EXPLORATIVE INVESTIGATIONS INTO NON-CONSCIOUS VISUAL LOCALIZATION OF STIMULI USING A PARADIGM OF HYPNOTICALLY INDUCED BLINDNESS

POSSIBLE ANALOGUES TO BLINDSIGHT

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This Masters Thesis has been presented at the conference
Toward a Science of Consciousness,"Tucson 2000", April 10-15, 2000
as
D.J.Bierman, J.J.Fahrenfort (2000). Explorative Investigations Into Non-Conscious Visual Localization of Stimuli Using a Paradigm of Hypnotically Induced Blindness: Possible Analogues to Blindsight. *Consciousness Research Abstracts*, p. 149

Abstract of that constribution:
6 subjects (50% highly hypnotizable, 50% badly or non-hypnotizable) were presented with stimuli on a 20 inch monitor (50% were blanks, 50% contained an open circle in one of six possible locations). For each trial they had to give two responses on a response panel. The first response indicated whether or not they had seen the circle, the second response was used to indicate the location of the circle. Half of the subjects were 'blinded' for a portion of their visual field using a hypnotic induction procedure; the other half simulated having undergone such a procedure. The experimenter was not informed of their condition. The same subjects had to do the same task in normal waking condition with the only difference that stimulus presentation times were drastically reduced and stimuli were obscured with the use of backward masking, thus resulting in suboptimal presentations. The following hypotheses were tested: (1) are there blindsight components in the perception of hypnotically induced blind subjects, (2) are there differences in the responses of hypnotized subjects vs. simulating subjects, (3) can blindsight components be found in the normal waking condition when stimuli are presented suboptimally. Overall results showed that hypnotized subjects were more likely to locate stimuli above chance level on 'unseen' trials (blindsight) whereas simulators scored under chance or around chance. However, due to small sample size these results could not be generalized with certainty to 'hypnosis' and 'simulator' populations. Non-hypnotized subjects showed stronger evidence for demand characteristics in their data. Some evidence for blindsight could also be found in the data from the suboptimally presented stimuli. (Also available at: http://www.imprint-academic.demon.co.uk/T2000/05-03.html)

Supervisor:	Prof. Dr. D.Bierman
With *extraordinary* thanks to:	Drs. D.Wernars
	The subjects
And cooperation from:	Hypnose opleiding TranceArt te Baarn
	Nederlandse Academie voor Psychotherapie te Amsterdam

Without all of you this experiment could not have taken place. Thanks!

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Introduction

The syndrome of blindsight has been the focus of widespread attention during the past couple of decades. Blindsight is the phenomenon occurring in some patients with a lesion or damaged area in their visual cortex. These patients claim to have no visual awareness in the part of their visual field that is located contralateral to the damaged area in their visual cortex. Surprisingly these patients do have the ability to locate and even identify stimuli in this hemianopic field by guessing. (Weiskrantz, Warrington, Sanders & Marshall, 1974; Weiskrantz, 1995). In effect, this is localization without conscious awareness. Blindsight phenomena have also been found in ‘normal’ subjects with the use of subliminal/suboptimal presentation of stimuli (Cowey, 1995; Graves & Jones, 1992; Meeres & Graves, 1990; Kolb & Braun, 1995). Meeres and Graves (1990) presented their subjects with masked stimuli using four different presentation times (50% of the stimuli were open circles in one of six possible locations, the other 50% were blanks). Subjects were asked to indicate whether and where they thought they saw the stimuli. According to an SDT analysis subjects were more sensitive for the location than for the detection decision, thus indicating blindsight. Graves and Jones (1992) replicated this result.

While following cortical damage or suboptimal presentation one can be blind to stimuli even though localization abilities are relatively intact, it also is also possible to induce ‘blindness’ in hypnotized subjects while some implicit knowledge about the location of stimuli remains present (Bryant & McConkey, 1989a, 1989b, 1990). These subjects seem to have no phenomenological awareness of stimuli even though they still make use of the location of these stimuli (Bryant en McConkey, 1989a, Farthing, 1992). Subjects made blind using a hypnotic induction procedure often evade a chair flawlessly when asked to cross a room, even though they claim to have had no awareness of the chair whatsoever (Farthing, 1992). In an experiment by Bryant and McConkey (1989a), subjects had to perform a decision task following a ‘blindness’ induction. The task was to turn off a tone by pressing one of three buttons on a machine. In one condition the correct button was indicated by a light while in the other condition no visual cues were presented as to which button was the correct one. Subjects gave more correct responses in the condition with visual cues, even though subjects indicated that they were completely blind. This phenomenon, which is an instance of what has been called the 'hidden observer effect' in hypnosis literature, could be interpreted as another analogue to the blindsight phenomenon.

One could argue however that these results were caused by subjects' sensitivity to demand characteristics. In order to safeguard against such objections most experiments into the subject of hypnosis make use of a simulator and a 'real' hypnosis group, as was done in this experiment by Bryant & McConkey (1989a). If one *then* takes a look at their experiental measures, it becomes clear that demand characteristics are not (at least not solely) responsible for the effects. A significantly larger portion of the simulating subjects reported complete blindness in comparison to reals. In the real group respectively 37.5% and 17.4% (2 experiments) reported that they could see normally after the blindness induction while this was 0% in the simulator group for both experiments. Reals also gave more correct responses (meaning more responses correspondent with the visual cues) than simulators. This indicates that subjects do not simply follow instructions during hypnosis and that demand characteristics play a bigger role in simulators than in reals. Reals seem to answer according to truth concerning their phenomenology more often while simulators deliberately and intently try to fulfill apparent experimenter expectations.

Some evidence for the idea that hypnotized subjects do not simply conform to demand characteristics can also be found in VEP research that has been done into hypnotically induced blindness. Spiegel, Cutcomb, Ren and Pribram (1985) found that a hypnotic blindness induction procedure resulting in the hallucination of an obstruction (meaning the suggestion of a screen obscuring the view on stimuli) led to a reduced P_{300} amplitude in the VEP's of their subjects. Jasiukaitis, Nouriani, Hillyard and Spiegel (unpublished) report a reduction of the P_{200} amplitude over stimuli covered by hypnotically induced partial obstructions of the visual field. Zakrzewski and Szeleberger (1981) however could find no easily interpretable reduction of VEP amplitudes during hypnotically induced blindness. Other experiments show mixed results. Some find a reduction of VEP amplitudes under conditions of hypnotically induced blindness; others show no such relation (Spiegel & Barabasz, 1988). Spiegel and Barabasz (1988) wrote a review article after having found contradicting results (Spiegel et al., 1985; Barabasz & Lonsdale, 1983). Herein they put forward the hypothesis that the manner in which the blindness induction is being administered to the subject is crucial to whether reduction of VEP amplitudes will result. When an induction is given where the instruction is *“You will no longer see any stimuli”* according to Spiegel and Barabasz (1988) an instruction analogous to *”Don’t think of pink elephants”* is given. Such an instruction will not lead to reduced VEP amplitudes since the subject is to busy looking at the stimulus in order not to see it. When the instruction is *“you will no longer see due to a cardboard screen covering your field of vision”* this will in their view result in reduced VEP amplitudes since the hallucination is not primarily disturbed by that which needs to be ‘hallucinated away’ (the stimulus itself).

