1123.1	336.88	0.60	(0.60)	0.53	(1.15)	1.01	0.46
s2d1	14.00	646.29	173.77	0.20	(0.60)	-1.72	(1.15)	0.33	-1.49
s2d3	14.00	673.14	180.17	0.29	(0.60)	-1.72	(1.15)	0.48	-1.49
s2d7	14.00	776.43	197.41	0.41	(0.60)	-1.44	(1.15)	0.68	-1.25
s2d15	14.00	970.43	283.82	0.56	(0.60)	-0.50	(1.15)	0.94	-0.43
s3d1	14.00	588.93	151.44	0.51	(0.60)	-0.74	(1.15)	0.85	-0.64
s3d3	14.00	620.14	150.94	0.18	(0.60)	-1.52	(1.15)	0.31	-1.31
s3d7	14.00	731.14	182.82	0.46	(0.60)	-0.76	(1.15)	0.77	-0.66
s3d15	14.00	919.36	248.39	0.32	(0.60)	-1.19	(1.15)	0.54	-1.03
s4d1	14.00	573.21	143.62	0.55	(0.60)	-0.98	(1.15)	0.92	-0.85
s4d3	14.00	592.43	144.28	0.71	(0.60)	-0.63	(1.15)	1.19	-0.55
s4d7	14.00	696.07	182.27	0.82	(0.60)	-0.19	(1.15)	1.38	-0.16
s4d15	14.00	901.57	271.18	0.45	(0.60)	-0.21	(1.15)	0.75	-0.18
s5d1	14.00	554.14	147.48	0.85	(0.60)	-0.38	(1.15)	1.42	-0.33
s5d3	14.00	565.57	130.81	1.02	(0.60)	0.17	(1.15)	1.71	0.15
s5d7	14.00	660.00	148.05	0.27	(0.60)	-0.23	(1.15)	0.45	-0.20
s5d15	14.00	814.00	213.62	-0.04	(0.60)	-0.40	(1.15)	-0.06	-0.35

Table 2

Descriptive Statistics for CVs of High and LH Participants in Different Conditions of Experiment 2b (with the group standard error in parentheses). The Skewness and Kurtosis z scores were obtained by dividing the value of Skewness and Kurtosis by their respected SEs.

	N	Mean	SD	Skewness		Kurtosis		Skew z score	Kurt z score
High Hypnotizable Participants									
cvs1d2	10	0.308	0.055	0.236	(0.687)	-1.332	(1.334)	0.344	-0.999
cvs1d1	10	0.222	0.044	-0.053	(0.687)	-1.573	(1.334)	-0.078	-1.179
cvs2d2	10	0.257	0.056	0.066	(0.687)	-1.123	(1.334)	0.096	-0.842
cvs2d1	10	0.184	0.064	0.404	(0.687)	0.710	(1.334)	0.588	0.532
cvs3d2	10	0.235	0.051	0.583	(0.687)	-1.168	(1.334)	0.849	-0.875
cvs3d1	10	0.172	0.045	0.040	(0.687)	-0.793	(1.334)	0.058	-0.594
cvs4d2	10	0.218	0.042	-0.805	(0.687)	2.606	(1.334)	-1.172	1.953
cvs4d1	10	0.154	0.034	-1.084	(0.687)	0.007	(1.334)	-1.577	0.005
cvs5d2	10	0.221	0.039	0.235	(0.687)	-1.212	(1.334)	0.342	-0.908
cvs5d1	10	0.146	0.040	1.170	(0.687)	2.438	(1.334)	1.703	1.828
LH Participants									
cvs1d2	10	0.242	0.052	1.090	(0.687)	3.038	(1.334)	1.587	2.277
cvs1d1	10	0.202	0.034	0.484	(0.687)	-1.391	(1.334)	0.705	-1.043
cvs2d2	10	0.235	0.037	0.112	(0.687)	0.621	(1.334)	0.163	0.465
cvs2d1	10	0.181	0.043	0.824	(0.687)	-0.047	(1.334)	1.199	-0.035
cvs3d2	10	0.231	0.031	-0.220	(0.687)	-0.906	(1.334)	-0.320	-0.679
cvs3d1	10	0.153	0.038	-0.505	(0.687)	0.424	(1.334)	-0.734	0.318
cvs4d2	10	0.227	0.029	-0.330	(0.687)	2.547	(1.334)	-0.481	1.909
cvs4d1	10	0.159	0.029	-0.850	(0.687)	2.259	(1.334)	-1.238	1.693
cvs5d2	10	0.228	0.045	0.613	(0.687)	-0.823	(1.334)	0.893	-0.617
cvs5d1	10	0.178	0.054	0.542	(0.687)	-1.021	(1.334)	0.790	-0.765

Appendix D

Analyses of the Mean reaction times (RT) in the targets present condition of experiment 2 and experiment 2b.

Analysis of the mean reaction times (RTs) in the target present (TP) condition in the experiment 2

A 3 x 3 x 5 x 4 (Hypnotizability by Load by Session by Distractors) between-within analysis of variance (ANOVA) was performed on the CVs. In this analysis, hypnotizability (high, medium and low) and load (0, 3, 5) served as between subject factors, and the within subject factors consisted of session with five levels (1, 2, 3, 4, 5) and distractor with four levels (1, 3, 7, 15). The analysis revealed that there was a significant main effect of session ($\underline{F}$ (4, 116) = 58.7, $\underline{p} < .001$, $\eta_p^2 = .67$) with the mean RT and 95% confidence intervals (CI) of 940 [860, 1021]; 827 [759, 896], 783 [725, 842]; 743 [687, 799], and 725 [675, 775], for session one, two, three, four, and five, respectively. As expected and consistent with the visual search literature, participants' reaction time became faster as they progressed through the sessions. The Bonferroni pairwise comparison test showed that apart from session four and five, all sessions were significantly different from each other (the complete ANOVA tables can be found in Appendix A, Table 5).

A main effect of distractor was also observed ($\underline{F}$ (3, 87) = 194.8, $\underline{p} = .001$, $\eta_p^2 = .87$) with mean reaction times and 95 % CIs of 668 [620, 715]; 699 [649, 749]; 818 [759, 878], and 1031 [941-1120] for one, three, seven and 15 distractor conditions, respectively. The Bonferroni pairwise comparison test revealed that the mean RT of the four distractors differed significantly from one another. As was discussed in the introduction and consistent with previous works in visual search research, it took longer for the participants to find the target letter as the number of distractors increased.

