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Lateralized Direct and Indirect Semantic Priming Effects in Subjects with Paranormal Experiences and Beliefs

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Key Words

Associative processing · (Indirect) semantic priming · Hemispheric differences · Schizotypy · Paranormal belief

Abstract

The present investigation tested the hypothesis that, as an aspect of schizotypal thinking, the formation of paranormal beliefs was related to spreading activation characteristics within semantic networks. From a larger student population (n = 117) prescreened for paranormal belief, 12 strong believers and 12 strong disbelievers (all women) were invited for a lateralized semantic priming task with directly and indirectly related prime-target pairs. Believers showed stronger indirect (but not direct) semantic priming effects than disbelievers after left (but not right) visual field stimulation, indicating faster appreciation of distant semantic relations specifically by the right hemisphere, reportedly specialized in coarse rather than focused semantic processing. These results are discussed in the light of recent findings in schizophrenic patients with thought disorders. They suggest that a disinhibition with semantic networks may underlie the formation of paranormal belief. The potential usefulness of work with healthy subjects for neuropsychiatric research is stressed.

Introduction

Inappropriate, 'loose' associations have long been considered a key feature of the language of patients with acute schizophrenia [1]. It has been suggested that this 'loosening' of associations may be a consequence of a decreased inhibition of the spreading activation within semantic networks [2]. Spreading activation theories of the functional architecture of semantic memory [3] assume that concepts are represented as nodes, and are interconnected by a network of links along which activation proceeds automatically. In a properly working cognitive system, closely related semantic concepts are more strongly interconnected with each other than distantly related concepts, and will be coactivated with a high probability. On the other hand, in schizophrenia, the activation in these networks, rather than spreading from one concept to a neighboring concept in a focused manner, is supposed to proceed along new links, reaching several widespread, only loosely interconnected nodes (i.e. associative intrusions arise; see [4–7] for the electrophysiological and pharmacological mechanisms involved).

In schizophrenia research, the paradigm of semantic priming has repeatedly been employed to measure the 'spread of activation' within semantic networks. In this paradigm, subjects are required to decide whether the second of two consecutively presented letter strings is a real word. Semantic priming effects refer to shorter reaction

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times to the second (target) word when it is preceded by a semantically related (prime) word as compared to a non-related prime. Compatible with the postulated mechanism of disinhibition, increased semantic priming effects ('hyperpriming') in schizophrenic patients was demonstrated in some studies [8–13]. However, no hyperpriming was observed in other experiments [14].

More recent studies employed the paradigm of indirect semantic priming [15] and significantly extended these results. In this paradigm, prime (e.g. lion) and target (stripes) words are indirectly related, i.e. they are both related to a third, mediating concept (tiger or zebra). In healthy persons, indirect priming effects are smaller than direct priming effects, a finding which corroborates the view that the amount of spreading activation is inversely related to the semantic distance (i.e. the number of associative steps) between two concepts [15]. Interestingly, indirect as compared to direct semantic priming allows a better monitoring of presence or absence of thought disorder in schizophrenic patients [11–13, 16]: whereas patients with thought disorder treated indirectly related prime-target pairs as directly related, several control groups of non-thought-disordered subjects treated them as unrelated. Taken together, these studies on direct and indirect semantic priming presented evidence of a faster and farther-spreading activation in the semantic network of patients with schizophrenia.

The concept of 'schizotypy' proposes the presence of schizophrenia-like signs in healthy subjects [17, 18]. These include hallucination-like experiences and delusion-like, 'paranormal' beliefs [18, 19]. Qualitatively, there are considerable commonalities in the performances of schizophrenic and schizotypal individuals on tasks relevant to associative processing [20–23]. For instance, one recent study employing a verbal fluency task demonstrated that healthy subjects with a high frequency of paranormal experiences and beliefs produced a high percentage of uncommon word associations [21], a finding paralleling previous observations in patients with productive symptoms of schizophrenia [24].

To understand the mechanisms underlying this enhanced availability of specifically 'distant' associations, we propose to integrate results from two hitherto unconnected neuropsychological research fields. First, lateralized semantic priming tasks presented evidence for a right hemisphere (RH) preference for coarse as opposed to focused semantic analysis [25–28]. Second, as recently reviewed by Crow [29] and Leonhard and Brugger [30], one prominent feature of both schizophrenia and schizotypy is an absence of a clear dominance of the left hemisphere for linguistic processing. Taken together, these two observations suggest that a reduced left hemisphere (LH) participation may favor the emergence of 'loose' associations by a relative overreliance on unfocused activation within RH semantic network (see [30] for the experimental evidence).