The questions asked in the current studies were threefold: [1] Can the ‘blindsight in normal subjects’ results of Graves and Jones (1992) and Meeres and Graves (1990) be replicated under conditions of hypnotically induced blindness, [2] are there differences between the responses of hypnotized subjects and simulating subjects, [3] can the Graves and Jones (1992) and Meeres and Graves (1990) results be replicated under normal waking conditions using suboptimally presented stimuli.

Study 1

Method

Subjects
Six right-handed subjects with an average age of 41.8 years (Sd=11.1) and normal or corrected to normal vision took part in the experiment. Three were female, the rest was male. All subjects were selected through the use of a professional hypnotherapist, who also did the hypnotic inductions.

Stimuli
The stimuli consisted of blanks and open circles with a visual angle of 1.43° and located 9.53° of central fixation. Each circle could occur in one of six possible locations, corresponding to 1, 3, 5, 7, 9 and 11 o’clock. Before, during and after the presentation of the stimulus, a fixation-point would be visible (figure 1). In total there were six stimulus blocks, each consisting of 120 trials.

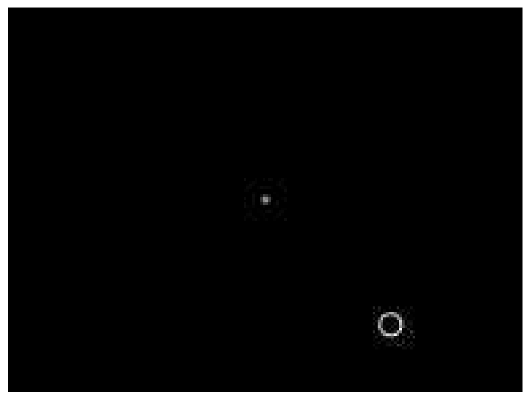

Figure 1. *Screenshot of a stimulus at five o'clock and fixation in the middle.*

Materials
The apparatus consisted of a stimulus computer connected to a 20-inch monitor on which the stimuli were presented and responses were recorded. Responses were made on a response panel containing eight buttons. The computer and the experimenter were located in a room next to the room where the experiment took place, the monitor and response panel were connected with the computer via wires through the wall. Subjects were seated in a reclining chair approximately 80 cm from the screen. The room was dimly lit whilst stimuli were shown on a black screen in white outline.

Responses

Subjects made two responses on each trial. The first response was made with their left hand on one of two buttons to indicate whether they saw the stimulus or not. The instructions for responding whether they saw anything were practically the same as the detection variable in the Graves and Jones (1992) and Meeres and Graves (1990) studies; they either pressed the left button if they "felt that they saw something, e.g. a blur, shadow, or intuition" or the right button if they felt that they "saw absolutely nothing". The second response was made with their right hand. They had to press one of six concentrically positioned buttons to indicate the location of the stimulus on the screen. A button represented each possible stimulus location. Buttons and stimuli were homologous in relation to each other. The subjects had to indicate a position, even when they saw nothing. This is (just like in blindsight patients) somewhat counter-natural. In order to prevent subjects from systematically pressing a predefined location button whenever they had not seen anything, subjects were instructed to press as randomly or versatile as possible on such trials.

Procedure

Subjects were informed of the procedure of the experiment. The experimenter explained the computer task and a short set of exercise-trials was presented. After this the experimenter left the room while the hypnotherapist remained in the room with the subject. At this point the hypnotherapist would either start a hypnotic induction procedure or talk in a relaxed way to the subject in order for a relaxed atmosphere to arise. 50% of the subjects were hypnotized and 50% were not. The experimenter was unaware of their condition and subjects were to simulate being hypnotized as well as they could if they were in the simulating condition.

The experimenter had access to a monitor on which he could follow the procedure if he wished to. The experimenter would occasionally look at the monitor, though he remained blind to the experimental conditions. Six blocks of trials were presented to the subject. Before each block, regardless of the experimental condition of the subject, a suggestion for a hallucination was given to the subject. Before the first and the third block the subject was told to hallucinate a cardboard screen covering the left half of the monitor. Before the second and the fourth block subjects had to hallucinate a cardboard screen covering the right half of the monitor. Before the fifth block subjects were told to hallucinate a screen covering the complete monitor and in the last block subjects were told they could see everything clearly. The hypnotherapist gave the experimenter a sign through an intercom after each induction to indicate a new block of trials could begin.

After the onset of each trial a fixation point in the form of a star appeared which was shown throughout the trial up until the subject had to make the responses. Trials lasted a minimum of 3 seconds but did not end until the subject had made at least two responses. Subjects were instructed to keep looking at the fixation point and not let their eyes wander off as a result of appearing stimuli. 680.6 ms after the onset of the fixation either a circle would appear in one of six locations or nothing would appear (a blank). The circle (or blank) was shown for 116.2 ms. Then the screen would be blank (except for the fixation point) for 680.6 ms after which a soft beep was emitted from two loudspeakers in front of the subject. At this point the fixation point disappeared which together with the beep was the cue for the subject to make the two responses. After the responses the next trial would begin.

Each of the six blocks consisted of 120 randomized trials. 25% of the trials were blanks thus resulting in 30 blanks per block and each location occurring 15 times per block resulting in 90 circle presentations.

After the experiment an exit interview was given concerning their subjective experiences during the experiment. All exit-interviews were conducted in writing and collected by the hypnotist, not to be given to the experimenter until all experimental sessions were concluded. The following questions were asked, sometimes differently phrased for hypnotized subjects (in italic) or simulators:

1. Were you successful at imagining/*hallucinating* a piece of cardboard between the monitor and yourself?

2. During the experiment, did you have the sense that the image/*hallucination* of the cardboard was real?

3. Was the image/*hallucination* – if you had one – see-through at any point or was it always solid?

3a. If it was see-through, was it always see-through?

3b. On the occasions it was see-through, did you actually respond you could see the stimulus or did you respond you could not?

4. Did you, at any point during the experiment, answer you could not see a stimulus, whilst in reality you could?

Results

Experimental categories

This paragraph is meant to shed light on the difference between trials that fall 'within protocol' and trials that fall 'outside protocol' and to elucidate the meaning of the experimental categories that were used. Trials were considered to fall 'outside protocol' if a subject would not react according to the experimental manipulations. That is to say that if subjects would respond they had seen a particular stimulus while this stimulus should have been rendered invisible through suggestion of a cardboard screen then this trial was considered to fall 'outside protocol'. The same was true for trials where subjects would respond they had not seen a particular stimulus while no suggestion of a cardboard screen was covering the stimulus. These trials were excluded from primary analyses. Furthermore incorrect responses (meaning double button presses and extremely long reaction times) were excluded from analyses.

The reason for using this protocol was to ensure the success of experimental manipulations on trial-level. Blanks could fall into two categories; Correct Blank for a correctly identified blank and False Positive Blank for blanks on which a 'Seen' response was given. This left a total of six categories (table 1).

Table 1
The six categories of trials falling 'within protocol'

	Unseen response	***Seen response***
Correctly located	*Unseen~Hit (Blindsight)*	*Seen~Hit*
Incorrectly located	*Unseen~Miss*	*Seen~Miss*
Blank	*Correct Blank*	*False Positive Blank*

Another thing that needs mentioning: in the results and discussion section of this paper all subjects have a subject specific number in order to identify them throughout. Numbers ***1*** and ***2*** and ***3*** are the simulators, ***4*** and ***5*** and ***6*** are the hypnotized subjects. In order to guarantee anonymity subjects will always be referred to as 'she'.