The interaction between distractor and hypnotizability was significant ($\underline{F}$ (6, 348) = 3.37, $\underline{p} = .005$, $\eta_p^2 = .189$). The source of interaction as Figure 1 depicts and confirmed by Bonferroni-corrected t-test, is due to the fact that the HH group had a significantly longer reaction time for the four distractors.

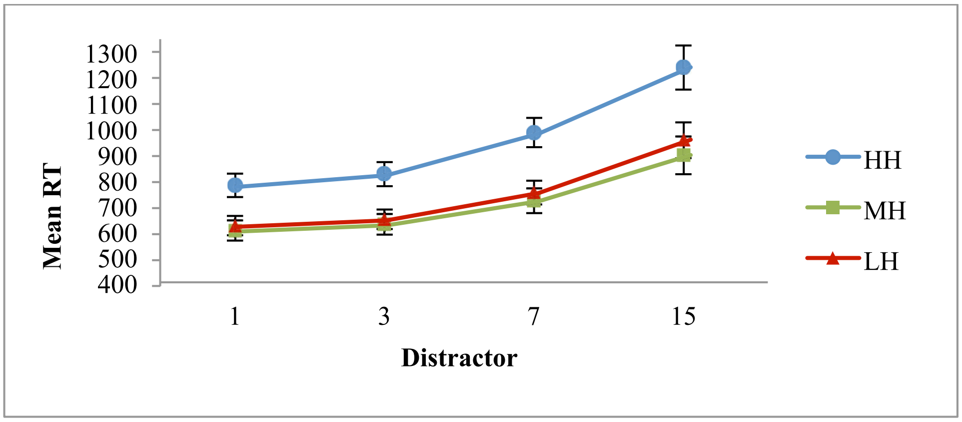


Figure 1: The interaction between Hypnotizability and Distractor in the TP condition of experiment 2.

The analysis also indicated that the interaction between session and distractor was significant (F (12, 348) = 16.6, p = .001, η_p^2 = .36). The interaction is depicted in Figure 2. The test of simple effect using Bonferroni-corrected t-test revealed the reaction time differences between distractor 15 and other distractors was greater in the first session. However, these differences became smaller by the fifth session.

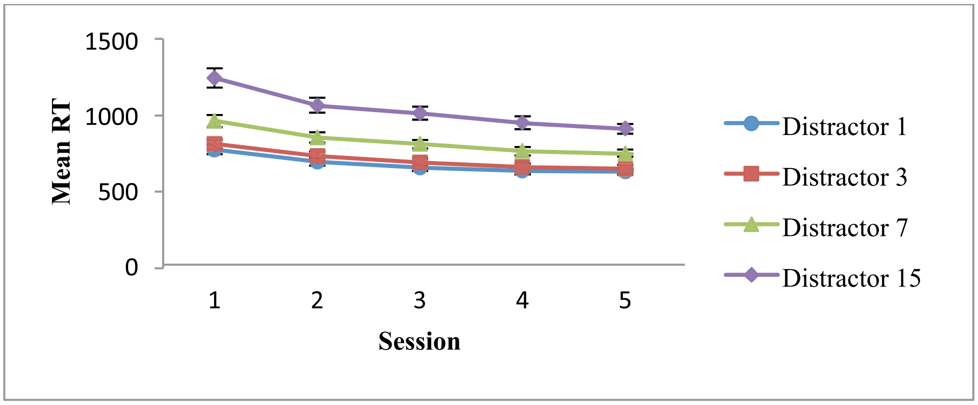


Figure 2: The interaction between Distractor and Session in the TP condition of experiment 2.

There was a three-way interaction between Session, Distractor, and Hypnotizability (F (24, 348) = 2, p < .004, η_p^2 = .122). As Figure 3 shows, the source of interaction is due to the longer mean RT of HH participants in the first session of the experiment than the RT of MH and LH participants when they were searching for the target among 15 distractors.