The present experiment examines spreading activation processes as a function of the stimulated hemisphere in subjects differing in their declared belief in paranormal phenomena. Based on the literature reviewed above, we predicted that (1) specifically for indirectly related prime-target pairs, believers show larger semantic priming than disbelievers, and (2) this effect is more pronounced after left visual field (LVF)/RH stimulation than after right visual field (RVF)/LH stimulation.

Method

Subjects

Three hundred and fifty-two undergraduate psychology students of the University of Zurich were given a 6-item questionnaire assessing belief in and experience of paranormal phenomena (mainly telepathy and precognition) on a 4-point scale (possible score 0–18 [31, 32]). Subjects were also asked about their willingness to participate in an experiment on 'neuropsychological and electrophysiological correlates of belief in extrasensory perception'. Among the 117 students (91 women) returning the questionnaire and indicating their willingness to participate, 12 individuals scoring in the highest 25% of the questionnaire ('believers' 16.3 ± 1.2, mean ± SD) and 12 scoring in the lowest 25% ('disbelievers' 3.3 ± 2.9) were contacted. Since there were only 5 men among the believers, and we had planned to investigate subjects of one gender only (because gender is a confounding variable in laterality research; see Beaton [33] for overview), only women were asked to participate.

All participants were right-handed [34] native Swiss-German speakers, and had no history of psychiatric or neurological disorders. Believers and disbelievers did not differ with respect to age (26.3 ± 6.2 vs. 26.8 ± 4.3 years), handedness score (13.7 ± 1.3 vs. 13.2 ± 0.6 [34]) and parameters of menstrual cycle (duration 29.3 ± 2.9 days vs. 28.3 ± 1.2 days; days after last menstruation 16.3 ± 7.4 vs. 16.7 ± 10.7 [35]). The study was approved by the Ethics Committee of the University Hospital Zurich, and each subject gave informed written consent. Subjects received CHF 40.00 for their participation in the experiment.

Stimuli

All stimuli were letter strings between 3 and 7 characters. There were 240 prime-target pairs divided into 4 categories of prime-target relations. While all primes were nouns (n = 240), the target was either a directly related noun (n = 40), an indirectly related noun (n = 40), an unrelated noun (n = 40) or a pronounceable nonword (n = 120). Several word pairs of the first two categories were selected from prior priming experiments [15, 26, 27]. Prior to the experiment, the semantic relatedness between prime and target words was rated on a 7-point scale (1 = unrelated, 7 = strongly related) by 18 independently recruited subjects. In order to diminish the overlap between catego-

ries, 18 word pairs were replaced, and a rerating by another 21 subjects was done. Eventually, the prime-target pairs of the three categories were higly significantly different according to their semantic relatedness (ANOVA F = 581.8, d.f. = 2, 78; $p < 0.001$), with mean values of 6.4 (± 0.4), 3.4 (± 0.9) and 1.7 (± 0.4) for directly related, indirectly related and unrelated word pairs, respectively.

Words of the different categories did not differ with respect to word length and frequency of occurrence in German texts [36]. They were also comparable with respect to emotionality and imaginability as rated on a 7-point scale by another 24 students who did not participate in the final experiment.

Stimulus Presentation

There were 8 stimulus blocks (separated by 30-second breaks), each consisting of 60 trials (prime-target pairs) belonging to 4 categories: 10 directly related, 10 indirectly related, 10 unrelated pairs and 30 word-nonword pairs. While all prime words were presented in the center of the visual field, half of the target words within each category were presented on the LVF/RH, the other half to the RVF/LH. Stimuli were presented white on a gray background. Target eccentricity was between 2° and 4.8° of visual angle.

Each trial consisted of three displays following each other without time gaps: for 1,000 ms, a centered fixation cross, for the next 200 ms a centered prime and for the last 150 ms the centered fixation again, simultaneously with a lateralized target. Thus, prime-target stimulus onset asynchrony (SOA) was 200 ms, ensuring automatic rather than controlled processing [37]. The screen remained blank until the subject's manual response initiated the next trial. Manual responses consisted in pressing two lateral keys simultaneously with both thumbs (on detecting a real word) or in pressing a third key with the right thumb (on detecting a nonword). Speed and accuracy were equally emphasized in the instructions.

