

HYPNOTIZABILITY AND SPATIAL ATTENTIONAL FUNCTIONS

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INTRODUCTION

Hypnosis is known to modify many aspects of conscious experience. However, the neural mechanisms underlying the hypnotic phenomena and hypnotizability are not well understood.

In the recent research on experimental hypnosis the notion of attention as an integral, determining aspect of the hypnotic process has been largely pointed out. In particular, many theories of hypnotic responding proposed that differences in hypnotic trait rely on differences in frontal attentional functions (for a review cf. (32, 37)). One of the models mostly supported by experimental evidences is the neuropsychological model of hypnosis introduced by Gruzelier (18) and Crawford and Gruzelier (9). According to this model, highly hypnotizable individuals (Highs), due to their peculiar focused attention capabilities, would be engaged in the first stage of hypnotic induction by easily focusing their attention on hypnotist's voice/instructions. A general decrease of frontal functioning associated with the suspension of critical evaluation and reality testing would follow, defining/marketing the transition into the hypnotic state.

While there is large neurophysiological and behavioral evidence that supports the alteration of attentional functioning in hypnotized Highs (5, 14, 17, 20, 21, 22, 27, 36), it is still controversial whether out of hypnosis Highs' anterior attentional system is more efficient than that of low hypnotizable individuals (Lows). In fact, although many of the experiments focused on those attentional functions – i.e. suppressing, concentrating and sustaining – that more frequently have been associated to hypnotic susceptibility and whose anatomical correlates have been fixed in the frontal areas (38), evidence of hypnotizability-related attentional abilities are still very scant (1, 10, 12, 13, 17, 23, 34).

The main purpose of the present study was to verify whether the hypothesized better focused attention characteristics of Highs could be highlighted in the spatial domain. We tested this idea on the Attention Network Test (ANT) (16), that consists of the combination of the classical cueing paradigm (28) and the flanker task (15), in which the ability to focus and select the relevant information among irrelevant distracters, strongly conditions the behavioral outcome. More specifically, ANT allows the independent analysis of the alerting, orienting and executive control components of the spatial attention through measure of specific reaction times.

According to Posner's theoretical model, attention cannot be considered a unitary faculty; it is rather a complex organ system subserved by multiple distinct neural networks each relying on different brain areas and neuromodulators that interact together to achieve the integrated function of attention (29). In short, alerting refers to the automatic process of attaining and maintaining a state of high sensitivity to incoming stimuli; orienting refers to the automatic function of selecting relevant information among sensory inputs; and executive control refers to the functional system that drives the intentional processes of monitoring and resolving conflicts in action planning, decision making, error detecting and overcoming habitual behavior. This control system relies on the anterior cingulate and lateral areas of the prefrontal cortex (26, 31).

In the present work we evaluated possible differences between the Highs' and Lows' spatial attention functions through the study of the automatic (alerting and orienting) and intentional (executive control) components of attention. Since focused attention abilities of Highs are supposed to be particularly efficient, Highs should be facilitated in the selection of information among distracters, thus showing better executive control functions than Lows.

Also, because there are general indications suggesting that females tend to be worse than males in spatial tasks (24) possible interactions between sex and hypnotizability as well as gender-related effects have been also evaluated.

METHODS

Subjects

Participants were 54 healthy volunteers (age $22,92 \pm 2,46$, mean \pm SD) recruited from a pool of students at the University of Pisa, who decided to participate to the experiment to obtain an extra credit for a Physiology Lab. Subjects had earlier been individually screened for hypnotizability by a medical psychologist using the Italian version of the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C) (40).

Twenty-seven individuals scored in the higher range of the hypnotizability scale (Highs, score 9-12; 15 females) and twenty-seven scored in the lower range (Lows, score 0-3; 15 females).

All subject reported normal or corrected-to-normal vision. Written informed consent, approved by the local Ethical Committee, was obtained from all participants.

The general attentional characteristics of Highs and Lows were preliminary evaluated through the four major subscales of the Differential Attentional Processing Inventory (DAPI) (10), and the Tellegen Absorption Scale (TAS) (39).

Stimuli and Procedure

The experimental task consisted of a shortened and slightly modified version of the Attention Network Test with respect to the original procedure described by Fan et al. (16). The experimental paradigm is illustrated in Figure 1.

Experiment was run on a FreeBSD PC system (Imago program, feanor.sssup.

