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ENDOGENOUS AND EXOGENOUS ATTENTION IN PATIENTS WITH CONVERSION PARESIS

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Endogenous and exogenous attention of patients with conversion paresis was investigated using Posner's "covert orienting of visual attention" task. In the light of previous evidence showing that inhibition of higher-level control functions plays a role in conversion paralysis (e.g., Marshall, Halligan, Fink, Wade, & Frackowiak, 1997), patients were expected to display weaker cue effects in the endogenous condition and weaker inhibition of return (IOR) in the exogenous condition. Eight patients with conversion paresis in one or more limbs and eight healthy controls were administered the attention task in a verbal response condition and in a limb response condition in which subjects responded with each limb separately. When responding verbally, patients showed relatively weakened endogenous cue effects on a 150-ms stimulus onset asynchronicity (SOA) and no IOR in the exogenous condition. Comparable effects emerged when patients responded with affected limbs but not when they responded with unaffected limbs. The findings suggest impairment in voluntary attention. High-level inhibition is suggested to interfere with the orientation to stimuli that prime responses with affected limbs. The fact that similar results were found for verbal responses is interpreted as supporting the view that attention deficits are manifested on a high, abstract level of cognitive processing.

Conversion disorder involves impairments of the voluntary motor or sensory functions that are suggestive of neurological causes but for which no neurological or organic cause can be identified. Symptoms are assumed to be associated with psychological stressors (American Psychiatric Association, 1994). Janet (1924) and Hughlings Jackson (1958) considered conversion symptoms as a progressive loss of the most complex, voluntary

functions in response to severe shock. Currently, conversion disorder is still regarded as a stress reaction in which higher-level explicit or intentional information processes become impaired, whereas lower-level implicit or automatic processes remain relatively intact (Kihlstrom, 1992a, 1992b; Roelofs, Näring, Keijsers, Hoogduin, Van Galen, & Maris, 2001). In the case of conversion paralysis, for example, this may result in a difficulty in intention-

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ally moving one or more parts of the body, whereas some movement may be observed in less controlled circumstances such as during sleep (Lauerma, 1993) and hypnosis (Moene, Hoogduin, & Van Dyck, 1998).

Towards the end of the 19th century the psychiatrist Janet (1859–1947) had already suggested that conversion symptoms arise from functional dissociations related to a deficit in attention (Janet, 1924). He argued that it is the task of the brain to create perceptions by integrating elementary sensations into assimilated units. Based on observations of over 120 patients with conversion symptoms he argued that deficits in attention result in a disintegration of memory, sensory, and motor functions. Integration of elementary sensations depends on the selection of relevant stimuli and the rejection of irrelevant ones. Early experimental studies showed that lack of attention or presence of distraction can impair the appreciation or recognition of peripheral stimuli (e.g., Hernández-Peon, Scherrer, & Jouvét, 1956). Event related potential (ERP) studies, for example, showed that attention to the stimulus input tends to increase the amplitude of the average evoked response, whereas inattention or distraction tends to reduce it (e.g., Callaway, 1966). Halliday (1968) and Hernández-Peon, Chavez-Ibarra, and Aguilar-Figueroa (1963) reported two case studies of conversion patients with hemianaesthesia, showing that somatosensory evoked responses of the affected legs were weaker than those of the unaffected legs. The latter authors also showed that, after administration of a barbiturate drug, this difference disappeared. These findings were interpreted as indicating that a fundamental capacity to screen sensory information—relevant for perception and motor performance—may be deficient in patients with conversion symptoms due to impairment in the functions of attention (Ludwig, 1972).

Some support for this hypothesis came from a psychophysiological habituation study by Horvath, Friedman, and Meares (1980), which showed that 11 conversion patients exhibited diminished habituation or ability to screen out irrelevant stimuli, compared to patients with anxiety disorders. These findings were interpreted as suggesting that impaired selective attention results in deficient

screening capacities in conversion disorder. Also two more recent ERP case studies (Fekuda et al., 1996; Lorenz, Kunze, & Bromm, 1998), showing intact early sensory processing accompanied by an altered P300, were taken to demonstrate deficits of the attentional awareness system. Furthermore, neuroimaging studies (Tiihonen, Kuikka, Viimaki, Lehtonen, & Partanen, 1995; Marshall, Halligan, Fink, Wade, & Frackowiak, 1997), finding prefrontal inhibitory brain structures (orbitofrontal and anterior cingulate cortex) to be involved in two cases of conversion disorder, were seen as indicative of the role an inhibition of the attentional awareness system plays in sensory and motor conversion symptoms (Sierra & Berrios, 1999).