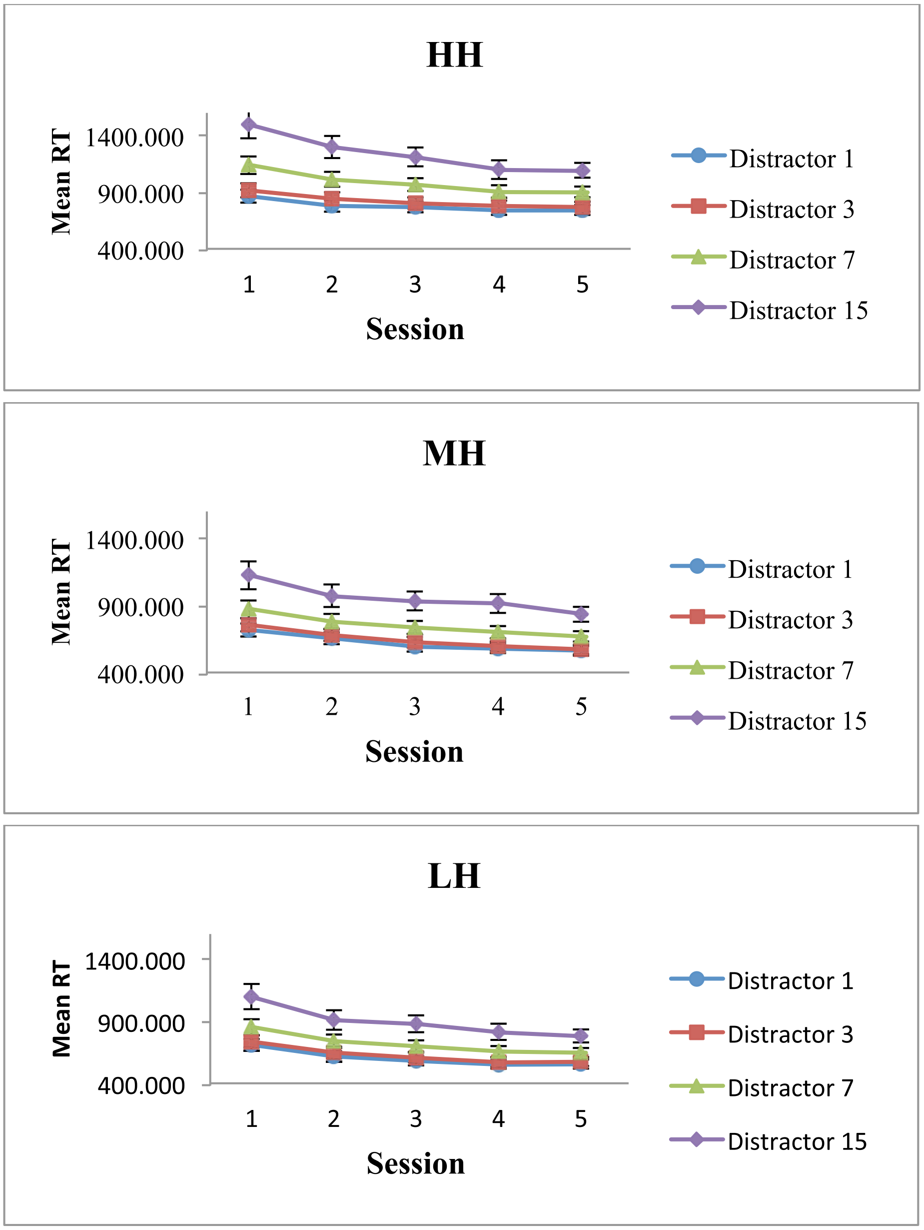
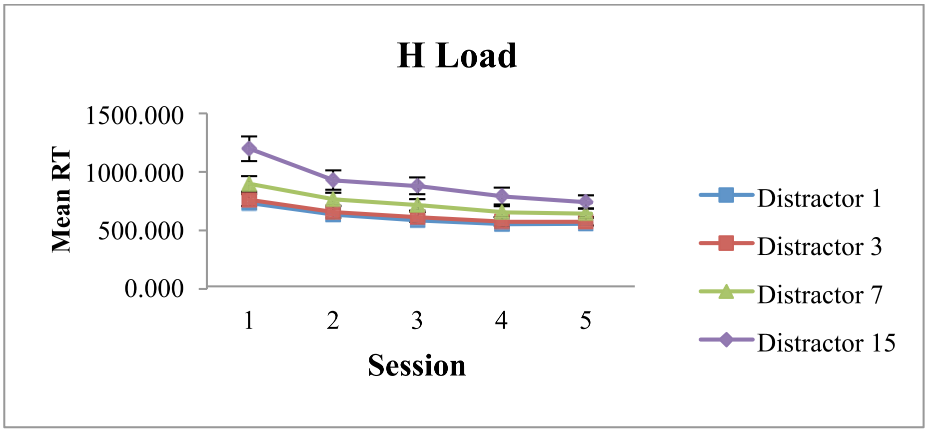
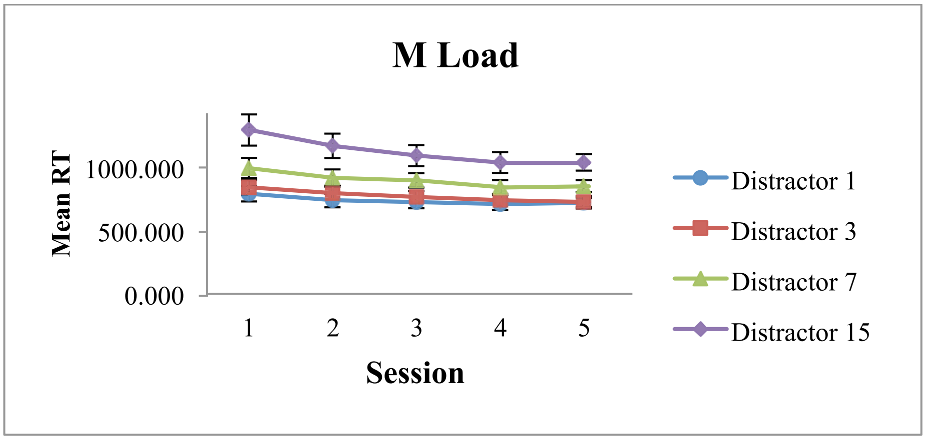


Figure 3: The three-way interaction between Session, Hypnotizability, and Distractor in the TP condition of experiment 2.

The interaction between Session, Distractor, and Load was significant (F (24, 348) = 2.11, p < .002, η_p^2 = .127). This interaction is displayed in Figure 4. As the graph displays, and it was confirmed by the test of simple effect using Bonferroni corrected t-test, the source of interaction is due to the fact that in session one, in the high load condition, the mean RT of distractor 15 was significantly different from other distractors. As the session progressed, the differences became non-significant.

There was a main effect of hypnotizability (F (2, 29) = 2, p < .006, η_p^2 = .29) with means and 95% CIs of 744 [840, 1047], 711 [648, 839], and 957 [612, 811] for low, medium and high hypnotizable groups, respectively. Tukey's HSD test indicated that the mean reaction times of the HH group were significantly different from the mean reaction times of the LH and the MH groups.





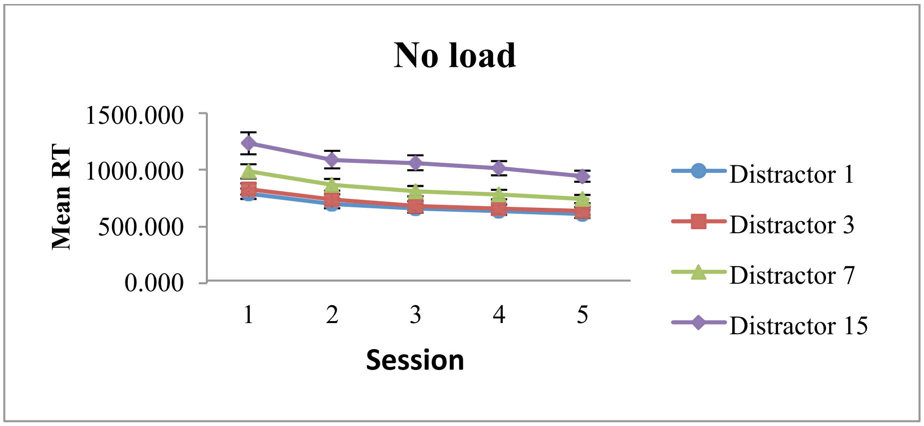


Figure 4: The interaction between Session, Load, and Distractor in the TP condition of experiment 2.