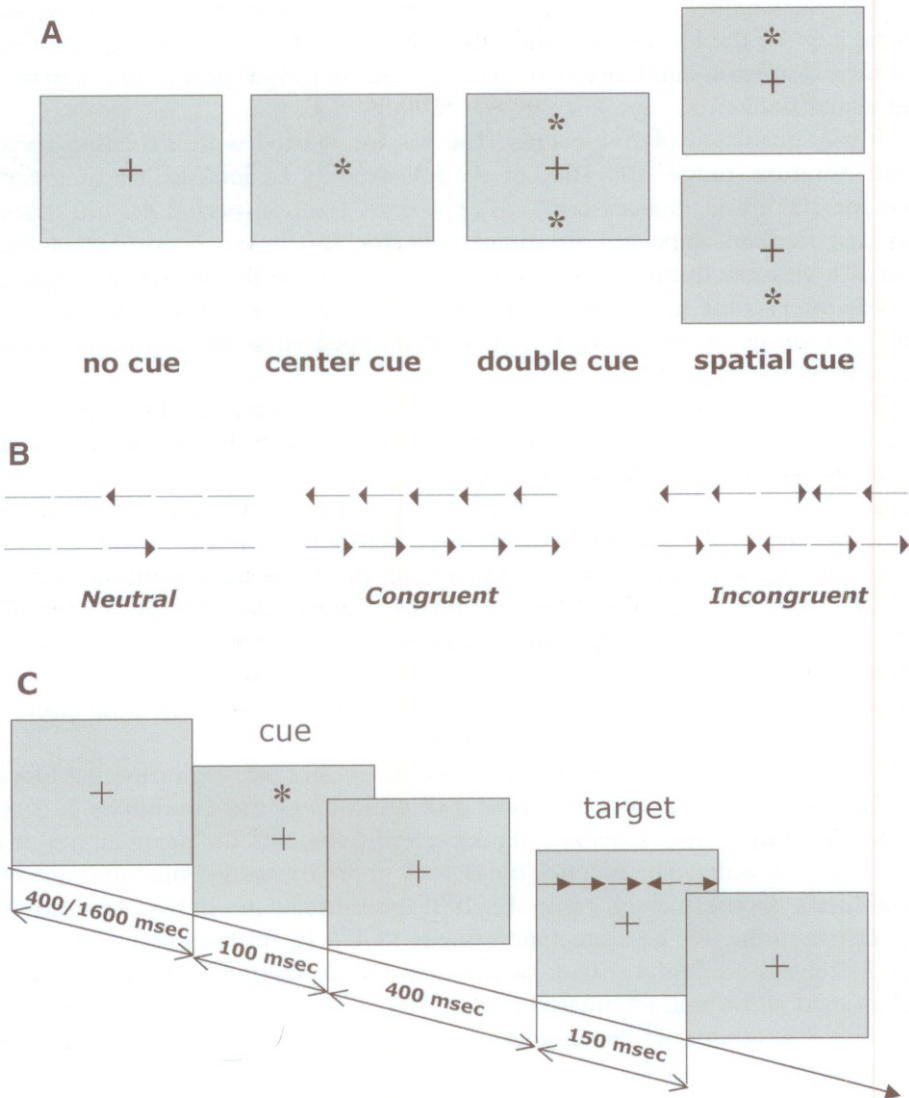


Fig. 1. – Attention Network Test: stimuli and experimental procedure. A) cue conditions; B) flankers and target conditions; C) experimental procedure.

it/~pv/). Participants viewed the screen from a distance of 57 cm, and responses were collected via two input keys on a keyboard.

Stimuli consisted of a row of five horizontal block lines presented against a gray background. The target was a leftward or a rightward arrowhead flanked on either side by two lines (neutral condition), or by two arrows pointing in the same direction of the target (congruent condition) or in the opposite one (incongruent condi-

tion). The participants' task was to identify the direction of the target by pressing a different key for the left and the right direction, with the index and the middle finger of their dominant hand, respectively. The stimuli (target plus flanker) covered 3° of the visual field.

Each trial consisted of five events. The session started with a fixation period of variable duration (range: 400-1600 msec) followed by an acoustic warning cue presented for 100 msec. Successively, after a short fixation period of 400 msec, the Target and flankers appeared simultaneously for 150 msec. A post-target fixation period of a variable duration (max 1500 msec) followed the stimuli disappearance. After this interval the next trial began. Each trial lasted for 3200-3400 msec.