Although the findings of these studies are consequently interpreted within the framework of theories claiming that attention deficits play a role in conversion disorder, the evidence offered is rather weak and frequently indirect. The reported impairments in the awareness of, and habituation to, external stimuli may indeed be a product of attentional deficits. There is, however, only one study available that directly examined attention processes in patients with conversion paralysis. Bendefeldt, Miller, and Ludwig (1976) studied 17 conversion patients and found them to show a less active orientation on a field dependency task (hidden figures test) and impaired attention processing on a face recognition test and a mental set shifting test, compared to 17 nonpsychotic control patients. These findings are indicative of attention deficits and impaired screening capacities in patients with conversion disorder. An important question, however, remains unanswered, viz. whether the attention deficits merely reflect problems in automatic orienting or whether, as claimed in dissociation theories of conversion disorder (Kihlstrom, 1992b; Roelofs et al., 2001; Roelofs, Van Galen, Keijsers, & Hoogduin, 2002b), the deficits reflect voluntary attention deficits in directing attention to relevant stimuli and inhibiting responses to irrelevant ones.

In order to get more insight into the nature of attention deficits in patients with conversion disorder, it is important to note that in general

two types of attention systems are distinguished (Norman & Shallice, 1986; Posner, 1980; Posner & Petersen, 1990). The endogenous attention system involves voluntary orienting of attention and is located in anterior brain areas, especially the anterior cingulate cortex (Pardo, Pardo, Janer, & Raichle, 1990). In contrast, at an automatic level, attention can be reflexively oriented to external stimuli. This is called the exogenous attention system, which is located in the parietal lobe, the pulvinar, and the superior colliculus (Peterson, Fox, Miezen, & Raichle, 1988). A well-known paradigm to study endogenous and exogenous spatial attention is offered by Posner's covert orienting paradigm. Subjects are asked to make a fast response as soon as they detect a target in their visual field. Just before the onset of the target, subjects are presented with a cue. In the endogenous attention condition the cue is a centrally presented arrow pointing left or right. It is called a central cue because it is a symbol representing direction, the interpretation of which requires central processing by the cognitive system. In the exogenous condition a peripheral cue appears on the position where the target may appear. It automatically attracts attention and, in contrast to a central cue, cannot be ignored. In both tasks, cues correctly predicting the target location (valid cues) result in decreased reaction times (RTs), whereas invalid cues result in increased RTs for target localisation (Posner, 1980).

The purpose of the present study is to investigate endogenous and exogenous spatial attention processing in patients with conversion paresis (muscular weakness). We have chosen patients with conversion paresis because this subtype of conversion disorder has a relatively high prevalence and because muscular weakness can be assessed relatively well. Furthermore, spatial attention is important for the planning and preparation of movement (Rizzolatti, Riggio, & Sheliga, 1994) and studying patients with conversion paresis allows us to investigate the influence of spatial cueing on responses with affected and non-affected limbs. Because conversion patients are suggested to have deficits in voluntary endogenous information processes, with relatively intact automatic,

exogenous information processing (Janet, 1924; Kihlstrom, 1992b; Marshall et al., 1997; Roelofs et al., 2001), we predict diminished cue effects in the endogenous task condition and normal early cue effects in the exogenous task condition.

Besides short-lived facilitatory effects, the exogenous condition also involves longer-lasting inhibitory components, observed when the time between cue and target (stimulus onset asynchronicity: SOA) increases. In normal subjects, a valid cue will only facilitate response time when the SOA is below 300 ms. When the SOA exceeds 300 ms, however, the attention focus leaves the cued side and shifts to the opposite side (Posner & Cohen, 1984). Consequently, when the target appears on the cued side with an SOA larger than 300 ms, extra time is needed to respond because the return of the attention focus to the cued side is inhibited. This phenomenon is commonly observed in healthy subjects and is called inhibition of return (IOR; Maylor, 1985; Posner & Cohen, 1984). It is considered to be an important mechanism through which the attention system favours novel spatial locations by inhibiting ones already scanned and, therefore, is likely to reflect a strategy for efficient visual search (Klein, 1988). Whereas the early cue effects are automatic stimulus-driven processes, IOR can be considered a top-down interference of the automatic cue effects. The fact that IOR can be controlled by higher-order processes (e.g., Berger & Henik, 2000) makes it sensitive to high-level inhibition processes previously detected as playing a part in conversion paralysis (Marshall et al., 1997; Tiihonen et al., 1995). For this reason, and based on the previously observed impairments in visual screening capacity in patients with conversion disorder (Bendefeldt, Miller, & Ludwig, 1976; Horvath et al., 1980), our second hypothesis is to find IOR effects to be disturbed in patients with conversion paresis.

In order to study attention processes without interference from the affected limbs, we instructed patients with conversion pareses to respond verbally to the cued targets (verbal response condition). However, when patients are instructed to respond by moving their limbs to the left or the right, the visual cues obtain the additional feature of priming

an actual limb movement. To investigate how visual cues are processed when they actually prime limb movements in space, in addition to the verbal response condition, participants were also tested in a limb response condition for each limb separately (two hands and two feet). Because conversion paresis is assumed to involve higher-level inhibitory processes, especially interfering with motor initiation with affected limbs (Marshall et al., 1997; Roelofs et al., 2001), our third hypothesis is to find more pronounced impairments in cue effects for patients with conversion pareses when they are responding using affected limbs, compared to using nonaffected limbs.