After 20 practice trials, each subject received the same pseudorandom sequence of trials, with the constraints that (1) no more than three trials of the same category were presented consecutively, and (2) no more than three targets in the same visual field were presented consecutively.

A PC with ERTS software (BeriSoft Cooperation, Frankfurt, Germany) was used for stimulus presentation and reaction time (RT) recording. A chin and head rest kept the distance between subject's eyes and the PC screen constant (100 cm).

Questionnaire

Before the priming task, subjects were administered the Magical Ideation scale [19], a commonly used schizotypy inventory that consists of 30 true/false items on hallucination-like experiences and delusion-like beliefs.

Results

Reported RTs are in milliseconds. All p values are two-tailed.

Magical Ideation

The two subject groups differed in their Magical Ideation scores (believers 13.75 ± 4.14; disbelievers 4.25 ± 2.93; t = 6.56, d.f. = 1, 22; $p < 0.0005$).

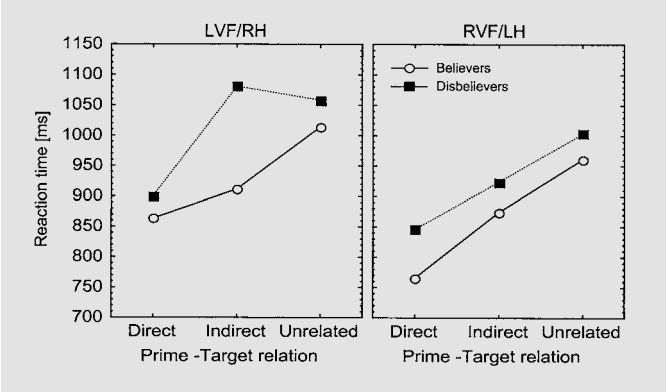

Fig. 1. Mean reaction times for believers (open circles, n = 12) and disbelievers (closed squares, n = 12) as a function of side of target presentation and of the semantic relation between prime and target (direct, indirect, unrelated).

Priming Task

A three-way ANOVA with 'Group' (believers, disbelievers) as between-subject factor, and 'Visual Field' (VF; LVF, RVF) and 'Category' (directly related, indirectly related, unrelated prime-target relation) as repeated measures was performed on individual mean RTs of correct lexical decisions, after removal of outliers (<400 ms, >2,400 ms; 2.3% of the data). Alternative strategies for outlier removal (calculated as suggested by peer review) did not affect the statistical results (first step: removal of RTs exceeding 3,000 ms as not reliably reflecting processes of semantic priming; second step: removal of RTs exceeding twice the mean RT [11, 12] for every combination of VF and Category). The same three-way ANOVA on accuracy scores did not reveal any effects or interactions with Group; therefore, further analyses concentrate on RT data. Three significant effects were observed: a main effect for VF (LVF 972 > RVF 896; F = 17.02, d.f. = 1, 22; $p < 0.0004$), a main effect for Category (direct 844 < indirect 948 < unrelated 1,010; F = 21.73; d.f. = 2, 44; Greenhouse-Geisser corrected $p < 0.0001$; post hoc comparisons, Neuman-Keuls, all $p < 0.02$) and a three-way interaction Group × VF × Category (F = 5.11, d.f. = 2, 44; $p < 0.01$; fig. 1).

To further explore the significant triple interaction, separate two-way (Group × VF) ANOVAs were performed for directly related, indirectly related and unrelated word pairs. Apart from the main effect for VF ($p < 0.05$ for all categories), these analyses revealed a significant Group × VF interaction only for indirectly related targets (F = 6.32, d.f. = 1, 22; $p < 0.02$). Believers had significantly shorter RTs than disbelievers when the indi-