The fixation point consisted of a cross that appeared at the center of the screen during the whole trial.

To introduce an attentional-orienting component to the task, the target was presented in one of two locations outside the point at which the subject was fixating, either 1° above or below the fixation point.

Target location was always uncertain except when spatial cue, consisting in an asterisk (duration 100 msec) shown 500 msec before the stimulus, was presented. To measure alerting and orienting, one no cue and three cueing conditions were used: center cue, double cue and spatial cue. In the center-cue condition a warning cue (asterisk) was presented at the same location of fixation cross; in the double-cue condition two asterisks were presented up and down the fixation cross, that is in the two possible target position; in the spatial-cue the asterisk indicated the target location.

A session consisted of a 15-trials practice block and two experimental blocks of trials. Each experimental block consisted of 48 trials (4 cue-conditions X 2 target-locations X 2 target-directions X 3 flanker-conditions) and the presentation of trials was in a random order. The practice block took approximately 1 min and each experimental block approximately 3 min. Each of the subjects ran in two sessions during 1 day. Between the two sessions, participants took a 10 minutes rest.

During the experimental sessions participants were seating in front of the monitor in a darkened and sound attenuated room. They were instructed to focus on the fixation point throughout the task avoiding eye movements, and to respond as quickly and accurately as possible. Reaction times (RTs) were measured as the interval between stimulus presentation and key-pressing response.

For all subjects test was carried out by one of the authors (E.C.), who had not taken part to the hypnotizability assessment; participants were not informed about the relevance of their hypnotic ability to the test and throughout the experimental sessions hypnosis was never mentioned to them.

Data Analysis

For each subject and for each flanker and cue condition RTs have been measured. Repeated measures ANOVA was performed on RTs medians following a 2 (Hypnotizability: Highs, Lows) X 2 (Sex: male, female) X 4 (Cue: no cue, center cue, double cue, spatial cue) X 3 (Flanker: neutral, congruent, incongruent) design,

with Hypnotizability and Sex as Between-subjects factors, and Cue and Flanker as Within-subjects factors.

In order to evaluate possible differences between Highs and Lows in the efficiency of the attentional process, alerting and orienting functions were calculated, respectively, by subtracting the means of the median RTs' of the double cue conditions obtained in the 3 flanker configuration from those of the no cue conditions (alerting) and by subtracting the means of median RTs' of the spatial cue conditions obtained in the 3 flanker configuration from those of the center cue conditions (orienting).

Possible hypnotizability-related differences in the executive control were also studied by comparing the interference effect exerted by incongruent flankers in Highs and Lows. This function is obtained by subtracting the means of median RTs' of all congruent flanker conditions, averaged across cue types, from those of the incongruent flanker conditions (I-C). In order to better clarify the role of congruent and incongruent flankers with respect to the no flanker (neutral) condition, neutral-congruent (N-C) and incongruent-neutral (I-N) components of interference were also measured and compared between the two groups.

Separate univariate ANOVAs, with hypnotizability and Sex as Between-subjects factors, was carried out on alerting, orienting, executive control and error rates.

RESULTS

Neuropsychological Characterization

Highs' scores on absorption (TAS) were higher than those of Lows (one way ANOVAs; $F(1,52)=8.353$; $p<0.006$). Similarly, on the DAPI, Highs obtained higher scores than Lows on the whole scale ($F(1,52)=7.522$; $p<0.008$) even though separate analysis of the four subscales revealed that Highs differed from Lows only on the extremely focused attention items ($F(1,52)=12.276$; $p<0.001$). Indeed, no differences between Highs and Lows were found either on the moderately focused attention scale or on the scores of the two subscales related to dual attention abilities. In both neuropsychological questionnaires no significant gender effects were found.

RTs Data

Table 1 and Figure 2 (a, b) show the reaction times (RTs) scored by Highs and Lows during the two experimental sessions as a function of cue and flanker condition. Data refers to correct trials only. Error rates are shown in Figure 3 (a, b). As can be observed, the performance accuracy was very high in all subjects also in the incongruent condition (error rate $< 1\%$). No difference between Highs and Lows as well as between genders was found.

Repeated measures ANOVA on RTs showed that hypnotizability did not reach significance ($F(1,50)=3.551$, $p<0.065$), even though Highs' RTs tend to be shorter than Lows'; Sex yielded a significant main effect ($F(1,50)=4.489$, $p<0.039$), with males generally faster than females.