The interaction between Hypnotizability and Load was also significant (F (4, 29) = 2, p < .025, η_p^2 = .31). The interaction is presented in Figure 5. The test of simple effect using Bonferroni-corrected t-test revealed that the mean reaction time of the HH group was slower than the mean reaction time of the LH and the MH groups in the high load and in the medium load conditions but all groups had similar reaction times in the no-load condition.

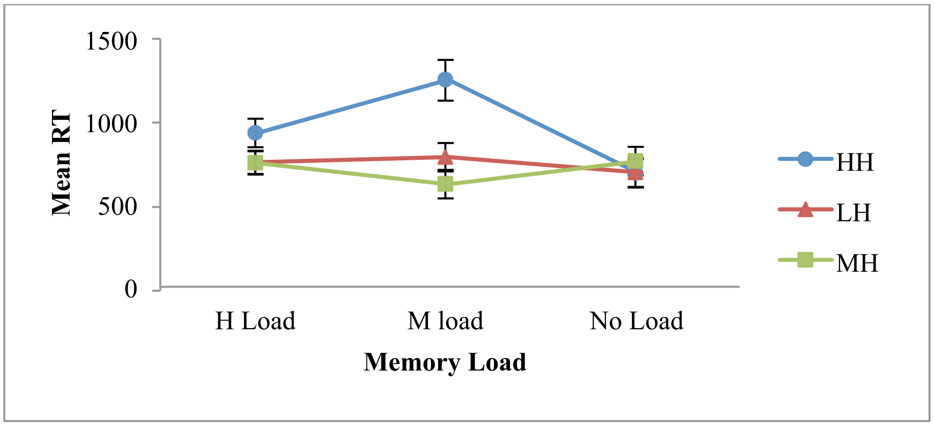


Figure 5: The interaction between Load and Hypnotizability in the target present condition in the TP condition of experiment 2.

Analysis of the mean reaction times (RTs) in target present (TP) condition for experiment 2b

A 2 x 2 x 5 x 2 (hypnotizability x load x session x distractors), between-within analysis of variance (ANOVA) was performed on the mean CVs. In this analysis, hypnotizability (high and low) and load (0, 5) served as between subject factors, and session (1, 2, 3, 4, 5) and distractor (1, 15) were the within-subject factors. The analyses revealed a main effect of session (F (4, 64) = 34.8, p < .001, η_p^2 = .31, with mean reaction times and 95% CI of, 843 [713, 973], 711[599, 825], 665 [558, 771], 647 [555, 739], 636 [553, 719] for session one, two, three, four, and five, respectively (the complete ANOVA tables can be found in Appendix A, Table 6). Bonferroni pairwise comparison test indicated that the mean RT of session one was significantly different from the mean RT of session 2, session 3, session 4, and session 5. The mean RT of session 2 was also significantly different from the mean RT of session, 3, session 4, and session 5. There was also a main effect of distractor (F (1, 16) = 97.2, p < .001, η_p^2 = .85) with mean reaction time of 616 [525, 707], and 785 [669, 900] for distractor 1 and 15, respectively.

The interaction between session and distractor is significant (F (4, 64) = 14.4, p < .001, η_p^2 = .47). As Figure 13 displays, the source of the interaction is due to the fact that the mean reaction times of distractor 15 decreased more than the mean reaction times of distractor 1 over sessions. This conclusion was confirmed by a test of simple effect using Bonferroni's test.

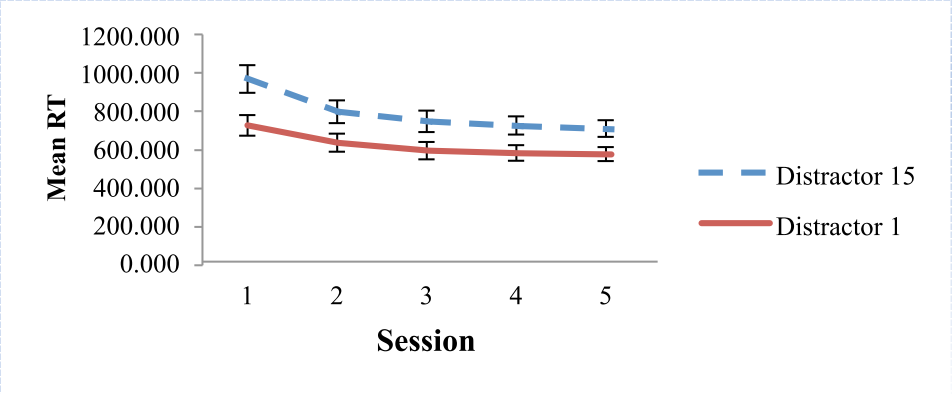


Figure 6 : The interaction between Session and Distractor in the TP condition of experiment 2b.

The three–way interaction between session, load and hypnotizability was significant (F (4, 64) = 3.7, p < .008, η_p^2 = .19). Although the interaction was significant and it seemed that in the no load condition, the HH group's reaction time decreased more in the distractor 15 condition in comparison to the distractor one condition, the Bonferroni test of simple effects indicated that these differences were not significant. As the figure seven displays, the interaction is due to the larger decrease of RT of HH participants in the no-load condition.