METHOD

Participants

A total of eight patients, diagnosed with conversion disorder according to the DSM-IV criteria (American Psychiatric Association, 1994), and showing paresis as major symptom, were studied. The patients had been referred for either inpatient—or outpatient treatment to a general psychiatric hospital specialising in the treatment of conversion disorders. A psychiatrist performed the psychiatric screening using the criteria of the DSM-IV. A trained psychologist checked for other Axis-I diagnoses using the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-1/p; First, Spitzer, Gibbon, & Williams, 1996) and the Structured Clinical Interview for DSM-IV Dissociative Disorders (SCID-D; Steinberg, 1993). Axis-II disorders were assessed using the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II; First, Gibbon, Spitzer, Williams, & Benjamin, 1996). A neurologist screened all patients for somatic and neurological disorders. When necessary, additional diagnostic techniques, such as serial computed tomography (CT) brain scans or magnetic resonance imaging (MRI), were undertaken. Whenever the somatic screening revealed any deviations that might explain the symptoms, the patient was not diagnosed with conversion disorder and was

excluded from the study. To allow reliable task administration and to establish a relatively homogenous group, exclusion criteria were symptoms involving pseudoneurological insults, tremors, sudden movements, deteriorated speech, deteriorated vision, and paralysis of all limbs. A total of seven female and one male patients were included; their mean age was 34.8 ($SD = 12.6$ years). Table 1 shows relevant information with respect to the patients' ages, sex, handedness, duration of complaints, comorbidity, and medication.

The control group consisted of eight healthy participants who were matched to the sample of conversion patients with respect to gender, age, and handedness. The control participants were recruited via acquaintances and colleagues of the experimenters. A total of seven females and one male were included in the control group and their mean age was 38.2 ($SD = 13.7$ years). Seven of them were right-handed and one was left-handed. All participants provided their informed consent and received the Dutch equivalent of 10 USD for their participation.

Of all participants, the maximum force per limb was assessed in a force application measurement that required the same movements as the ones needed to respond in the limb response conditions (see Table 2).

Procedure and materials

A trained psychologist administered the SCID-I, SCID-II, and SCID-D within 2 weeks of intake. Subsequently, spread over 2 days, the participants were administered the computerised exogenous and endogenous spatial attention tasks in a darkened room. Both tasks were administered in two response conditions: a verbal and a limb response condition. On the first day, participants started with the verbal response condition (duration 25 min) and after a 10-min break they continued with the first half of the limb response condition (45 min). On the second day, the second half of the limb response condition was administered and, subsequently, the force measurement for each limb took place (10 min).

Table 1. *Patient information*

<i>Patient</i>	<i>Age</i>	<i>Sex</i>	<i>Hand pref^a</i>	<i>Duration of complaints</i>	<i>Axis-I comorbidity (SCID-I)</i>	<i>Axis-II comorbidity (SCID-II)</i>	<i>Medication</i>
1	45	F	R	2 years	Dysthymic disorder; social phobia	Avoidant; obsessive-compulsive pd ^b	Paroxetine 20 mg/d
2	20	F	L	11 years	Generalised anxiety disorder	–	Oxazepam 10 mg ^c
3	35	M	R	4 years	–	–	–
4	21	F	R	1 year	–	–	–
5	49	F	R	2 years	PTSD; social phobia	Avoidant pd	Paroxetine 20 mg/d
6	46	F	R	11 years	Depression in remission; PTSD	Dependent pd	–
7	42	F	R	12 years	Depression in remission	–	–
8	20	F	R	9 years	–	–	–

^a Hand preference: Assessed using Annett's Handedness Questionnaire (Annett, 1970); R = right-handed; L = left-handed.

^b pd = personality disorder.

^c Patient used medication on an irregular basis and refrained from taking the drug 10 hours prior to the experiment.

The computer tasks were programmed on a personal computer (Pentium III 450 MHz) with a vision master pro 410 monitor (adjustment: 1280 × 1024 pixels; frequency: 85 Hz). The subjects were seated in front of the screen with their eyes at 50 cm distance from the monitor. Each task was preceded

by computerised instructions, and a practice phase in which feedback was given. In every trial, subjects were first presented with a 300-ms fixation point (a circle, diameter 0.5 cm) in the centre of the screen, on which they were instructed to fixate their eyes throughout the experiment. The screen remained

Table 2. *Overview of the controls' and patients' mean force (in Newtons) in non-affected and affected limbs*

<i>Participants</i>		<i>Left arm</i>		<i>Right arm</i>		<i>Left leg</i>		<i>Right leg</i>	
		<i>Mean</i>	<i>(SD)</i>	<i>Mean</i>	<i>(SD)</i>	<i>Mean</i>	<i>(SD)</i>	<i>Mean</i>	<i>(SD)</i>
Controls	(N=8)	10.0	(4.8)	11.0	(4.9)	10.1	(4.9)	10.5	(5.8)
Patient	1	10.4	(5.5)	8.2	(3.2)	5.7	(2.5)	0.0	(0.0)*
	2	7.7	(3.6)	2.2	(0.6)*	10.0	(6.7)	1.7	(0.6)*
	3	8.2	(1.1)	10.4	(1.2)	4.1	(2.7)*	3.6	(0.9)*
	4	5.8	(1.8)	3.2	(0.8)	4.9	(1.3)	3.2	(0.5)*
	5	0.4	(0.2)*	1.2	(0.3)	0.7	(0.1)*	0.3	(0.2)*
	6	6.6	(2.5)	1.0	(0.3)*	1.0	(0.4)*	0.1	(0.0)*
	7	6.2	(1.9)*	9.6	(2.6)*	6.8	(1.6)*	5.3	(1.7)*
	8	5.9	(1.9)*	5.9	(4.6)*	5.6	(1.6)*	5.5	(1.4)*

* = Affected limb.