Table 1 – Mean reaction times (ms) of Highs and Lows under each conditions.

		WARNING TYPE				
		No Cue	Center Cue	Double Cue	Spatial Cue	
CONGRUENCY	HIGHS	Neutral	464,80 (44,92)	435,02 (45,46)	439,48 (58,54)	444,37 (41,68)
		Congruent	486,20 (61,36)	440,46 (49,26)	446,96 (48,57)	439,30 (44,76)
		Incongruent	578,74 (57,16)	568,30 (64,86)	546,63 (56,61)	531,52 (55,02)
	LOWS	Neutral	492,52 (57,81)	459,91 (62,42)	451,80 (63,51)	465,43 (60,97)
		Congruent	538,80 (80,07)	480,04 (80,11)	476,06 (74,57)	457,93 (70,69)
		Incongruent	626,30 (93,77)	599,93 (83,64)	570,06 (78,14)	548,11 (67,83)

SDs are shown in parenthesis

Significant Within-subjects effects were Cue ($F(3,150)=68.376$, $p<0.0001$), and Flanker ($F(2,100)=346.027$, $p<0.0001$); the interaction Cue X Flanker was also significant ($F(6,300)=9.799$, $p<0.0001$). As can be observed in Figure 2, under all cueing conditions, the presence of incongruent flankers increased RTs and this effect was enhanced when subjects were given no cues or alerting cues containing no spatial information (center or double cues). This effect was particularly evident in Lows. Significant Cue X Hypnotizability ($F(3,150)=4.058$, $p<.008$) and Cue X Sex ($F(3,150)=4.577$, $p<.004$) interactions were also found. Specifically, as shown in Figures 4 and 5, Highs were significantly faster than Lows in the no cue ($F(1,52)=7.276$, $p<.009$) and central cue condition ($F(1,52)=4.040$, $p<0.05$) and males were faster than females in the center ($F(1,52)=8.439$, $p<0.005$) and double cue condition ($F(1,52)=4.908$, $p<.031$).

No Hypnotizability X Sex interactions were found.

Even though N-C and orienting effects tend to be smaller in Highs, ANOVA yielded significant difference between Highs and Lows in alerting effect ($F(1,50)=6.901$, $p<0.011$), only. No Hypnotizability differences were found in interference and I-N effects (Fig. 6).

As concern possible influences of gender (Fig. 7) on alerting, orienting, and executive control functions, male performance appeared to be less influenced by the presence of the spatial cue. This was confirmed by statistical analysis which yielded a significant difference between males and females in the orienting effect ($F(1,50)=10.436$, $p<0.002$).

DISCUSSION

This study was designed to investigate the relationship between hypnotizability and executive control components of attention in the spatial domain.