Manipulation of the independent variable

Since this was not a straightforward experiment it is important to give some attention to whether the manipulation of the independent variable, the induction of (partial) blindness through suggestion for hypnotized subjects and simulation of blindness by simulators, was successful or not. There are two ways of assessing its success. One is indirect; meaning one can infer success by examination of the response-data from hypnotized versus non-hypnotized subjects. The other is direct, namely direct answers by subjects on questions in the exit-interview regarding their phenomenology. First some relevant response data will be presented that give a global insight into some of the differences that emerged between the hypnotized versus the non-hypnotized group that make success of the experimental manipulation credible (table 2).

Table 2
Number of unseen stimuli as a percentage of the total number of 'within protocol' stimuli for individual subjects

		Simulators		Hypnotized
Subjects	*1*	49.5 %	*4*	43.8 %
	2	49.3 %	*5*	8.7 %
	3	49.9 %	*6*	2.2 %
Mean:		49.6 % (SD 0.29)		18.2 % (SD 22.37)

From the table one can see that each simulator indicated she could not see approximately 50% of the total amount of stimuli (excluding blanks and non-protocol stimuli). This number corresponds exactly to the number of stimuli they should indeed not see according to the suggestions given; i.e. it corresponds with the number of stimuli that *should* fall in the Unseen category if no stimuli were excluded by the protocol. For each hypnotized subject the number of Unseen stimuli was much lower, as can be seen by the lower percentages. This means that hypnotized subjects indicated they could actually see a lot of stimuli they were not 'supposed' to see if the suggestions given were one hundred percent successful. Contraintuitively enough, this actually supports the notion that manipulation of the independent variable was successful, at least for those cases where hypnotized subjects responded they did not see a stimulus. More in depth interpretation of these data will follow in the discussion section.

Somewhat unconventional, but in this case justified because they are tied in with success of the manipulation of the independent variable, the answers on the exit-interview will be presented in this section of the paper. All simulators answered they were unsuccessful in imagining a cardboard screen, mostly by responding they "did not see any cardboard", sometimes regarding it a stupid question. All subjects in the hypnosis group however answered they did hallucinate a cardboard screen, although at times this hallucination would fade away and then return. In the case of subject ***4*** this was accompanied by some spontaneous negative hallucinations[1], particularly a disappearing monitor or 'black hole' on the 'cardboard' side. All subjects had realized the hallucinations were not real, except subject ***4***, who in the case of the spontaneous hallucinations experienced a sense that these hallucinations *were* real. For subject ***4*** and ***6*** the hallucination would sometimes be see-through, for subject ***5*** it was always solid. All hypnotized subjects said that they would always respond they could see the stimulus on the occasions the hallucination was see-through, that they - in effect - were honest about their phenomenology regarding seeing or not seeing the stimulus. All of the simulators said they were in effect lying on all of their "no see" responses, whereas all hypnosis subjects answered they *never* responded they could not see a stimulus if in reality they could. A schematic representation of these answers is given in table 3.

Table 3
Schematic representation of answers on the exit interview. n.r. means 'not relevant'

	Simulators			**Hypnotized**		
	1	***2***	***3***	***4***	***5***	***6***
1. Hallucination?	No	No	No	Yes	Yes	Yes
2. Real?	n.r.	n.r.	n.r.	Sometimes	No	No
3a. See-through?	n.r.	n.r.	n.r.	Sometimes	Never	Sometimes
3b. If so Honest?	n.r.	n.r.	n.r.	Yes	Yes	Yes
4. Honest?	No	No	No	Always	Always	Always

These data, especially in combination with the response data presented earlier this section, support the notion that the manipulation of the independent variable was successful. Again, this subject will be discussed in more detail in the discussion section of this paper.

Blindsight effects

A blindsight effect is exposed if a subject is able to localize unseen stimuli above chance level. We will call the rate of correct localizations (i.e. the percentage of Unseen~Hits in the population of unseen stimuli) *blindsight percentage* or *localization accuracy*.

*Blindsight percentage = (Unseen~Hits) / (Unseen~Misses + Unseen~Hits) * 100%*

For a truly blind subject, one would expect 1 out of 6 trials of the unseen trials to fall within the Unseen~Hit category (chance level: 16.67%) and 5 out of 6 to fall within the Unseen~Miss category (83.33%), since there

[1] In hypnosis literature, negative hallucinations are hallucinations where an object or part of an object *disappears* whereas positive hallucinations are hallucinations where something *appears*. Positive hallucinations often carry a negative aspect within them in the sense that when something *appears*, the corresponding background has to *disappear*! Positive hallucinations can at times also have a see-

were six possible stimulus locations. A crosstab of response frequencies for each subject and each experimental category is presented in table 4.

Table 4
Frequencies of trials falling within the six experimental categories for each subject

		Unseen~Hit (Blindsight)	Unseen~Miss	Seen~Hit	Seen~Miss	Correct Blank	False Positive Blank	Total:
Simulators	***1***	29	207	233	8	157	11	645
	2	25	234	265	1	176	0	701
	3	40	178	214	5	178	0	615
	Total:	94	619	712	14	511	11	1961
Hypnotized	***4***	44	129	191	31	165	7	567
	5	16	7	236	7	172	1	439
	6	0	6	214	48	174	2	444
	Total:	60	142	641	86	511	10	1450

For subject ***1*** for example one would expect (29+207)/6=39.33 trials to fall in the Unseen~Hit and (29+207)*5/6=196.67 trials to fall in the Unseen~Miss category. These are the expected frequencies for these cells. 16.67% being chance localization accuracy, the following blindsight percentages were calculated for each subject and tested against their expected values with a chi-square test: Subject ***1*** 12.29%, χ^2 (df=1, N=236) = 3.25, p=0.071; Subject ***2*** 9.65%, χ^2 (df=1, N=259) = 9.16, p=.002; Subject ***3*** 18.35%, χ^2 (df=1, N=218) = .447, p=.504; Subject ***4*** 25.43%, χ^2 (df=1, N=173) = 9.59, p=.002; Subject ***5*** 69.57%, χ^2 (df=1, N=23) = 46.36, p=.000; Subject ***6*** 0%, χ^2 could not be calculated due to an empty cell. Adopting either a conservative α of .01 or a Bonferroni significance level of α=.05/6=.0083 leads to statistically significant aberrations from chance for subject ***2*** (under chance) and ***4*** and ***5*** (above chance, i.e. blindsight).

One has to take into account the fact that an assumption for independence has been made to calculate these chi-squares. This means that each trial was regarded as an independent observation, as an independent experiment if you will. In doing this, the assumption was made that for each new trial the chances that a subject would make a certain response was independent of the previous responses made, which is probably a reasonable but not entirely irrefutable assumption. The fact that the very large number of trials were thoroughly randomized and that an experimental session consisted of multiple blocks does give some additional credibility to the assumption of independence though.