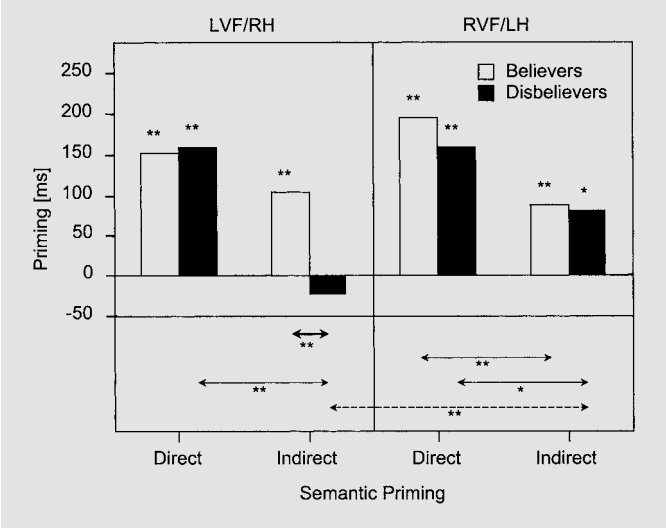

Fig. 2. Mean direct and indirect semantic priming effects for believers (open bars; n = 12) and disbelievers (closed bars; n = 12) as a function of side of target presentation. Significance of priming effects according to post hoc tests of the three-way ANOVA of the mean RTs. Arrows illustrate significant differences between groups (heavy line), within groups (thin lines) and between visual fields (dashed line) according to the three-way ANOVA of the priming effects. * $p < 0.05$; ** $p < 0.001$.

rectly related target was in the LVF ($p < 0.0003$), but not when it was in the RVF ($p > 0.3$).

Post hoc tests assessed direct and indirect semantic priming effects comparing RTs for directly related, indirectly related and unrelated targets. For disbelievers, the following results emerged: (1) within each VF, RTs to directly related targets (LVF 900 ± 90; RVF 846 ± 109) differed from both RTs to indirectly related (LVF 1,081 ± 209; $p < 0.001$; RVF 924 ± 160; $p < 0.05$) and to unrelated targets (LVF 1,058 ± RVF 1,004 ± 177), i.e. direct semantic priming was significant in both VFs (fig. 2); (2) RTs to indirectly related targets differed from those to unrelated targts only in the RVF, i.e. indirect semantic priming was significant only in the RVF (fig. 2). For believers, it was found that: (1) within each VF, both RTs to directly (LVF 864 ± 146; RVF 766 ± 114) and to indirectly related (LVF 912 ± 177; RVF 875 ± 199) targets differed from those to unrelated targets (LVF 1,014 ± 256; RVF 961 ± 271), i.e. both direct and indirect semantic priming were significant in both VFs (fig. 2); (2) RTs to directly related targets differed from those to indirectly related targets only in the RVF ($p < 0.005$).

In order to closely compare our results with those of prior studies [11–13], direct and indirect semantic priming effects (i.e. RT differences) were subjected to a three-way ANOVA with Group, VF and 'Type of priming' [direct semantic priming = RT (unrelated) – RT (direct); indirect semantic priming = RT (unrelated) – RT (indirect)] as factors. This analysis revealed a significant main effect for Type of priming (direct semantic priming 166 > indirect semantic priming 62; $F = 21.40$, d.f. = 1, 22; $p < 0.001$) and a significant Group × VF × Type of priming interaction ($F = 10.74$, d.f. = 1, 22; $p < 0.005$). Post hoc tests (fig. 2) showed that (1) for disbelievers, direct semantic priming (LVF 158 ± 214; RVF 158 ± 112) differed from indirect semantic priming (LVF –23 ± 92; RVF 80 ± 80) within each VF; (2) for believers, direct semantic priming (LVF 151 ± 184; RVF 196 ± 180) differed from indirect semantic priming (LVF 103 ± 153; RVF 87 ± 100) only in the RVF; (3) for disbelievers, VF differences were significant only for indirect semantic priming, and (4) the only group effect was in the LVF and exclusively for indirect semantic priming.

Discussion

Semantic priming, a paradigm developed for the study of automatic spreading activation within semantic networks [3], is increasingly used within a neuropsychiatric framework (see Spitzer [4] for review). It is argued that the 'oblique', 'distant' or 'indirect' associations observed in the language of patients with thought disorder [1] are a direct consequence of a disinhibited spreading activation (i.e. a faster and farther spread of semantic activation) and may manifest themselves as increased semantic priming effects [2, 10]. More recently, the technique of 'indirect semantic priming' (which uses prime-target pairs exclusively related through a semantically mediating concept) was recognized as more sensitive for the differentiation between thought-disordered and non-thought-disordered schizophrenic patients; while indirect semantic priming was enhanced in patients with thought disorder, direct semantic priming was not [11–13, 16].