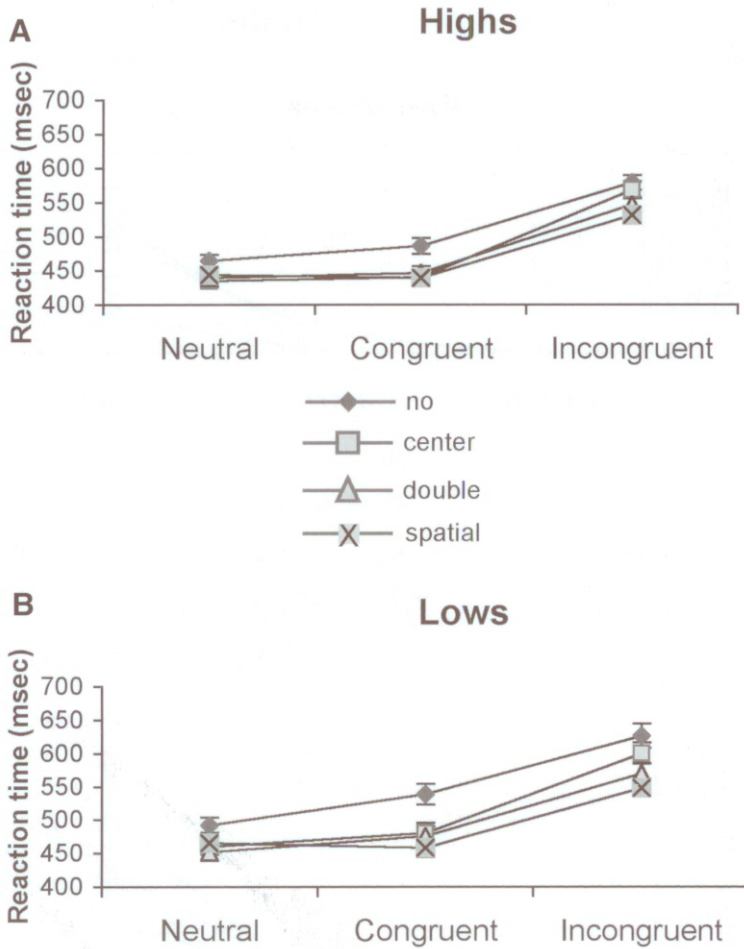


Fig. 2. – Reaction times. Figures A and B show, respectively, Highs and Lows mean (\pm SE) reaction times from correct trials as a function of cue and flanker condition.

Our preliminary evaluation of subjects showing higher scores of Highs on extremely focused attention and absorption with respect to Lows confirms previous neuropsychological findings that suggested an association between the hypnotizability trait and particularly efficient focused/sustained attention abilities (10, 23, 35).

Our results with the shortened version of ANT replicate the general findings obtained with the original test by Fan et al. (16), thus indicating that this modified version of the test can be used as a reliable tool to investigate spatial attention functions. In fact, in all subjects regardless of the level of hypnotizability, the presence

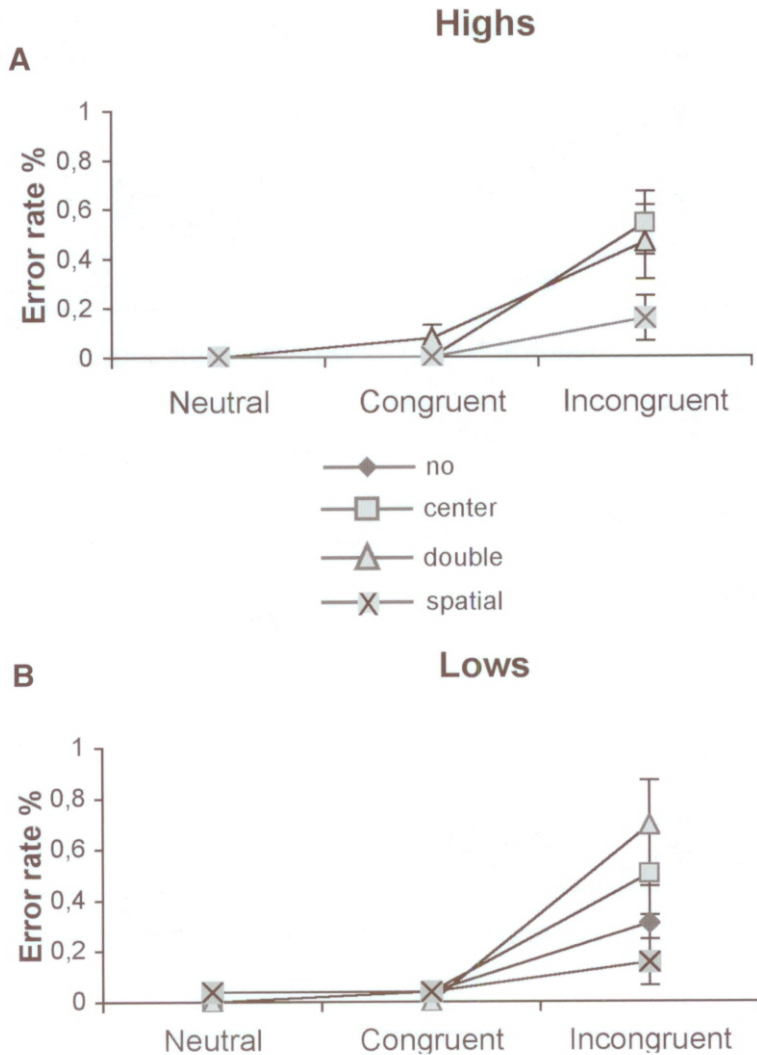


Fig. 3. – Error rate.

Figures A and B show, respectively, Highs and Lows mean error rate (%) as a function of cue and flanker condition.

of incongruent flankers increased RTs under all cueing conditions; this effect was enhanced when subjects were given no spatial information.