From table 4 one can see that subject ***6*** has an empty cell that causes a blindsight percentage of 0% over which no chi-square could be done. It is not improbable that the small number of observations in the Unseen category caused the empty cell for subject ***6***. Realizing it is a bit like playing with fire to first introduce an experimental protocol only to dismiss it when the data do not fit, it was cautiously decided *post hoc* to take a look at the trials falling outside the protocol for this subject. These were trials the subject responded she could not see a particular stimulus, while she was supposed to be able to see it according to the suggestion given.

The total number of unseen trials falling outside the protocol comprised 7.9% of all the unseen stimuli for all subjects taken together. One can infer from figure 1 that including these trials does not make much of a difference for subjects ***1*** to ***5***. When performing chi-square tests between the Unseen frequencies for trials falling within the protocol and the unseen trials combined with the trials falling outside the protocol no significant differences were found. Moreover, for subject ***1*** to ***5*** the outcomes of the chi-square tests for the blindsight-percentages are exactly the same if one adds the 'outside protocol' trials. However, another 8 unseen trials for subject ***6*** can be added now. Since the total number of unseen trials was so small for this subject it is reasonable to infer that this subject was very cautious in giving a 'no see' response. This can also be inferred from the high number of responses that were reported as seen but were actually located incorrectly, which minimizes the chance of adding trials that were mistakenly reported as unseen. Adding these trials results in a blindsight percentage of 42.86%, χ^2 (df=1, N=14) = 6.92, p=.009 for subject ***6***.

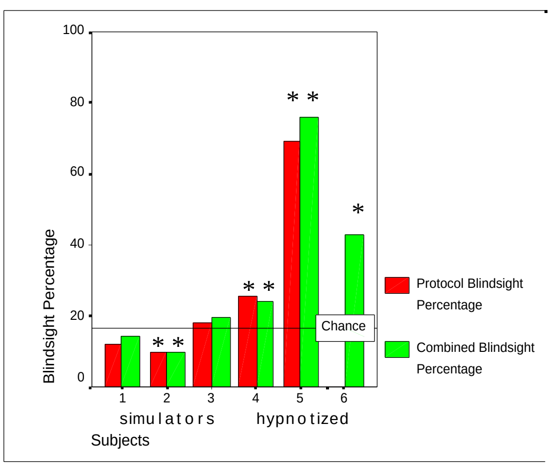

Figure 1. *Blindsight percentages for trials falling within protocol and combined percentages with trials outside protocol for each subject. Significant aberrations from chance at the .01 level are marked with an asterisk (*).*

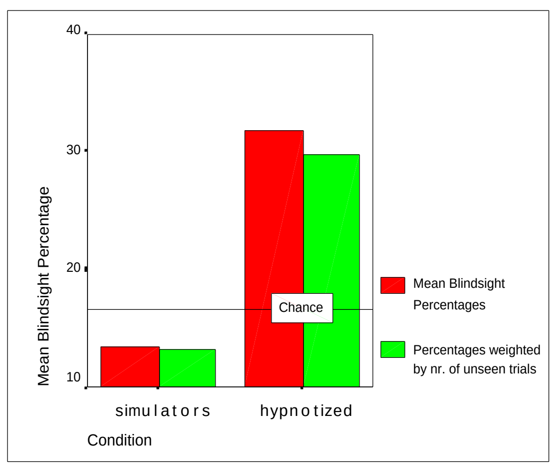

Figure 2. *Mean blindsight percentages for simulating and hypnotized subjects. Both mean percentage and the percentage weighted by the number of unseen trials are given. All means are based on trials from the protocol.*

Figure 2 gives a more global insight into the differences between simulators and hypnotized subjects. Both the average blindsight percentages are given as well as the average blindsight percentages weighted by the number of unseen trials. This was done to give an impression of the extent to which the results were caused by mammoth effects based on few trials in a single subject. As can be seen from figure 2 this is hardly the case.

In order to present the effect-sizes in an insightful way, the natural logarithm of the odds-ratio[1] was calculated for each subject. This gives a measure of effect-size independent of the number of trials and ranging from -∞ to ∞ with zero indicating no effect. Subject ***1*** had a $\ln\hat{\alpha} = -.35$, Subject ***2*** $\ln\hat{\alpha} = -.63$, Subject ***3*** $\ln\hat{\alpha} = .12$, Subject $\ln\hat{\alpha} = .54$, Subject ***5*** $\ln\hat{\alpha} = 2.45$ and Subject ***6*** $\ln\hat{\alpha} = 1.34$. See figure 3.

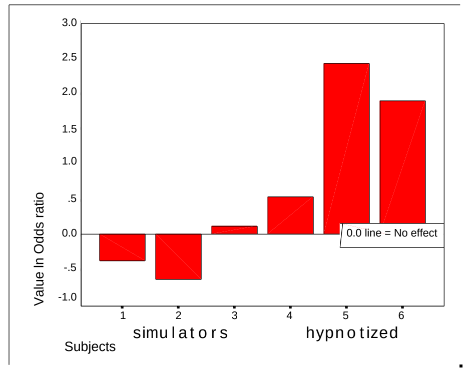

Figure 3. *Graph of the values of the natural logarithm of the odds ratios for individual subjects.*

No analyses were done over the aggregated data since it is was deemed inappropriate to treat trials coming from one subject the same way as trials coming from another subject. For the simulators this would not have been so much of a problem since their data look very much alike but the differences between the hypnotized subjects are prominent, especially when one looks at the data provided in the section concerning the manipulation of the independent variable. The prominence is actually not so much present in the blindsight percentages themselves, more so in the extent to which a hallucination was experienced (number of unseen trials etc.). Altogether it seemed inappropriate and somewhat unnecessary to do a chi-square over the aggregated data, but if one were to do so anyway it would be easy to predict the outcome.

Another option would have been to perform t-tests over the location accuracy percentages, grouping by experimental condition and treating each percentage as a single observation, but the number of subjects is too small to make such an analysis a sensible enterprise. From these data it can be said with certainty however that all hypnotized subjects showed blindsight effects to *at least* some extent whereas all simulators were operating on or below chance level and this conforms exactly to the hypotheses.

[1] The odds-ratio is denoted by α and is calculated in this case through multiplying the observed frequency of Unseen~Hits with the expected frequency of Unseen~Misses and dividing this by the observed frequency of Unseen~Misses multiplied by the expected frequency of Unseen~Hits. The odds can be interpreted as the number of times the event occurs (i.e. an Unseen~Hit) for each time that it does not (an Unseen~Miss). The natural logarithm (ln) is taken to ensure equal scales for positive and negative effects and to assign a sign to the effects. For Subject ***6*** the non-protocol trials have been

Study 2

Method

Subjects
The same six right-handed subjects from study 1 participated in this experiment.

Stimuli
The same stimuli as in Study 1 were used. A mask was used to obscure the stimuli. Since only location and not identity of the stimulus was of importance in this study, it was possible to create a 'perfect' mask by using the stimulus itself. The mask thus consisted of six open circles coinciding with all possible six locations, each circle covered with an X-like figure (figure 4).

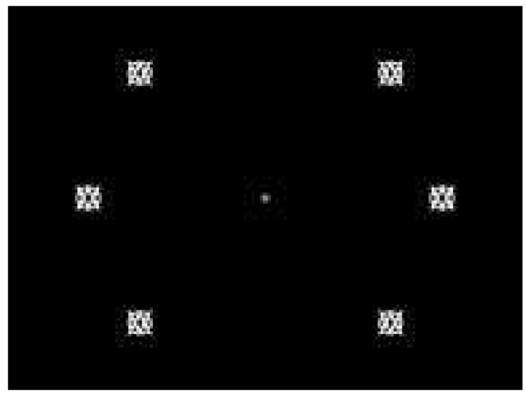

Figure 4. *Screenshot of the mask (with fixation in the middle)*

Materials
The apparatus was essentially the same as in Study 1.