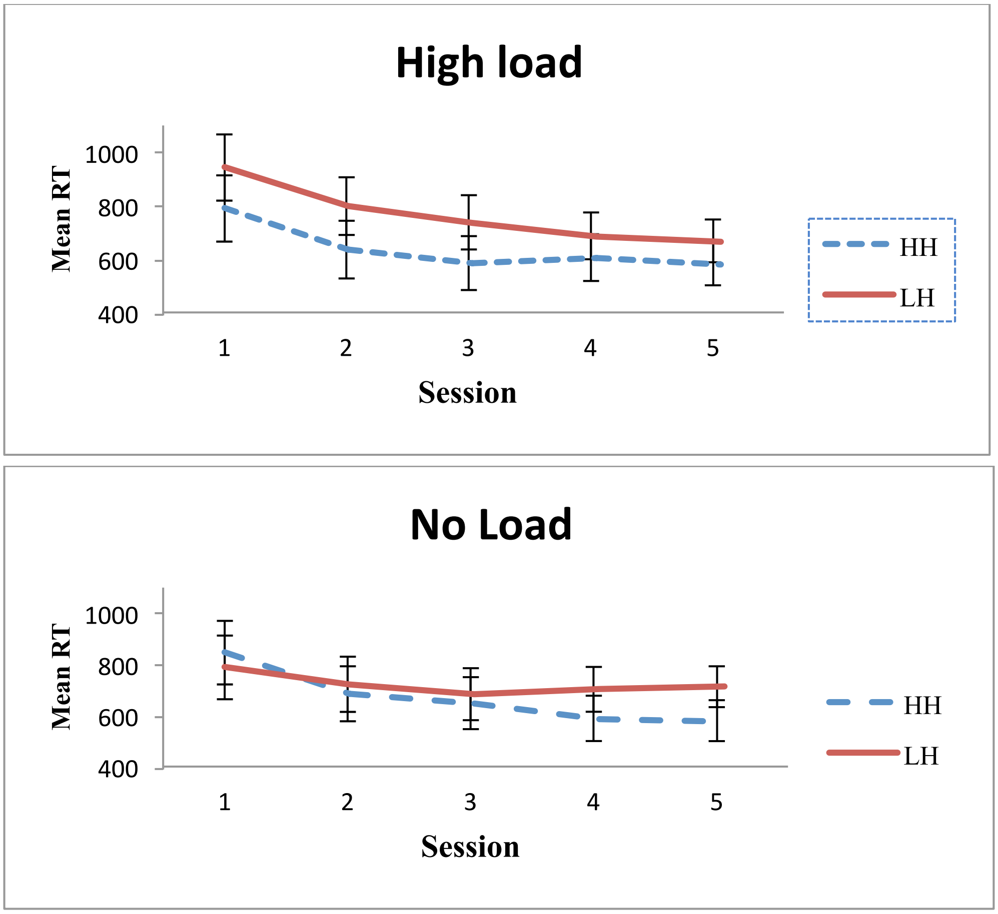


Figure 7: The interaction between Session, Load, and Hypnotizability in the TP of experiment 2b.

The three-way interaction between session, distractor, and hypnotizability was significant F (4, 64) = 4.07, p < .005, η_p^2 = .203). As Figure 8 displays and was confirmed by a test of simple effects, the interaction is due to the larger decrease of RT of HH participants over sessions.

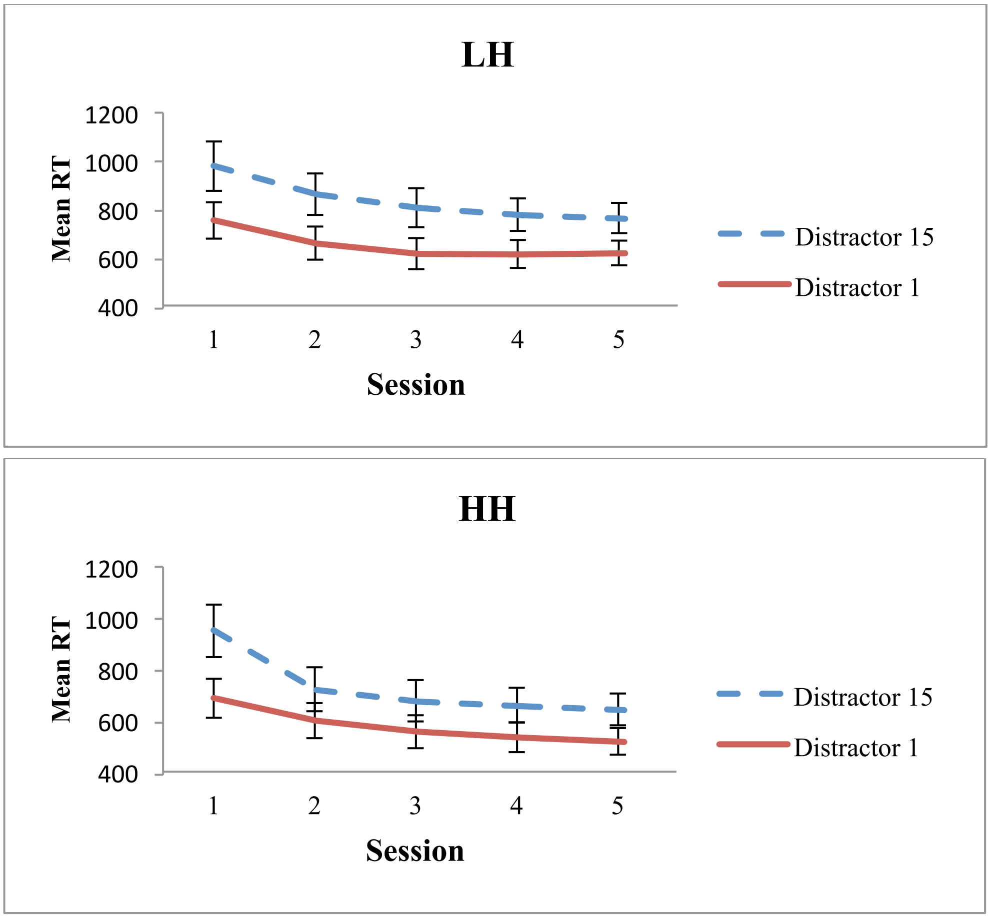


Figure 8: The interaction between Session, Distractor, and Hypnotizability in the TP condition, experiment 2b.

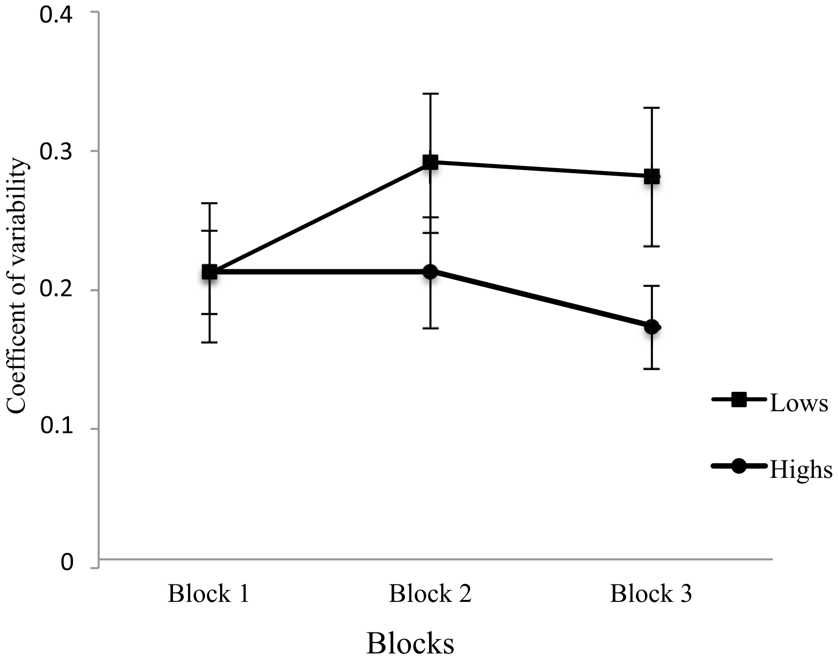


Figure 2. The interaction between coefficients of variability (CV) and blocks. Error bars represent the standard error of the mean.