The aim of the present study was to investigate, in healthy volunteers, direct and indirect semantic priming as a function of one particular aspect of 'schizotypal' thought, i.e. a belief in 'paranormal' phenomena. Such belief is assumed to be a consequence of 'seeing' connections between remotely (or even randomly) associated concepts or events, which results in an attribution of 'meaningfulness' to coincidences [20, 38–40]. A relative preference for distant over close associations may reflect an overreliance on semantic processing characteristics of the RH (i.e. a coarse as opposed to focused analysis [25–

28]). Since believers in paranormal phenomena repeatedly showed an enhanced RH participation in a variety of lateralized verbal tasks [30, 41, 42], we predicted that believers would show enhanced indirect semantic priming specifically when targets were presented to the LVF. This hypothesis was confirmed; in our sample of preselected high and low scorers (all women) on a brief paranormal belief scale [31], we found that the two subject groups differed only in their RTs to indirectly related prime-target pairs and exclusively after LVF/RH presentation. Believers showed stronger indirect (but not direct) semantic priming effects than disbelievers after LVF (but not RVF) stimulations, indicating a faster appreciation of specifically distant semantic relations which was, however, confined to the RH. In fact, after LVF/RH stimulation, believers treated indirectly related prime-target pairs like directly related pairs, while disbelievers treated them like unrelated pairs. The RT pattern displayed by the disbelievers is thus similar to that of the normal control subjects in previous studies of indirect semantic priming in patients with schizophrenia [11–13]. The believers' RT pattern to directly and indirectly related prime-target pairs, on the other hand, is comparable to the one found in groups of thought-disordered patients [11–13]. One discrepancy to a previously published study concerns the interaction between type of priming and the visula field of presentation. Weisbrod et al. [13], in a lateralized direct and indirect semantic priming experiment with thought-disordered and non-thought-disordered schizophrenic patients found indirect semantic priming also in the LH of thought-disordered subjects. Procedural differences between these authors' and the present experiment may account for this discrepancy. First of all, all subjects in Weisbrod et al. [13] were men, while we tested only female subjects. As a rule, the regular LH superiority for the processing of linguistic material is more pronounced for men than women [33]. Also, all patients in the previous study were on neuroleptic medication, and neuroleptics are known to stabilize hemispheric asymmetries, in particular by a normalization of LH functioning [43]. Finally, with respect to the parameters of stimulus presentation, we note that differences between the two studies in SOAs are unlikely to account for the LH contribution observed in the Weisbrod et al. study; both these authors (SOA = 250 ms) and ourselves (SOA = 200 ms) used values well below those considered to tap controlled rather than automatic semantic processes [37]. On the other hand, we presented the lateralized target words for 150 ms, while Weisbrod et al. used an exposure time of 200 ms. RH participation in lexical decision processes generally increases as exposure time decreases [44, 45]. Nevertheless, while the minor discrepancy between the two studies with respect to LH participation may thus be explained by procedural differences, we would like to emphasize that, with respect to the main point of interest, i.e. RH participation in the processing of specifically indirect semantic associations, the findings between the two studies were identical 'in that the most pronounced indirect priming effect was found in the right hemisphere of thought-disordered subjects' [13, p. 146] ('thought-disordered subjects' to be replaced by 'paranormal believers' in the case of the present study).

In view of these findings, we propose that both paranormal and delusional forms of 'seeing' connections between remotely associated concepts or ideas rely on an increased spread of activation within semantic networks. However, the same mechanisms may also be responsible for a creative style of thinking, i.e. the ability of 'forming associative elements into new combinations' [46, p. 221]. (For the electrophysiology of loosened connectivity in schizophrenia see [4–7].) A disinhibition of semantic network functioning may indeed by the physiological basis of the commonalities between 'genius and madness', noted for over a century [47]. Crow [29] recently pointed to the longstanding puzzle how 'genes predisposing to schizophrenia survive in all populations without a balancing advantage being apparent' [29, p. 339]. The view of a continuum of associative loosening seems to provide a solution to this puzzle: while a pronounced disinhibition may lead to maladaptive, disordered thought, more moderate forms can lead to creative insights and thus constitute an obvious evolutionary advantage.

While our findings provide insight into the formation and maintenance of paranormal belief, their implications for neuropsychiatry may be much broader. They illustrate the usefulness of testing healthy subjects for the understanding of the neuropsychobiological mechanisms potentially underlying psychiatric symptoms. This approach has considerable advantages over testing patients, a procedure often meeting serious problems with respect to patients' compliance, interpretation of medication effects and, in priming studies, of RT baseline differences between patient and control groups [9].

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