On the basis of their supposed better-focused attentional abilities we had expected that Highs would have been little interfered by the presence of incongruent flankers. In contrast, our results on executive control functions did not show any significant difference between Highs and Lows. Similar findings have been reported in

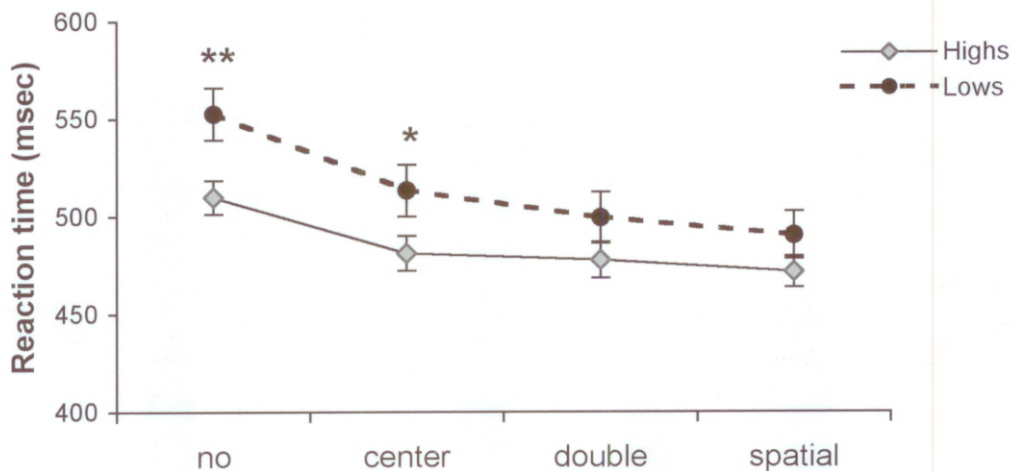


Fig. 4. – Cue effect: hypnotizability-related differences. Highs and Lows mean (\pm SE) reaction times as a function of cue condition. Significant differences between Highs and Lows are shown (** $p < .01$; * $p < .05$).

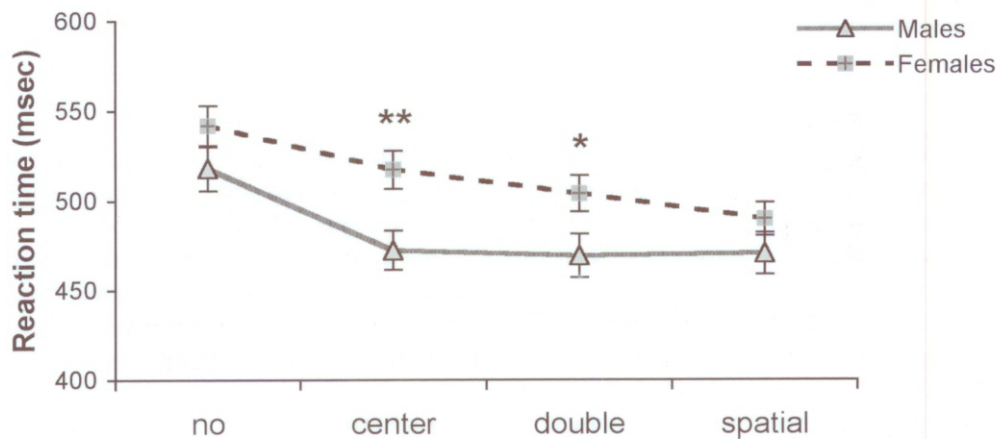


Fig. 5. – Cue effect: gender-related differences. Males and Females mean (\pm SE) reaction times as a function of cue condition. Significant differences between Males and Females are shown (** $p < .01$; * $p < .05$).

studies in which the ability to suppress a feature that is relevant but inappropriate to the task requirements has been evaluated. In these experiments that were in most of the cases based on Stroop-like paradigms, Highs performance resulted similar or even worse than that of Lows (12, 13, 22, 23, 36). One could hypothesize that Highs' higher focused attentional skills should be interpreted as the more efficient general