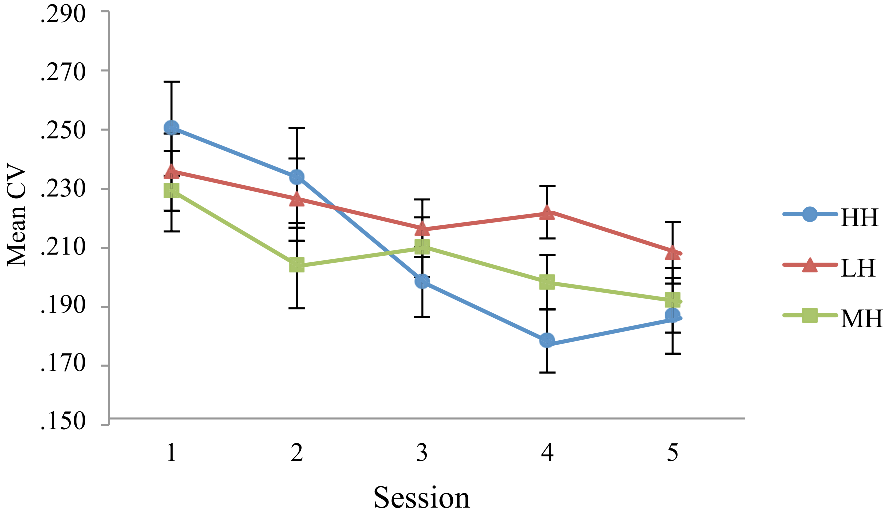


*Figure 3***.** The interaction between session and hypnotizability for CVs in experiment 2. HH (high hypnotizable), LH (low hypnotizable), MH (medium hypnotizable).
CV is the coefficient of variability. Error bars represent the standard error of the mean.

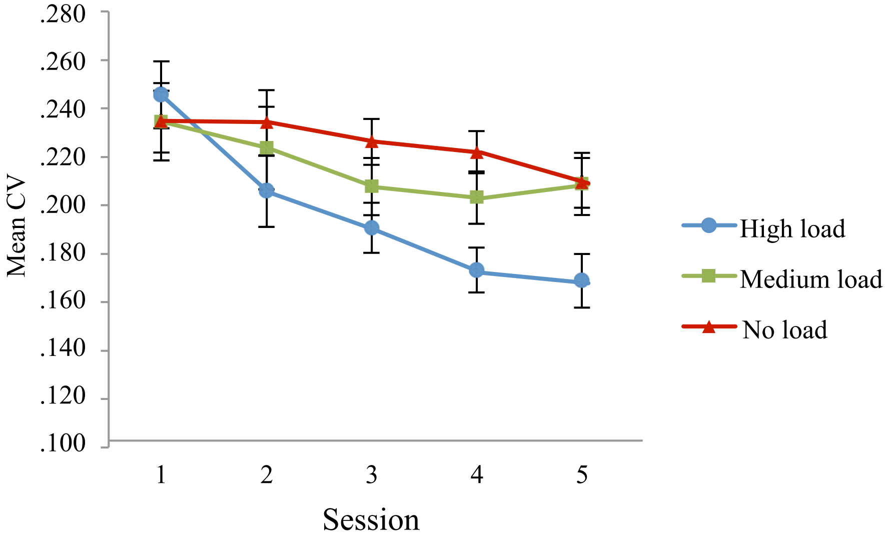


Figure 4. The interaction between session and load for CVs in experiment 2. HH (high hypnotizable), LH (low hypnotizable), MH (medium hypnotizable). CV is the coefficient of variability. Error bars represent the standard error of the mean..

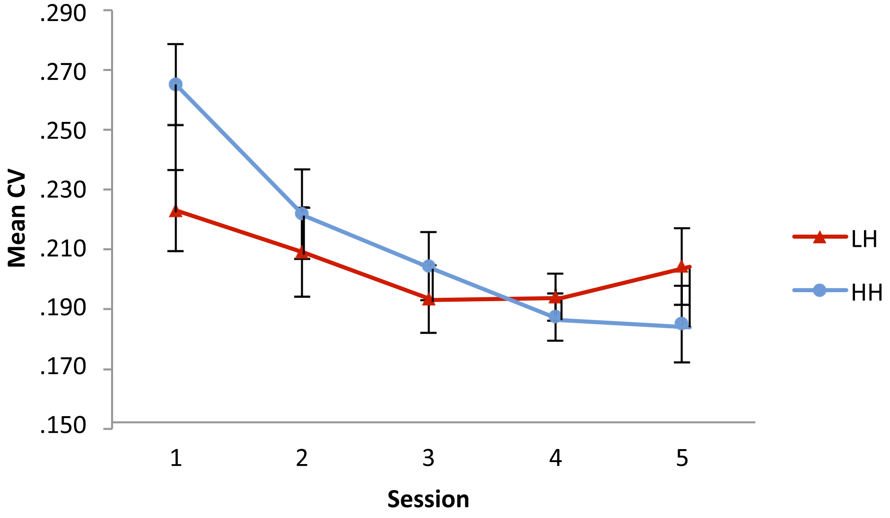


Figure 5. The interaction between session and hypnotizability. HH (high hypnotizables), LH (low hypnotizables). CV is the coefficient of variability. Error bars represent the standard error of the mean.