Responses
Subjects had to make the same responses as in Study 1.

Procedure
The experimenter explained the computer task after which a short set of exercise-trials was given. Then the experimenter would leave the room and the task would begin.

Each trial started with a fixation point, which would remain until the subject had to make the two responses. Trials lasted a minimum of 3 seconds but did not end until the subject had made at least two responses. 680.6 ms after the onset of the fixation either a circle would appear in one of six locations or nothing would appear (a blank). The circle was presented at four possible presentation times; 16.6, 33.2, 49.8 and 66.4, all multiples of 16.6, the refresh-rate of the monitor. Directly following the stimulus the mask was displayed for approximately 1 second. At this point the fixation point disappeared which together with the beep was the cue for the subject to make the two responses. After the responses the next trial would begin.

A total of 180 trials were randomly presented. 20% of the trials were blanks making 36 blanks. For each presentation time the circle was presented six times at each location resulting in 4*6*6=144 presentations. Afterwards the experimenter posed three questions in the exit-interview:

1. During the experiment, did you ever respond not seeing a stimulus only to realize at the moment of pointing out the location that you had seen something?
2. If so, did this happen often?
3. Did you correct this error if you made one?

Results

Experimental categories

The same experimental categories were used as in study 1, with the exception that there were no 'within protocol' or 'outside protocol' trials. Only incorrect responses (double button presses and extremely long reaction times) were excluded from the analyses.

Manipulation of the independent variable

With respect to success of the manipulation of the independent variable (reduction of consciousness through shortening of presentation times), the same direct and indirect measures will be presented as in study 1. First the indirect measure, the number of unseen stimuli as a percentage of the total number of stimuli is presented in table 5. Figure 5 shows the mean percentages for each presentation time.

Table 5
Number of unseen stimuli as a percentage of the total number of stimuli (no blanks) for individual subjects. Presentation times were pooled.

Subjects	*1*	26.6 %
	2	18.8 %
	3	89.1 %
	4	61.3 %
	5	56.0 %
	6	94.9 %
Mean:		57.8 % (SD 31.2)

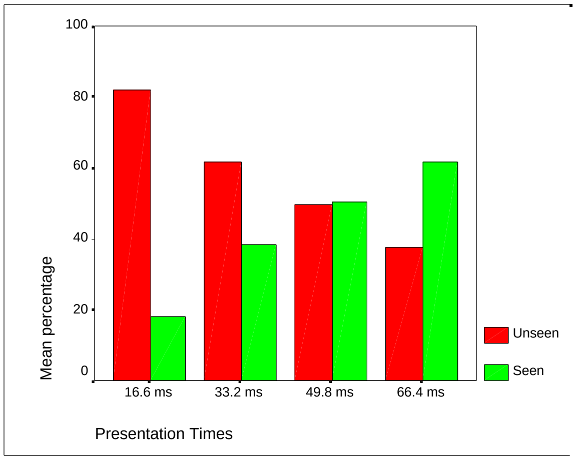

Figure 5. *Mean percentages of Seen and Unseen stimuli for the different presentation times.*

As can be seen from table 5 an average of more than halve of the stimuli (excluding blanks) was classified by subjects as Unseen. This indicates an acceptable overall success rate. If one takes a look at the rate of unseen stimuli for the different presentation times it is apparent that the proportion of unseen stimuli is much higher for shorter presentation times, indicating a higher success rate for the manipulation for these times, as can be expected. The turning point is at 49.8 ms, when subjects start *seeing* more stimuli then *not* seeing them.

On the exit interview all subjects except for subject ***4*** indicated they had never incorrectly given an Unseen response. Subject ***4*** answered that this *had* happened but only on very few occasions. Also, this subject always corrected if she made the error so these erroneous data are not part of the data set.

Blindsight effects

As in the first study, concern is with the presence of blindsight effects. Since the number of trials is insufficient to do meaningful analyses otherwise, presentation times were pooled for analyses over the data of individual subjects. Table 6 contains the data of the six subjects in the six categories.

Table 6

Frequencies of trials falling within the six experimental categories for each subject. Presentation times were pooled.

		Unseen~ Hit (Blindsight)	Unseen~ Miss	Seen~ Hit	Seen~ Miss	Correct Blank	False Positive Blank	Total:
Subjects	***1***	11	26	96	6	27	5	171
	2	6	20	103	9	33	2	173
	3	22	101	5	10	33	0	171
	4	32	55	49	6	35	0	177
	5	23	56	26	36	26	10	177
	6	25	106	2	5	35	1	174
	Total:	119	364	281	72	189	18	1043

The following blindsight percentages were calculated for each subject and tested against their expected values (16.67% being chance localization accuracy) with a chi-square test: Subject ***1*** 29.73%, χ^2 (df=1, N=37) = 4.546, p=.033; Subject ***2*** 23.08%, χ^2 (df=1, N=26) = 0.769, p=.380; Subject ***3*** 17.89%, χ^2 (df=1, N=123) = .132, p=.717; Subject ***4*** 36.78%, χ^2 (df=1, N=87) = 25.345, p=.000; Subject ***5*** 29.11%, χ^2 (df=1, N=79) = 8.813, p=.003; Subject ***6*** 19.08%, χ^2 (df=1, N=131) = .551, p=.458. Even though all subjects showed localization accuracy above chance only subject ***1, 4*** and ***5*** had significant percentages at a significance level of α=.05. When all subjects were pooled the combined blindsight localization accuracy was 24.64%, χ^2 (df=1, N=483) = 22.096, p=.000.

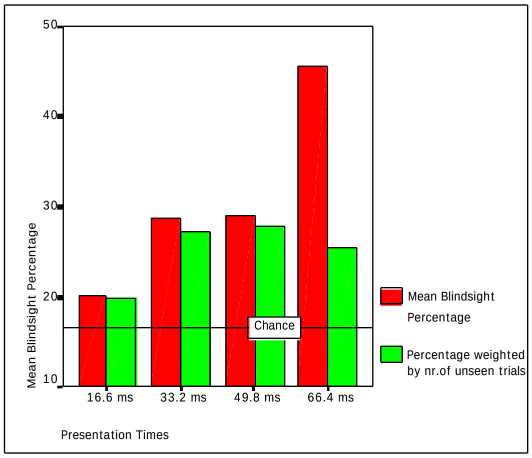

Figure 6. *Mean blindsight percentage for each presentation time and mean percentage weighted by the number of unseen trials per subject.*

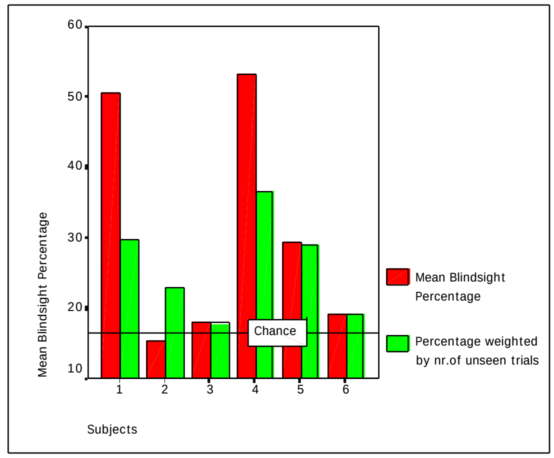

Figure 7. *Mean blindsight percentage for each subject and mean percentage weighted by the number of unseen trials at each presentation time.*

Figure 6 shows the mean blindsight percentages for each presentation time, together with the blindsight percentages weighted by the number of trials. In figure 7 the same was done for the blindsight percentages in each subject with pooled presentation times.