To assess force in a hand, the participants' arm was fixated from the elbow to the wrist in an armrest, while the hand held a fixed horizontal stick (diameter 1 cm). The index finger pointed forward with the top placed in a fixed finger hull. Participants were instructed to press the index finger as hard as possible to the left or the right side for 3 s. Force was recorded digitally in Newtons using load cells. To assess force in a foot, the foot was fixated on an adjustable footstool. The participants were instructed to push the forefoot as hard as possible for 3 s to the left or the right. The participants pushed five times to each side with both hands and feet. The force per limb was estimated by averaging the force of the 10 trials per limb. The relatively high force level of patient's 7 right arm is attributable to the fact that this patient had pareses of the shoulder and arm accompanied by normal power in the fingers. Furthermore, both patient 7 and patient 8 had intermittent loss of force in the arms and legs.

blank for 250 ms, after which a central (endogenous task condition) or peripheral (exogenous task condition) cue lasting 75 ms appeared. After a variable SOA of 150, 350, or 550 ms the participants were presented with a target (a cross, diameter 0.5 cm) that appeared 11° left or right of the fixation point and disappeared when the subject responded. The participants were instructed to respond to the target as quickly and accurately as possible by indicating, either verbally (verbal response condition) or by a limb movement (limb response condition), whether it appeared to the left or right of the fixation point. Reaction times (RTs) were recorded using an electronic timer with an accuracy of approximately 1 ms. The experimenter recorded each answer using a soundless button-box. Trials with RTs faster than 150 ms or slower than 1000 ms in the verbal or 1500 ms in the limb response condition were regarded as anticipatory and misses, respectively, and were repeated at the end of the task. After approximately every 30 trials a break was inserted in which feedback was given on the mean RT and participants were motivated to decrease the RT in the next block.

Task conditions

Endogenous task condition. In this condition the cue was an arrow (1.7 cm long, 0.7 cm wide) appearing in the centre of the screen. The subjects were told that attending to the arrow was a useful strategy because 70% of the arrows would be valid (pointing to the side where the target was going to appear). Fifteen per cent of the cues were invalid (arrow pointed towards the opposite side of the target) and 15% were neutral (arrow pointed to both sides). Clusters of 60 trials—3(SOA) × 20(14 valid + 3 invalid + 3 neutral cues)—were presented in two blocks of 30 trials.

Exogenous task condition. Cues were squares (1 × 1 cm) appearing 11° left or right of the fixation point. To minimise the use of strategy, the cue validity (valid–invalid rate) was 50%: A total of 42% of the cues were valid (appeared on the same side as the target was going to appear), 42% were invalid (appeared on the opposite side of the target), and

16% were neutral (cue appeared on both sides of the fixation point). In this condition participants were also informed about the cue validity. Clusters of 57 trials—3(SOA) × 19(8 valid + 8 invalid + 3 neutral cues)—were presented in two blocks.

Response conditions

Verbal response condition. The participants responded to the target by saying “left” when the target appeared on the left side and “right” if the target appeared on the right side of the fixation point. The RTs were recorded using a voice key attached to a headset the participants were wearing. In each group half of the participants started with the exogenous task and the other half started with the endogenous task (within groups the order of administration was randomly assigned). The clusters of 60 trials in the endogenous and 57 in the exogenous tasks were each presented once in the practice phase and twice in the test phase.

Limb response condition.

1. *Hands:* In this response condition the index finger of the participants’ response hand rested on the marked centre of a horizontal plate. At a distance of 3 cm to each side of the marked centre a touch button was placed, so that a response required minimal effort. The participants were instructed to respond to the target by moving their index finger to the left or to the right when the target appeared on the left or the right side, respectively.

2. *Feet:* In this response condition the heel of the participants’ response foot was fixated on an adjustable footstool. At a distance of 2 cm to each side of the foot a low resistance button was situated, so that responding required minimal effort. The participants were instructed to respond to the target by moving their foot to touch the left or the right button when the target appeared on the left or the right side, respectively.

In the limb response condition, responses were tested separately for each hand and foot. The total clusters of 60 trials in the endogenous and 57 in the exogenous task condition were presented only once

per limb. Each cluster was preceded by 20 practice trials. On the first day of testing half of each group started with the endogenous task condition and the other half with the exogenous task condition. On day two this order was reversed. Within each task condition, the order for the four response limbs was Latin Square randomised.