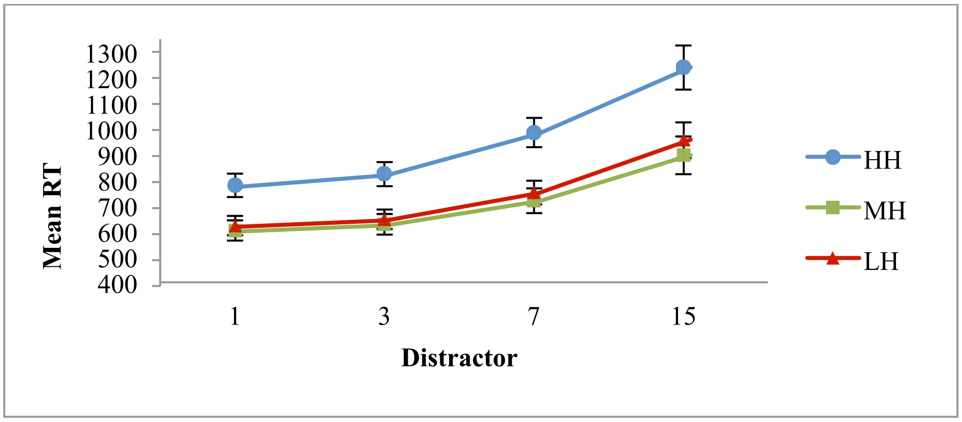


Figure 1: The interaction between Hypnotizability and Distractor in the TP condition of experiment 2.

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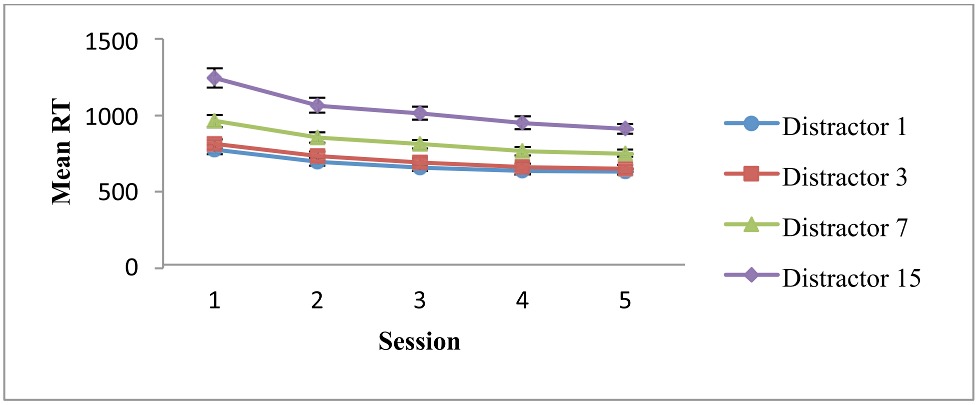

Figure 2: The interaction between Distractor and Session in the TP condition of experiment 2.

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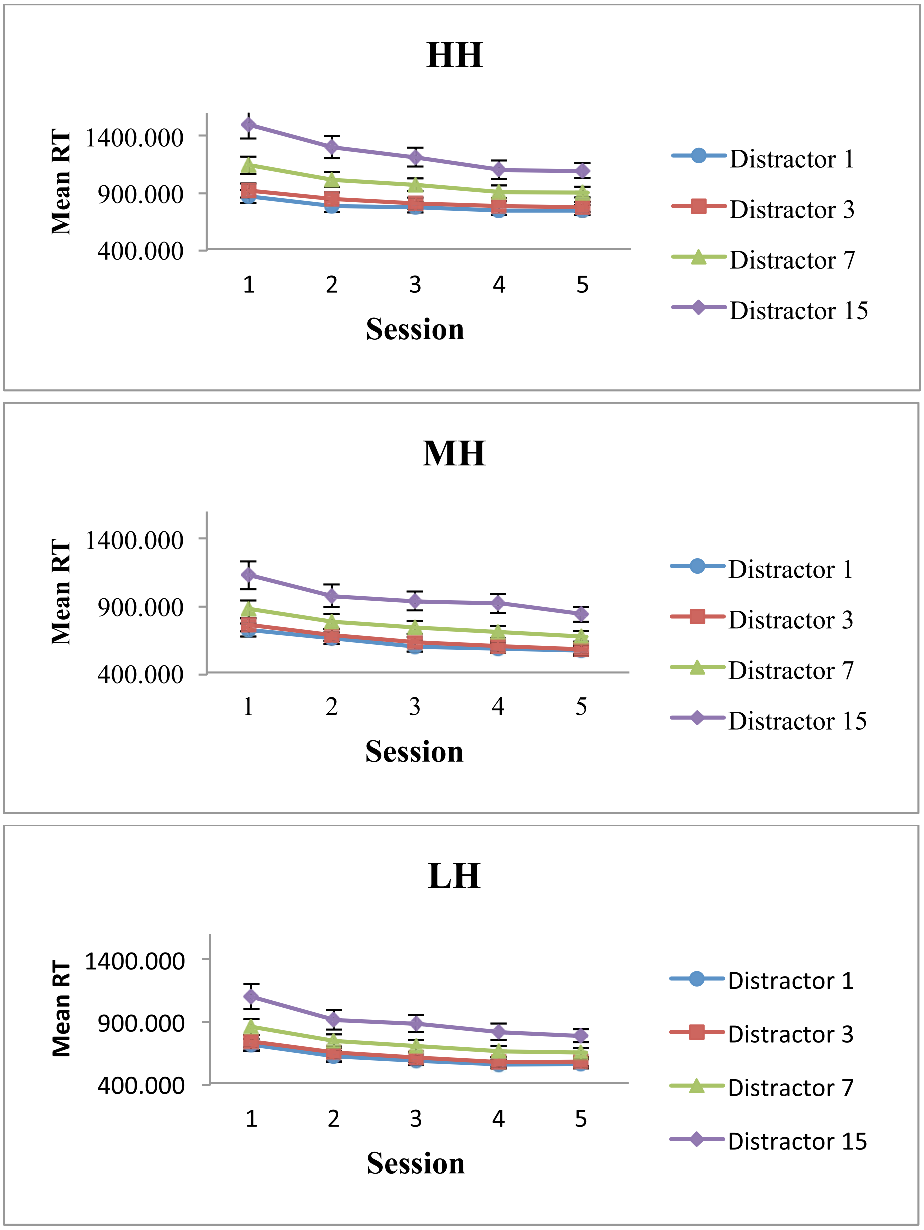