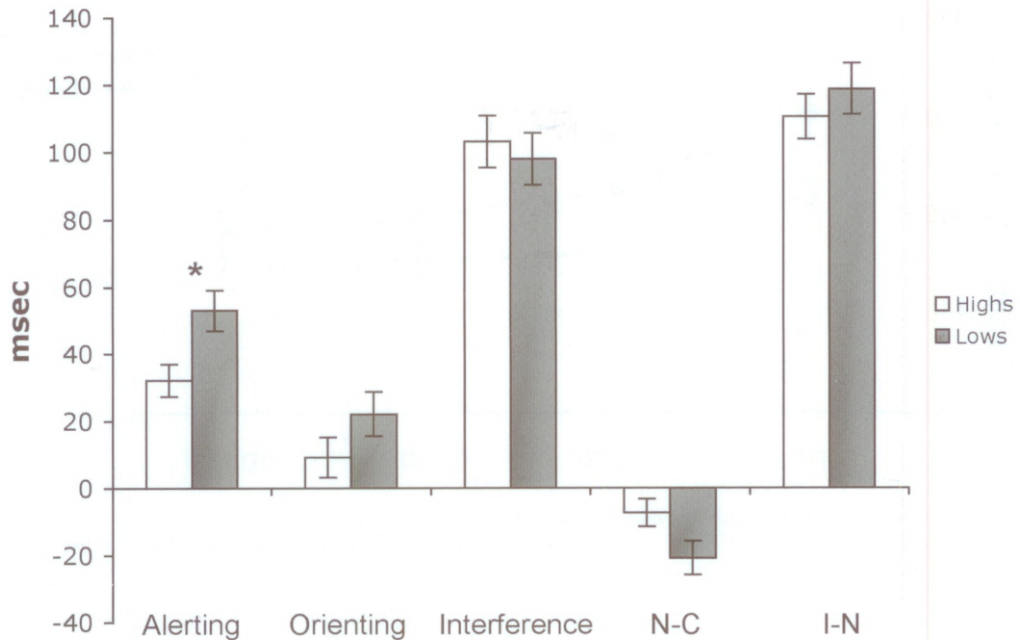


Fig. 6. – Attentional functions: hypnotizability-related differences.

Attentional functions mean (\pm SE) scores of Highs and Lows. Significant differences between Highs and Lows are shown (* $p < .05$).

ability of Highs to be strictly engaged with a specific task as a whole, avoiding distraction, rather than the more efficient capability to select specific details of a stimulus, suppressing the irrelevant information. Otherwise, Highs could be able to process stimuli more automatically. If this was the case, target and distractors could result simultaneously processed and this would consequently lead to a higher interference effect. Thus, any facilitating effect due to the more efficient focused attention capabilities would be hampered/masked by the automatic processing effects. Indeed, the notion that Highs' ability to process words more automatically could negatively influence their performance in the color naming Stroop task has been previously hypothesized (12, 13, 33).

The main finding of this study is that Highs were generally faster than Lows. This tendency was particularly marked in the no cue condition in which the basal level of subject's vigilance is considered a relevant factor in conditioning the performance by modulating the speed of response selection (16). Highs' capability of exhibiting fast responses in spite of the lack of specific warning cues was particularly evident in the most complex situation that is the incongruent flankers condition. In this case, at difference with Lows whose RTs appeared to get shorter going from the no cue to the location cue condition (see Fig. 2, Fig. 4), Highs performance was scarcely improved by the presence of warning cues. This finding is further sustained by

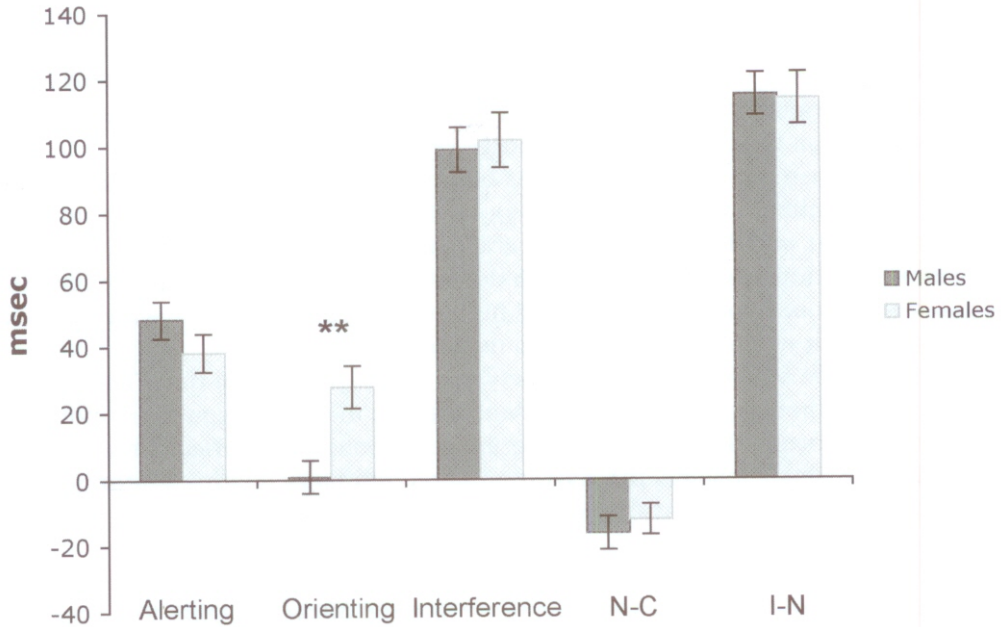


Fig. 7. – Attentional functions: gender-related differences.