In both graphs percentage means weighted by the number of trials are given in order to control for mammoth effects caused by single subjects or single presentation times. The differences between means and weighted means were predominantly in the same direction with weighted means resulting in somewhat lower percentages, except for subject ***2*** in figure 7 when only the blindsight percentage for the weighted mean was above chance.

For each of the presentation times t-scores were calculated to see whether the blindsight percentages differed from chance (16.67%) for particular presentation times. Because the number of subjects was so small, making it extremely hard to get significant results, the significance level of α was chosen to be at 0.2. At this rather liberal level of significance (one out of five tests could by chance alone turn out to be significant) all presentation times resulted in significant aberrations from chance. For the 16.6 ms presentation the blindsight percentage was 20.28% ($t[5]=1.97$, $p<0.15$), for 33.2 ms it was 28.88% ($t[5]=2.26$, $p<0.1$), for 49.8 ms it was 28.95% ($t[5]=1.63$, $p<0.2$) and the 66.4 ms blindsight percentage was 45.73% ($t[5]=1.65$, $p<0.2$). The probability for all four tests to turn out significant by chance alone at this level is $0.2^4 = 0.0016$.

Although only half the subjects showed blindsight at a statistically significant levels a tendency for blindsight was present in all subjects. Moreover the lack of significance seems for the larger part due to small sample size and the smaller number of trials in Study 2 in comparison to Study 1. This was supported by the fact that pooling of data resulted in significant results and that all t-tests over presentation times were significant, be it at a rather liberal level of significance. It seems inevitable though that a small increase in sample size would result in significant results at a more conservatively chosen level of significance.

Discussion

Results

In Study 1, all hypnotized subjects showed a statistically significant ability to locate stimuli above chance level, though in one subject this could only be demonstrated by including 'non-protocol' cases. All simulators were localizing stimuli on, or in one case significantly below chance level. In the suboptimal task of Study 2 half the subjects were localizing stimuli significantly above chance level. The other subjects did localize above chance, although this was not significant. T-test over individual presentation times hint at massive effects when more subjects had been used.

Thus, all questions from the introduction can be answered affirmatively: (1) Blindsight-effects can be found under conditions of hypnosis, (2) doing this results in vast differences between the hypnosis and the simulator group even though these results have to be treated with caution when generalized to the population of hypnotizables and (3) the blindsight-effect can also be replicated under conditions of suboptimal presentation.

Converging Operationalisation

In this paragraph an attempt is made to say something about how Study 1 and Study 2 relate to each other. What was actually achieved in these two studies is a *reduction of conscious perception*. In Study 1 this was achieved through hypnotic induction and in Study 2 by presenting stimuli at suboptimal presentation times. In both studies, subjects located a significantly larger proportion of the unseen stimuli correctly than one would expect on the basis of chance. This ability to be able to locate stimuli outside of conscious awareness was termed blindsight.

Just to be sure: the reduction of consciousness is not something new or crazy in experimental designs. Reduction of consciousness through subliminal or suboptimal[1] presentation of stimuli has been the order of the day in psychological research for over three decades, but goes back as far as 1898 (Merikle, 1992). The fact that in Study 1 this happened through hypnotic suggestions is what might make some people skeptical or uninterested but make others *particularly* interested.

The fact remains that the only experimental manipulation in Study 1 was the *reduction of consciousness* in one group, and the simulation of

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[1] The author of this paper realizes that subliminal and suboptimal perception have different meanings in the framework of contemporary psychological research, but concern here is not with squabbling about the meanings of these concepts, but with the fundamental notion of reduction of consciousness *per se*. For an overview of problems concerning adequate measures of *unconsciousness* see Merikle (1992).

such a reduction in another group, and that this manipulation produced vastly different results in both groups. More importantly, the actual 'reduction group' (i.e. the hypnotized subjects), showed a very similar response pattern to that found in subjects who had to perform a very similar task whereby the reduction of consciousness was achieved through subliminally/suboptimally presented stimuli (Graves & Jones, 1992; Meeres & Graves, 1990) or caused by brain damage (Weiskrantz, Warrington, Sanders & Marshall, 1974; Weiskrantz, 1995). These facts taken together validate the following two conclusions; (I) achieving reduction of consciousness through hypnotic suggestion can in essence be an alternative or complement to the reduction of consciousness through paradigms of subliminal/suboptimal presentation or to the studying of brain lesioned subjects (II) the fact that these very different manipulations can apparently produce very similar results supports both the existence of the blindsight effects and the validity of the different experimental manipulations with which these effects were found, a typical example of something that has been coined 'Converging Operationalisation'[2] in the past (Beijk, 1977).

Implications for the notion of blindsight

Another conclusion that can be drawn from the present research is that blindsight is not limited to brain lesioned patients. The phenomenon can also be seen in normal subjects in a wide variety of settings (Cowey, 1995; Graves & Jones, 1992; Kolb & Braun, 1995; Meeres & Graves, 1990) as well as in hypnotized subjects. It looks as though blindsight is not so much a function of brain damage, but more so of (the absence of) consciousness. Independent of the way in which this is achieved, a reduction of consciousness to the level where a subject can no longer see a stimulus, subjects are still able to locate these stimuli without being aware that they are doing so.

This is not so strange as popular wisdom would have us believe. In daily life we regularly drive around in our cars while talking to our co-passengers without getting hit. We are hardly aware of our surroundings but we are still automatically dodging all kinds of objects on the basis of location information. It might seem invalid to compare this to the classical notion of blindsight but it might not be so far fetched. Although nobody seems to know what consciousness is (Farthing, 1992), many people believe that for instance flies do not have it. Although others might believe flies do have some form of consciousness, it can be said

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[2] It is actually called "Convergerend Operationalisme" (Dutch), which has been translated by the author of this paper as "Converging Operationalisation". This term refers to the fact that multiple operationalisations of one construct can both support the validation of the construct and can at the same

that most people would agree that they do not have the same kind of consciousness that we do. Still, flies navigate their way through the world without a problem. Could this not be construed as a very basic form of blindsight? And why would humans be different?

From an evolutionary point of view this is a very logical and useful hypothesis. Irrespective of what consciousness actually is, we all agree that it takes time. As classical studies by Libet (1985) have shown, people are often 'voluntarily' (re)acting before they consciously know they are doing so. Apparently consciousness lags behind, not only in perception, but even in the consciousness of *our own actions*. And in critical situations this can mean the difference between life and death. A so called 'false positive' (for instance nervously jumping away for the shadow of a cloud that comes over, only to realize seconds later that it was only a cloud) is from an evolutionary point of view harmless. A 'false negative' however (not taking cover right away for a tiger that jumps out of the bushes, only too late to realize that one should have) can be deadly. Who does not know the experience of *almost* getting hit by a car or truck, only to receive a shiver of discomfort when one realizes that one had reacted in time *after* one is safely back on the sidewalk?