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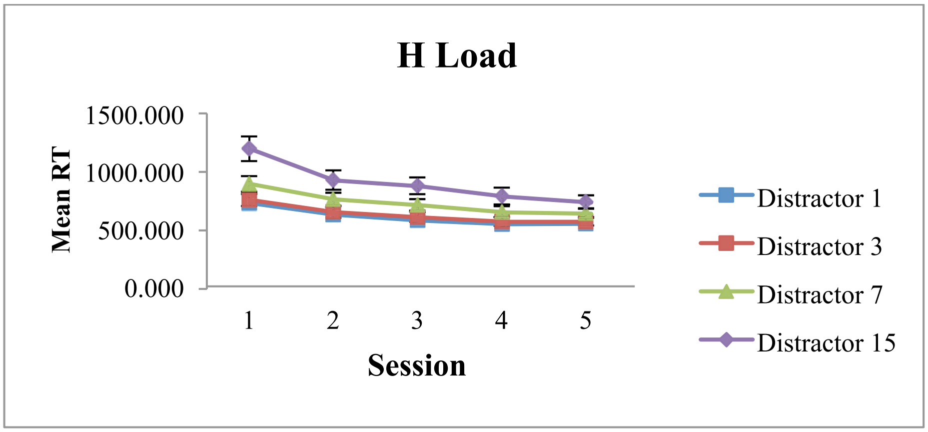

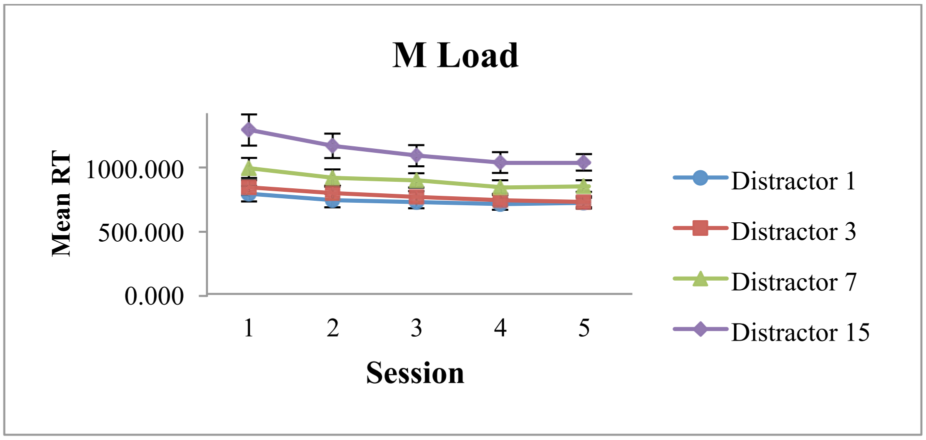

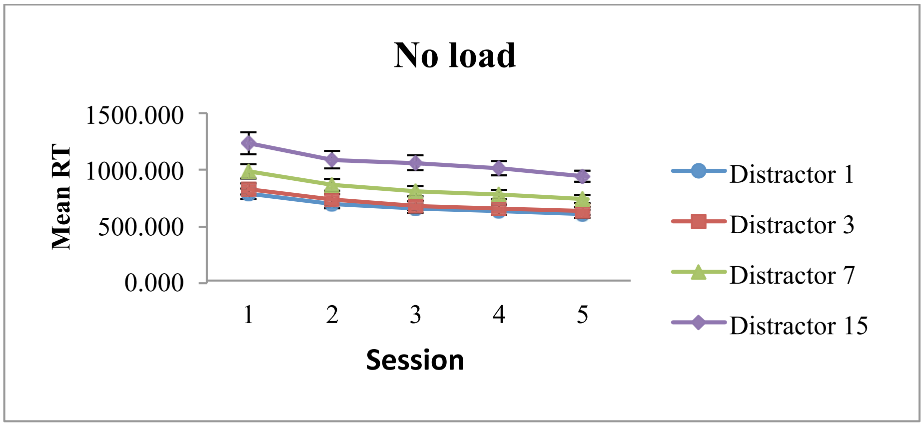

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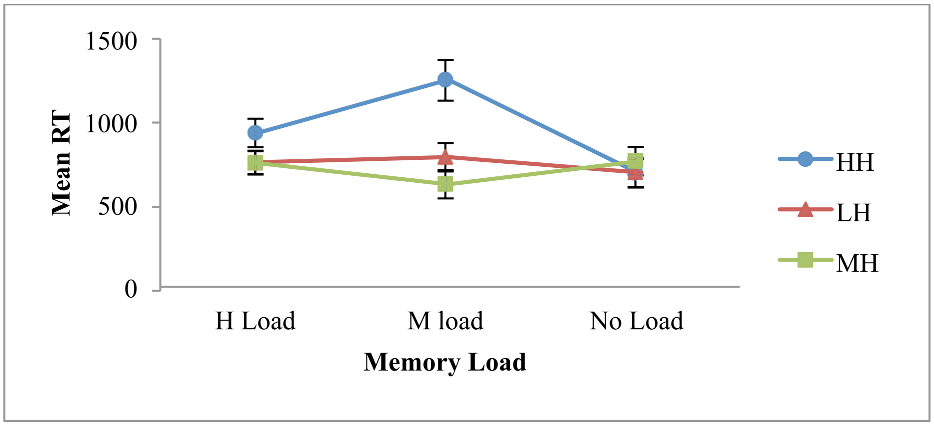

Figure 5: The interaction between Load and Hypnotizability in the target present condition in the TP condition of experiment 2.

Analysis of the mean reaction times (RTs) in target present (TP) condition for experiment 2b

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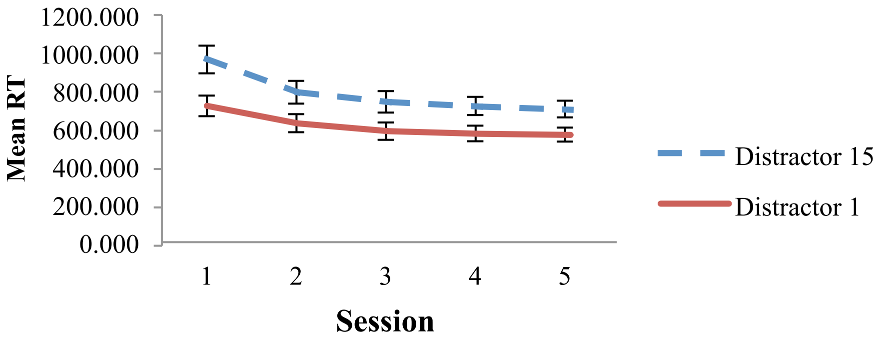

Figure 6 : The interaction between Session and Distractor in the TP condition of experiment 2b.