Data analyses

Only correct responses were used for analyses. For both tasks and for each participant median RTs (in ms) were calculated per SOA per cue type. Normally, RT benefits and RT costs for valid and invalid cues are calculated by subtracting the RTs associated with valid and invalid cues, respectively, from the RTs associated with neutral cues. In this study patients' responses to neutral cues did not, however, form a valid baseline because of the relatively long RTs associated with neutral cues. One-tailed ANOVAs repeated measures (rm) were conducted for the medians of the RTs with SOA (150, 350, 550 ms) and cue type (valid, invalid) as within-subject factors and group (patients, controls) as between-subject factor. The analyses were conducted separately for both response conditions (verbal, motor), and within each response condition they were conducted separately for both task conditions (endogenous, exogenous).

RESULTS

Verbal response condition

Endogenous task condition

The RTs for the controls' and patients' (correct) responses are presented in Figure 1a. The error rates (errors of choice and out-of-range responses included) for valid and invalid cues, respectively, were 2.1 and 2.8% for controls, and 5.5 and 6.3% for patients. An ANOVA with cue type and SOA as within-subject factors and group as between-subject factor showed the expected main effects: A significant effect for group, $F(1, 14) = 3.49, p < .05$, pointed at a relative slowing for patients; a significant effect for cue type, $F(1, 14) = 21, p <$

.0001, at a relative slowing for invalid cues, and a significant effect for SOA, $F(2, 14) = 25.7, p < .0001$, at a relative slowing of short SOAs. There were no significant two-way interaction effects and the three-way interaction did not reach significance, $F(2, 14) = 1.37, p = .14$. Visual inspection of Figure 1a, however, reveals a diminished cueing effect for patients on the 150ms SOA, compared to controls. An ANOVA for RTs on the 150ms SOA with the factors cue type and group confirmed this observation by showing a significant Group \times Cue type interaction, $F(1, 14) = 3.63, p < .05$. This finding shows that patients displayed diminished cue effects on a short cue-target interval, indicative of impaired voluntary attention processing.

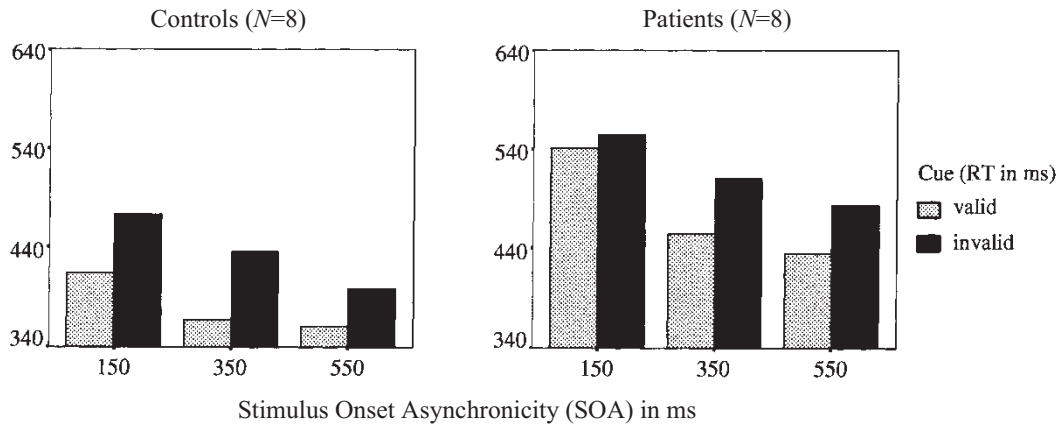
Exogenous task condition

The RTs for the correct responses are presented in Figure 1b. The error rates for valid and invalid cues, respectively, were 6.4 and 5.1% for controls and 8.8 and 9.6% for patients. An ANOVA again revealed the expected main effects for group, $F(1, 14) = 6.7, p < .05$, with a relative slowing for patients; for cue type, $F(1, 14) = 8.0, p < .01$, with a relative slowing for invalid cues; and for SOA, $F(2, 14) = 28.4, p < .0001$, with a relative slowing for short SOAs. Also, all two-way interactions were significant and, most importantly, there was a significant Group \times Cue Type \times SOA interaction, $F(2, 14) = 11.1, p < .0001$. As demonstrated in Figure 1b, these findings indicate that the early cue effects were intact in patients but, although controls did show the expected reversal of the cue effect (inhibition of return; IOR) at a SOA of 550 ms, patients did not show IOR (see Figure 1b).