Attentional functions mean (\pm SE) scores of Males and Females. Significant differences between Males and Females are shown (** $p < .01$).

results on specific attentional functions. Indeed, even though alerting, orienting and executive control effects were found in both groups, orienting tended to be smaller and alerting was significantly lower in Highs than in Lows.

All together these findings suggest that Highs are endowed with a basal higher efficiency in achieving and maintaining their readiness to respond to incoming stimuli and that this ability could offer a useful support for a better focused/sustained attention. Evidence from animal neurophysiological studies suggest that the noradrenergic neurons of locus coeruleus play a role in facilitating rapid neural responses in tasks requiring focused attention (3, 4, 6). In particular, the stimulus-induced phasic activity in the LC produces a temporary increase in responsiveness of efferent target neurons in cortical projections areas, which is thought to facilitate processing in response to a target stimulus (3). This synchronized activation mode would be driven by decision processes originating in the anterior cingulate and orbito-frontal cortices, and would then represent a mechanism to facilitate the behavioral and cognitive outcomes of decision-making (2). It could be suggested that Highs' ability to perform the task with a lower cost in response time could rely on the stronger phasic activation of their LC. The better anterior attentional functions postulated for Highs could then be related to the better efficiency of the anterior/frontal attentional-LC network.

Shorter reaction times in highly susceptible individuals than in low susceptible had been previously reported by Crawford et al. (11) in a binary choice task in which subjects were asked to distinguish between angry and happy faces. More recently Braffman & Kirsch (7) have showed that hypnotizability was associated with shorter simple reaction times and longer go/no-go response times.

Despite the methodological differences between these tasks and ANT concerning stimuli (faces/animal drawings vs arrows), attentional requirements (non-spatial vs spatial attention), and distractions (no distraction vs flankers), data on binary choice and simple reaction times are in line with our findings and could be likely explained on the basis of our hypothesis of a basal high efficiency of Highs in achieving and maintaining their readiness to respond to incoming stimuli.

As concern the positive relationship between go/no-go reaction times and hypnotizability the authors suggest that, consistent with the model of hypnotic response as an inhibitory process (8, 19), withholding the go response may reflect a bias of hypnotizable individuals towards the activation of an inhibitory control. Unfortunately, this hypothesis cannot be verified with ANT, being our subjects required to give a response for both directions of the arrows.

Our results on gender-related effects support the general finding that males tend to outperform females on spatial tasks (24). In spite of the fact that this notion is widely acknowledged, considerable dispute surrounds the magnitude, consistency and stability of sex-related differences on spatial abilities. In particular, sex differences have been found only on some types of spatial tasks (25) and, recently, it has been suggested that females' spatial abilities could be modified through attitudinal and experiential factors (30).

Moreover, since no interactions between sex and hypnotizability have been found there is no evidence indicating that the hypnotizability-related effects we have described could be modulated by gender.

SUMMARY

Many theories of hypnotic responding have proposed that differences in hypnotic trait rely on differences in frontal attentional functions. Evidence of hypnotizability-related attentional abilities are, however, very scant.

This study was designed to investigate the relationship between hypnotizability and executive control components of attention in the spatial domain. We chose the Attention Network Test that enables to analyze alerting, orienting and executive control functions by measuring reaction times (RTs) to targets cued for different locations in space.

According to Posner theory, alerting, orienting and executive control effects were found in both groups. No differences between highly susceptible (Highs) and low susceptible individuals (Lows) on executive control functions were found. However, in Highs alerting was significantly smaller than in Lows and Highs were significantly faster than Lows in the no and central cue conditions. These findings suggest

that Highs would be endowed with a basal higher efficiency in achieving and maintaining their readiness to respond to incoming stimuli. This relation between hypnotizability and alerting, is discussed in terms of a possible more efficient noradrenergic activity driven by frontal attentional systems.

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