In short: location information can very well do without consciousness and it is human arrogance to think it is such a necessary ingredient for our own actions in navigating through the world. Blindsight is not so much a strange and far-out phenomenon as much as an integrated part of our daily lives.

Alternative explanations

As mentioned in the results section more attention would be given to success of the manipulation of the independent variable in Study 1, i.e. reduction of consciousness through hypnotic suggestion. This part of the discussion section will deal with this and at the same time with possible alternative explanations. What the question of success of the manipulation of the independent variable boils down to, is whether there is evidence that the hypnotized subjects were honest with respect to their phenomenology or whether there is evidence that they were (consciously or subconsciously) giving socially desirable responses. If the subjects were both honest and competent giving the responses they did, it can be said that the manipulation of the independent variable was successful[3].

To start with, an analysis of the simulating subjects' behavior will be made, which is easier and somewhat intuitive due to the fact that most people can imagine what a simulators' train of thought would be. As a matter of fact it is quite easy to compile a set of assumptions that reasonably predicts and models the simulators' behavior. It is reasonable to assume that simulators, in trying to comply with the demand characteristics of the situation will try to mimic the behaviors of a hypnotized person to the best of their knowledge. All these simulators know is that hypnotized people will act according with the suggestions of a hypnotist. In faking hypnosis, they are most probably consciously aware of the fact that they should respond not seeing certain stimuli because of suggestions given to them by the hypnotist. They will respond not seeing a stimulus whenever it is on the right side of the monitor as a suggestion was given for a cardboard screen covering the right half of their visual field, and give analogous responses for left and complete visual field suggestions. This can indeed be seen clearly in the data and was also predicted. Concerning the localization accuracy of these pretenders one can conclude that the simulating subject would probably want to make it unlikely they are actually seeing the stimuli by either hitting the right location around chance level or actually dodging the correct location. And again, this was very much the outcome of the experiment. No problems there so far and no alternative explanations are needed.

To draw reliable conclusions from the data about the inner workings of the hypnotized subjects is a bit trickier, but a number of explanations can luckily be ruled out. The most conservative conclusion scientifically speaking would have been that - when instructed - hypnotized subjects (either consciously or subconsciously) use a completely different strategy from simulators in *faking* 'not seeing' certain stimuli. That is, they do actually see the stimuli but by virtue of their hypnotic state they comply with demand characteristics of the situation in a different way from simulators. We would assume that the underlying causes that produce the vastly different behaviors are not differences in the *level of consciousness* of the hypnotized brain but rather of the deceiving *strategies* of simulators and hypnotizables in order to comply with the demand characteristics of the experimental setting.

If we were to follow this line of line of reasoning we would be speaking of strategies in stead of processes for both simulating and

[3] It must be said that if one does not accept subjective measures as a valid operationalisation of (un)consciousness, these studies can of course not be counted as valid studies into the nature of consciousness. There are however very good reasons to accept subjective measures as valid measures

hypnotized subjects. We would then have to explain how the strategies for the two experimental groups result in such different sets of data and why they are different. In terms of strategies we could of course say that either group diverts its attention more effectively from stimuli if so instructed. But it would be unclear why this would lead to *above* chance localization accuracy for the hypnotized subjects. Moreover, subjects were explicitly instructed not to divert their attention from the fixation point making it even more unlikely that attention-diverting strategies are solely responsible for the observed effects.

What other strategies could be responsible for the differences between the two groups? Do hypnotized subjects somehow create different scripts or ideas on how to comply with demand characteristics after being hypnotized? And what would those scripts or ideas encompass? It is unlikely that hypnotized subjects realize on the one hand that they should respond not seeing certain stimuli but on the other hand do not realize that they should then also try not to localize these stimuli too often. Moreover, why, if hypnotized subjects do actually see the stimuli but are just reporting not seeing them, would they respond not seeing the stimuli on much fewer trials then simulators? Would one not expect a response pattern much more in accordance with the simulator data? In effect, the lower 'no see' percentages of the hypnotized subjects give extra credibility to the genuineness of their experience of not seeing the stimuli. As a matter of fact, if they were responding in a socially desirable way, they would report seeing stimuli on much fewer trials, closer to the number of trials they were supposed not to see according to the suggestion of the cardboard screen.

No argument of the social psychological kind seems to suffice. What other explanations could be considered? Could it be that hypnotized subjects have reduced cognitive capabilities? Could it be that subjects under hypnosis basically do not know what they are doing? If that were the case, we would infer that they were randomly pressing the Seen/Unseen button and randomly indicating positions for these stimuli. But as we saw, the hypnotized subjects are locating stimuli very well if they indicate they can see them and are in fact localizing them even when they indicate they can not. It is true that hypnotized subjects localize a higher number of stimuli incorrectly which they indicate to have seen, but these numbers are not so high as to suspect randomness or total confusion. As a matter of fact it is more likely that this is caused by the fact that all subjects were instructed to give a Seen response if they had even the slightest notion or flash of consciousness of a stimulus. They are thus giving a Seen response even when they are not seeing very much. This conclusion is supported by the fact that subject ***6***, of whom we remember that she had very little Unseen trials, also had the highest number of Seen~misses, indicating a very conservative strategy for responding not seeing a stimulus.

An even stronger argument for the fact that hypnotized subjects do not have reduced cognitive abilities lies in the fact that these subjects are at least as good as simulators in distinguishing blank trials from other trials. The numbers of correctly identified blanks and false positive blanks are essentially the same for simulators and hypnotized subjects. Altogether the hypothesis of reduced cognitive abilities is not a very plausible one.

As a matter of fact, the most plausible explanation for the observed effects seems to be that subjects under hypnosis actually do not see certain stimuli. Not only do the direct measures point in this direction (subjects actually *say* in the exit interview they could not see the stimuli) but so do the indirect measures, the button-press data, if we compare them to the data of the simulators.

One last issue that needs to be addressed is the selection of hypnotizables and non-hypnotizables. Some people could argue that the differences in outcome are due to differences in hypnotizables and non-hypnotizables and not so much due to the hypnosis. The fact that they are selected by the hypnotist to be in a certain experimental condition might have caused the difference because they are part of different populations; the population of hypnotizables and the population of non-hypnotizables. There is a very important argument that goes against this idea. The argument is that subjects did not differ on this dimension in Study 2. Subjects from the simulator and hypnosis group were both as likely to exhibit blindsight when they were reacting to suboptimally presented stimuli. If the effect was due to non-random selection it is unclear why the population of hypnotizables would exhibit blindsight in precisely a hypnosis situation whereas the population of non-hypnotizables would not if they are not showing this difference in other possible 'blindsight situations'. It is therefore reasonable to assume the effect in Study 1 was due to the hypnosis itself.

Future research

Some practical and some theoretical issues are important when considering future research into the matter of blindsight and the manipulation of consciousness through hypnotic suggestion and subliminal perception.

One very interesting research subject would be to repeat the current studies with a much larger sample (N=40 or more). One could then evaluate whether there is an intersubject correlation between the extent to which blindsight is exhibited in the hypnosis condition and in the suboptimal condition. If there were a positive correlation this would underscore the idea that the same processes (the ability to locate stimuli outside awareness) underlie the blindsight effects in both paradigms.