Limb response condition

In both controls and patients, the RT profiles associated with left and right limb responses were highly similar. There were also no significant differences between the RT profiles for hands and feet. The analyses for the limb response condition were therefore based on RTs collapsed for all limbs for the control subjects, and on RTs collapsed for affected and unaffected limbs for the patients. The mean RTs associated with the correct limb

(a) Endogenous task (verbal response condition)



(b) Exogenous task (verbal response condition)

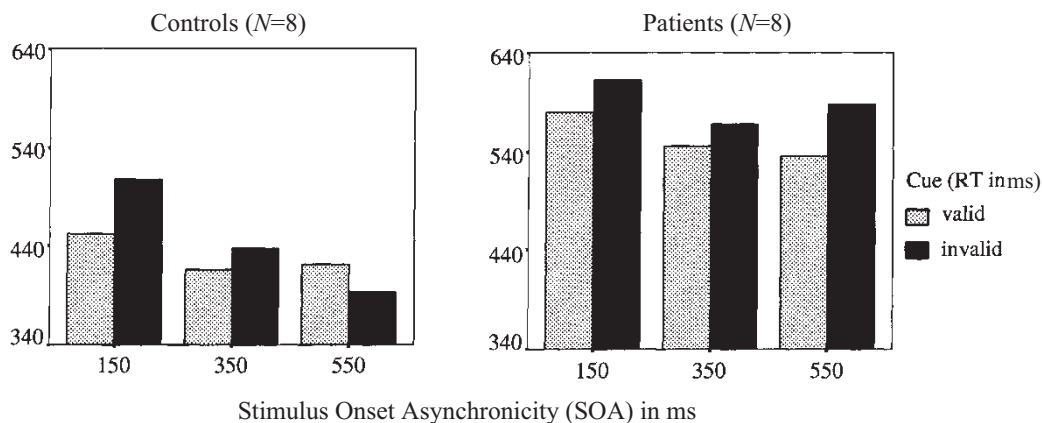


Figure 1. Mean reaction times for controls and patients on the endogenous and exogenous task in the verbal response condition.

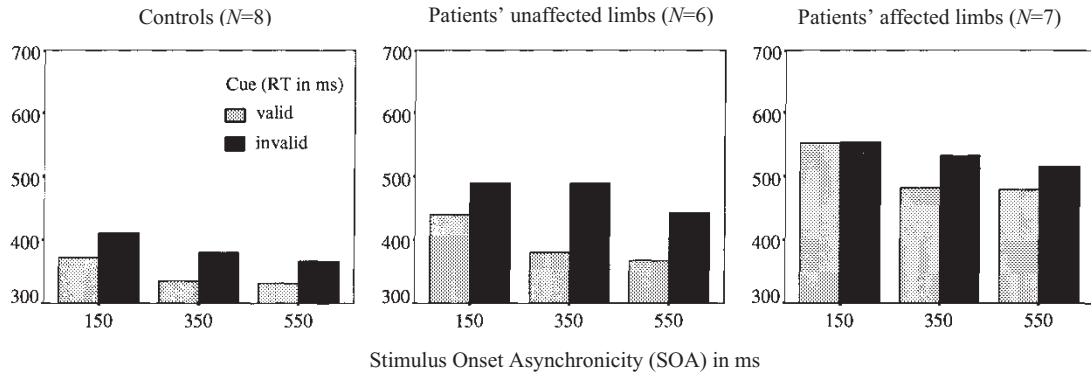
responses for controls and patients (responding with unaffected and affected limbs, respectively) are presented in Figure 2. As far as patients' unaffected limb responses are concerned, two patients had no unaffected limbs and were therefore excluded from the analyses. As far as patients' affected limb responses are concerned, one patient had to be excluded due to empty cells.

Endogenous task condition

The error rates for valid and invalid cues, respectively, were 1.1 and 4.0% for controls, 0.5 and 15.6% for patients' unaffected limbs, and 9.4 and

10.2% for patients' affected limbs. In order to assess possible differences in patients' responses with affected versus unaffected limbs, an ANOVA rm was conducted for the RTs with cue type and SOA as within-subject factors and limb (unaffected, affected) as between-subject factor. There were significant main effects for cue type, $F(1, 21) = 25.9, p < .000$, and SOA, $F(2, 20) = 6.5, p < .01$, but not for limb, $F(1, 21) = 2.3, p = .15$. In addition, there were significant interaction effects for cue type \times SOA, $F(2, 20) = 3.9, p < .05$, and, more importantly, for Cue Type \times SOA \times Limb, $F(2, 20) = 3.6, p < .05$. As shown in Figure 2a, these findings

(a) Endogenous task (limb response condition)



(b) Exogenous limb task (limb response condition)

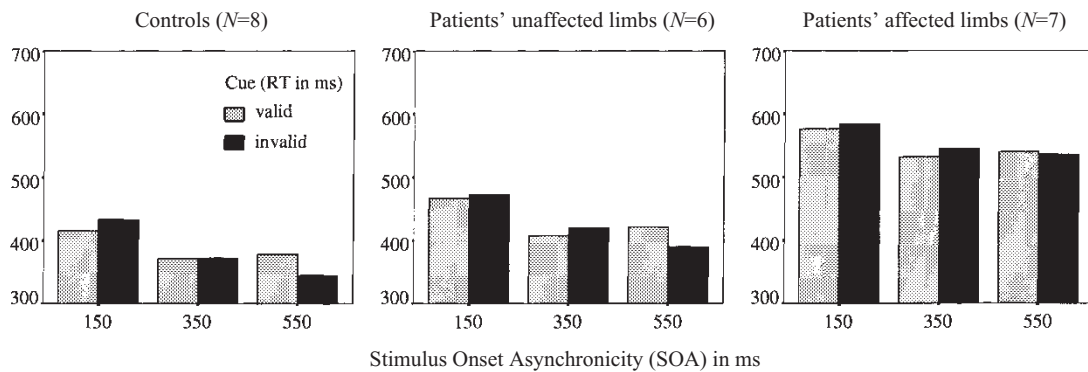


Figure 2. Mean reaction times for controls and patients responding with unaffected and affected limbs on the endogenous and exogenous task.

indicate that patients' responses with affected limbs resulted in diminished cue effects on short SOAs, when compared to patients' responses with unaffected limbs. These impairments for affected limb responses were comparable to the patients' impairments observed in the verbal response condition of the endogenous task (see Figure 1a). Findings of both the verbal and the limb response condition are indicative of impaired voluntary attention processing.

Exogenous task condition

The error rates for valid and invalid cues, respectively, were 1.0 and 3.3% for controls, 0.6 and 4.8% for patients' unaffected limbs, and 6.6 and 11.1%

for patients' affected limbs. An ANOVA for the RTs with cue type and SOA as within-subject factors and limb (unaffected, affected) as between-subject factor revealed significant main effects for SOA, $F(1, 22) = 81.9, p < .000$, but not for cue type, $F(1, 22) = 0.1, p < .75$, and limb, $F(1, 22) = 4.1, p = .06$. There were no significant interaction effects, except for a significant Cue Type \times Limb, $F(1, 22) = 6.2, p < .05$, interaction. Inspection of Figure 2b, suggests that this interaction effect is attributable to the presence of IOR in responses with unaffected limbs but not in responses with affected limbs. This absence of IOR for patients' affected limb responses was also found for patients in the verbal response condition of the exogenous task (see Figure 1b).

DISCUSSION

The purpose of the present study was to investigate endogenous and exogenous spatial attention in patients with conversion paralysis. Three hypotheses were tested. In the first place, we expected to find impaired endogenous cue effects in patients with conversion paresis, compared to control subjects. The results from the verbal response condition indeed showed patients to exhibit a diminished cue effect on a short 150 ms SOA, compared to controls. The later onset of the cueing effect in patients is interpreted as indicating that patients show impaired capacities to voluntarily orient their attention to relevant stimuli.

Second, we expected to find impaired inhibition of return (IOR) on the exogenous spatial attention task. Confirming this hypothesis, there was a significant Group \times Cue Type \times SOA interaction in the verbal response condition, showing that only control participants exhibited IOR. As mentioned before, IOR is an important mechanism favoring efficient visual search (Klein, 1988). The latter finding, therefore, suggests an impaired screening capacity in patients with conversion paralysis. This finding is in agreement with findings of Horvath et al. (1980), who found a diminished habituation to external stimuli in patients with conversion disorder, also indicative of inefficient screening. Bendfield, Miller, and Ludwig (1976) also observed a field-dependent or less active visual screening style in patients with conversion disorder.

Third, we tested participants in a limb response condition, expecting patients to show more pronounced impairments when the cues actually primed movements in space with the affected limbs, compared to the unaffected limbs. These expectations were confirmed by the results. On the endogenous task a diminished cue effect on a short 150 ms SOA was found for responses with affected limbs, compared to unaffected limbs. And in the exogenous task, responses with affected limbs, but not with unaffected limbs, were associated with diminished IOR effects. These findings are indicative of impaired higher-level attention processing. Although the effects of this attention deficit are not exclusively related to limb movement control, it

appears that the affected limb is more strongly afflicted than the unaffected limb. This implies that the higher-level deficit is not a generalised attentional disturbance with uniform implications for all motor control functions. The greater sensitivity of the affected limb for higher level attentional deficits needs further exploration and will be discussed from the perspective of other interpersonal and personal factors determining the manifestation of conversion paresis in the final paragraph of the discussion section.

The findings of the present study, showing higher-level attentional deficits, fit in with previous findings from brain-imaging studies (Marshall et al., 1997) that demonstrated frontal brain structures to be involved in the inability to move in a case of conversion paralysis. They are also in line with findings of the ERP study by Lorenz, Kunze, and Bromm (1998), suggestive of the selectional gating of processed information at a late stage in the processing chain, prior to the generation of conscious awareness in a case of conversion paralysis. The present study, together with findings from these previous studies, are in agreement with dissociation theories of conversion disorder claiming that high-level explicit information processes are disturbed (Jackson, 1958; Janet, 1924; Roelofs et al., 2001). These theories all stress the fact that high-level complex information processing, in particular, is sensitive to influences of traumatic or stressful circumstances.