On a practical level there are a few problems that were encountered doing this research; an important one is the duration of the hypnosis experiment. Because of the number of trials, subjects had to spend an extremely long time under hypnosis. It was very hard for subjects to 'hallucinate' for such long time periods, as well as the strain it took to take part in a reaction task for such long times. This resulted in discomfort for the subjects which resulted in fluctuating levels of hypnosis and hallucination. To undermine this, the number of trials could be shortened. Maybe use could be made of completely separate 'blocks' with substantial breaks in between. And finally it might be advisable to make use of self-report scales of hypnotic depth (Tart 1978, 1979) or other scales of hypnotic susceptibility (Shor & Orne, 1962; Weitzenhoffer & Hilgard, 1962) in order to control for fluctuations in hypnosis level and intersubject variability in susceptibility.

The suboptimal presentation task could be done in much the same manner although it would be advisable to drop the longest presentation time(s) and increase the number of trials for shorter presentation times. Ideally this experiment would also be done on a tachistoscope and not on a computer monitor since a tachistoscope does not have the limitations of refresh-rate a regular monitor has, which enables one to use even shorter presentation times.

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Appendix A

A chi-square analysis was also performed over all subjects and all trials, treating each subject as a different Unseen~Hit/Miss category-pair with corresponding expected frequencies. Only trials from the protocol were used, adding one observation for subject ***6*** in the Unseen~Hit category in order to get rid of the empty cell. The problem with calculating this chi-square was that some subjects showed effects that were not in the predicted direction. If one would just add all the effects, every subject would add to the chi-square, even though some effects actually go against the prediction. In order to prevent falsely adding to the effect, the squared differences for both subject ***6*** (because of localization accuracy being below chance) and subject ***3*** (because of localization accuracy being slightly above chance) were actually subtracted in stead of summed. The exact direction of effects can and already have been deducted from closer inspection of the data, which justifies showing a general effect at this point. For completeness and clarity the equation of the parameter and the complete calculation of the test statistic is given here:

$$\chi^2 = \sum_{\text{cells}} \frac{\left(x_{ij} - \hat{\mu}_{ij}\right)^2}{\hat{\mu}_{ij}} - \sum_{\text{cells}} \frac{\left(x_{hj} - \hat{\mu}_{hj}\right)^2}{\hat{\mu}_{hj}} \qquad i = \mathbf{1, 2, 4, 5} \qquad h = \mathbf{3, 6}$$

$$\hat{\mu}_{ij} = k\,\frac{x_{i\cdot}}{6} \qquad j = \text{Unseen~Hit, Unseen~Miss}$$

$$\hat{\mu}_{hj} = k\,\frac{x_{h\cdot}}{6} \qquad k = 1 \text{ for } j = \text{Unseen~Hit} \qquad k = 5 \text{ for } j = \text{Unseen~Miss}$$

$$\chi^2 = \frac{\left(29 - 236/6\right)^2}{236/6} + \frac{\left(207 - 5\,236/6\right)^2}{5\,236/6} + \frac{\left(25 - 259/6\right)^2}{259/6} + \frac{\left(234 - 5\,259/6\right)^2}{5\,259/6} - \frac{\left(40 - 218/6\right)^2}{218/6} - \frac{\left(178 - 5\,218/6\right)^2}{5\,218/6}$$

$$+ \frac{\left(44 - 173/6\right)^2}{173/6} + \frac{\left(129 - 5\,173/6\right)^2}{5\,173/6} + \frac{\left(16 - 23/6\right)^2}{23/6} + \frac{\left(7 - 5\,23/6\right)^2}{5\,23/6} - \frac{\left(1 - 7/6\right)^2}{7/6} - \frac{\left(6 - 5\,7/6\right)^2}{5\,7/6} = 67.87$$

Resulting in: χ^2 (df=11, N=916) =, p=.000.

Appendix B

A split was also made between suggestions for covering the left, right and complete visual field. Figure 8, 9 and 10 below show the outcome of this split for individual subjects and for both the normal and weighted means. Because this limited the number of trials even more, the author of this paper deemed it wise to present these speculative data in an appendix and not in the main body of the research paper. The data show so much inter-subject variability it is hard to draw any sound conclusions. Also, the normal and weighted means show contrariwise effects. Conclusions are therefore left to the interested reader.

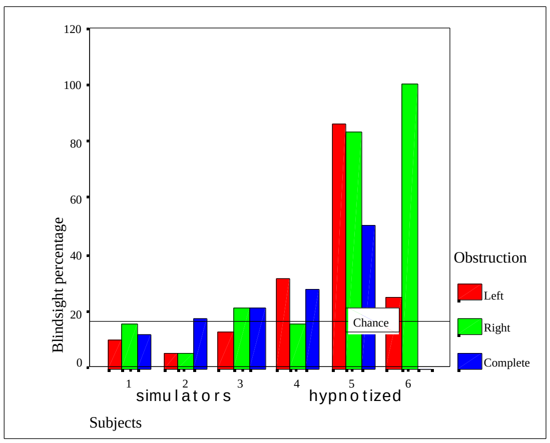

Figure 8. *Split blindsight percentages for each of the subjects. Data have been split between the three suggested obstructions: left, right and complete.*

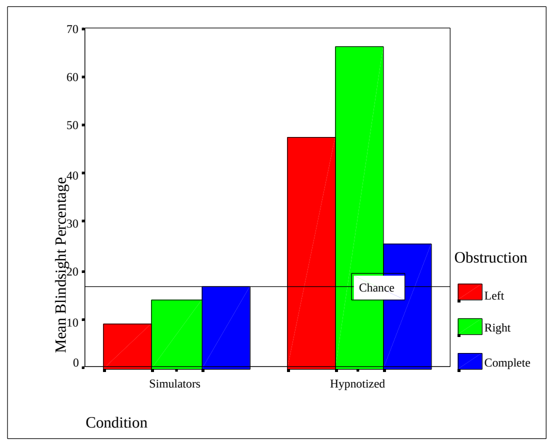

Figure 9. *Mean blindsight percentages for simulating and hypnotized subjects. Data have been split between the three suggested obstructions: left, right and complete.*

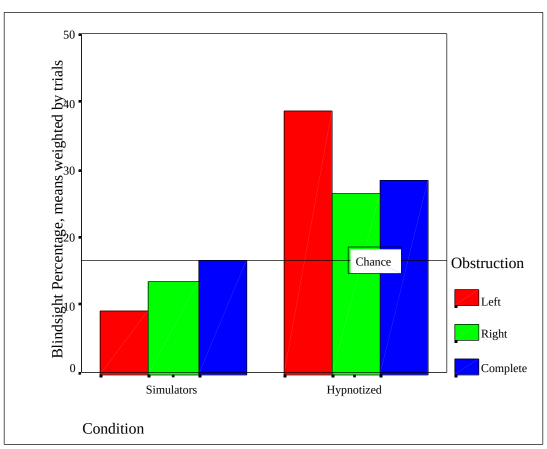

Figure 10. *Mean blindsight percentages for simulating and hypnotized subjects. Percentages have been weighted by trials in order to control for mammoth effects by single subjects. Data have been split between the three suggested obstructions: left, right and complete.*