Apart from the impaired higher-level endogenous attention control, we found impairment in the lower-level automatic orientation task: an absence of the IOR effect. Such an attention deficit is not unique to conversion paresis and has previously been found for patients with schizophrenia (Carter, Robertson, Chaderjian, O'Shora-Celaya, & Nordahl, 1994; Huey & Wexler, 1994). In these patients it was suggested that this otherwise low-level cognitive operation might be overridden by top-down processes producing heightened states of vigilance (Carter et al., 1994). From the attention literature we know that higher-level top-down processes can indeed interfere with IOR, while sparing the early exogenous cue effects (e.g., Berger & Henik, 2000). Thus, this finding also fits within

interpretations of conversion disorder in terms of increased inhibition of higher-level executive motor and perceptual functions (Ludwig, 1972; Marshall et al., 1997; Tiihonen et al., 1995).

Interestingly, these deviations in higher-level attention control in the verbal response condition were observed again; only in the RT profiles associated with affected limb responses and not in the data of the healthy limb responses (Figure 2). Visual inspection of the latter suggested relatively intact early endogenous cueing effects and intact IOR in exogenous cueing. This is interesting because it suggests that the response mode influences cue effects in patients. The fact that the attentional deficits associated with affected limb responses were also present when patients reacted verbally and not when patients reacted with their healthy limbs can be interpreted in the light of differences in "stimulus-response (S-R) compatibility" between the response conditions. The verbal response condition is featured by a lower S-R compatibility than the limb response condition. In the former, a target appearing in the left visual field refers to the semantic category "left," and in the latter, to an actual left-sided movement. As a result, the verbal response condition involves motor preparation on a higher, more abstract, categorical level and the limb response condition on a lower, more concrete, anatomical level. It is well known that high S-R compatibility results in faster response times, due to the fact that the responses involve stronger neural pathway activation (Posner & DiGirolamo, 2000). In a RT study in which different movement characteristics were precued and evaluated according to the resulting RT gains, Rosenbaum (1980), for example, showed that abstract movement features, such as direction and extent of movement, are less strongly represented than anatomical features (which limb to move). Previous studies of patients with conversion paralysis (Roelofs et al., 2001, 2002b) have shown that especially the higher-level central initiation of movement is impaired, whereas the lower-level peripheral motor execution is relatively intact. In this light, it is consistent that IOR for stimulus-compatible unaffected limb responses was intact. In the responses with the affected limbs, we suggest

that a higher-level interference with the otherwise intact lower-level processes occurred. The finding that IOR was especially disturbed in the more abstract verbal response condition further supports the idea that conversion disorder is associated with impairment of higher-level cognitive functions.

An important question left open is whether the presently observed impairments in voluntary attention control are restricted to the domain of spatial attention or whether they are also manifested in nonspatial domains of attention functions. This is a crucial question because spatial attention is important for the planning and preparation of movements and the brain areas involved in voluntary attention greatly overlap those active in motor initiation (Rizzolatti et al., 1994). Premotor and association areas in the brain are critical for planning an action based on perceptual information, past experience, and future goals, such as target location in space (Gazzaniga, Ivry, & Mangun, 1998). The problems in motor initiation in patients with conversion paralysis may, therefore, be directly related to a problem in the mental positioning of one's body in space (spatial planning). So, if the attention deficits observed in the present study are restricted to spatial attention, the deficits may just reflect a problem in movement planning. However, if the impairments in voluntary attention are also manifested in other nonspatial domains of attention, the deficits are more likely to reflect a broader impairment in selective attention. The latter option would be in line with Janet's (1924) and Ludwig's (1972) attention theories of conversion disorder. To further test these theories we recommend future research that should also focus on nonspatial aspects of voluntary attention, for example, by using a Stroop paradigm. In addition, testing patients with other conversion symptoms (e.g., sensory symptoms) may shed more light on this issue.

Notwithstanding the theoretical restrictions discussed in the preceding paragraph, the findings of the present study were consistent over verbal and limb response conditions. This outcome is suggestive of a locus of the deficit in higher-level attentional processing and not at an executive motor level. However, due to the small group sizes and the fact that the findings still need to be

replicated, the findings should be regarded as preliminary. It should also be noted that the findings of the present study concern fundamental cognitive processes observed in conversion disorder and not necessarily the mechanisms behind its evolution. The findings, for example, do not explain why a conversion paralysis develops in one specific limb and not in another. Although, there are no conclusive answers to this question, previous writings pointed to the fact that patients with conversion disorder show an increased suggestibility compared to patients with affective disorders (Bliss, 1984; Roelofs, Keihser, Näring, Hoogduin, Moene, & Sandijck, 2002a). The final manifestation of a conversion symptom may therefore be influenced by suggestions derived from the interpersonal and personal context. Such suggestions in the case of conversion disorder may be formed by observation of similar bodily deficits in the environment (role model), repeated examination by specialists (iatrogenic suggestions) or previously experienced somatic diseases or injuries (perceived weak somatic spot). The influence of these factors on the manifestation of conversion symptoms, however, still needs to be proven. Another question left open is whether the deficits in voluntary attention observed for the conversion patients indeed result from psychological stress, as was proposed by the theories of Janet (1924) and Ludwig (1972). Future research should therefore also address the proposed relation between attentional deficits and stress in conversion disorder.

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