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The effect of associative strength on semantic priming in schizophrenia

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ABSTRACT

The present research was designed to investigate the pattern of semantic priming in schizophrenia as a function of strength of association (or semantic distance between concepts in the semantic network). Thirty schizophrenia patients, without formal thought disorder, and twenty-nine healthy controls participated in a lexical decision task in which prime-target associative strength (strong, weak and not related) and stimulus-onset asynchrony (SOA: 250 ms and 750 ms) were manipulated. Patients and controls showed the same associative strength effect on RTs. In the short SOA condition priming effects were obtained for both strong and weak prime-target associative conditions. However in the long SOA priming was only significant for strongly associated pairs. This pattern of priming effects was similar in both groups, with higher priming on the short SOA and strong association conditions. Altogether results suggest that automatic semantic spreading activation is unimpaired in schizophrenia patients without formal thought disorder. These results are in line with the general evidence of impaired implicit priming observed only in patients with formal thought disorder. At the same time patients use context as controls to facilitate word processing. Finally, these findings evidence that, prime-target associative strength could moderate results in studies of semantic memory deficits in schizophrenia.

1. Introduction

In recent decades a large amount of research has used the semantic priming effect (Neely, 1991) to study the structure and function of semantic memory in schizophrenia, focusing on the relation between semantic memory deficits, symptoms, and cognitive dysfunctions such as language and thought disorder. However, findings are somewhat contradictory (for reviews see Lecardeur et al., 2006; Kuperberg et al., 2010; Minzenberg et al., 2002; Mohammad and DeLisi, 2013; Pomarol-Clotet et al., 2008; Wang et al., 2011) and discrepancies have been related with the characteristics of the patient sample and with how variables in the most commonly used task to study semantic priming, lexical decision, are set (Rossell and Stefanovic, 2007); for example the semantic "distance" between concepts in the semantic network, or the duration of stimulus-onset asynchrony (SOA; the interval between prime onset and target onset). Semantic "distance" refers to the idea that concepts are stored relatively close together in the psychological and neural space. Its manipulation is commonly used to provide empirical evidence that the activation of one concept sends an activating wave to concepts directly connected with it (Anderson, 1983; Collins and Loftus, 1975). This semantic "distance" has been operationalized as the number of concepts between two other concepts in the semantic network. Directly associated concepts do not have any intermediary concept between them (e.g. birthday – cake) and indirectly associated concepts have intermediary concepts between them (e.g. the association lemon – sour is mediated by the word sweet). On the other hand, stimulus-onset asynchrony (SOA) duration seems to determine the start-up of the processes that have been proposed to explain semantic priming: automatic spreading of activation or controlled processes (attention-based expectancy and post lexical matching) (Neely, 1991). SOAs below 500 ms would activate automatic spreading activation processes and SOAs above 500 ms might set off controlled or strategic processes.

Behavioral and ERP studies in patients with schizophrenia have been performed using short and long SOAs and directly and indirectly related prime-target pairs. Increased, reduced or normal priming has been reported using short SOAs (500 ms or less) and directly or indirectly related prime-target pairs (Condray et al., 2003; Kiang et al., 2008, 2012; Lecardeur et al., 2006; Minzenberg et al., 2002, 2003; Moritz et al., 2001; Neill and Rossell, 2013; Niznikiewicz et al., 2010; Ober et al., 1997; Pfeifer et al., 2012; Rossell and David, 2000, 2006; Spitzer et al., 1993). These contrasting findings have been attributed to a dysfunction of the automatic spread activation within semantic memory or to a disorganized storage/structure of semantic memory (Rossell and David, 2006; Tan et al., 2015). Evidence from studies comparing direct and indirect prime-target associates suggests there is

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an exaggerated diffusion of activation, due to a failure in the inhibition mechanisms of the automatic spreading activation process in the semantic memory network. Consequently, words indirectly related with the prime will be activated as words directly related with the prime. However, these results have not been consistently replicated, and have usually been associated with thought disorder patients (see reviews: Minzenberg et al., 2002; Pomarol-Clotet et al., 2008), although some reviews have not supported such an association (Rossell and Stefanovic, 2007).

Priming studies using long SOAs (above 500 ms) are assumed to involve controlled processes in semantic memory that facilitate the processing of related targets and slow down the processing of unrelated targets. Under these conditions results of both behavioral and neurophysiological experiments have shown increased, normal or no priming effects in conditions of direct prime-target associates (Kuperberg et al., 2007; Vistoli et al., 2011), though a reduced or absent priming has been the most frequent observation in conditions of indirect prime-target associates (Kiang et al., 2008, 2012; Kuperberg et al., 2007; Pfeifer et al., 2012). Some authors suggest that the reason for these conflicting results is impairment of the mechanism that controls the use of context to facilitate word processing (Kreher et al., 2009; Kuperberg et al., 2010; Mathalon et al., 2010; McCarley et al., 1999). According to this hypothesis, patients would not be able to generate possible target candidates after prime processing or to evaluate adequately a prime-target relationship to generate a faster response.

In summary, a substantial body of literature – obtained using lexical decision tasks – has relied in the manipulation of the type of relation between prime and target (direct or indirect) to throw light on semantic priming processing in schizophrenia. However, there is an alternative measure of semantic "distance", the associative strength between concepts in semantic memory. It is measured empirically through discrete free association ratings (e.g. Kučera and Francis, 1967; Nelson et al., 1998) that provide the proportion of individuals producing a word in response to another word, or the response probability of a target (e.g. steel) for a specific prime (e.g. metal). Strongly associated concepts are assumed to be closer in the semantic space and weakly associated concepts more distant (de Groot et al., 1982; McKoon and Ratcliff, 1992). Associative strength has been considered a more adequate measure of semantic "distance" than the direct-indirect relationship, as it is a continuous variable that can be measured empirically, and because the idea that there are differences in the strength of association between words is supported by numerous empirical studies (Coney, 2002; de Groot et al., 1982; Frishkoff, 2007; Lorch, 1982). According to the activation theory of semantic memory, priming will be higher in strongly associated pairs (e.g. elephant-trunk) than in weakly associated pairs (e.g. skirt-blouse) (Anaki and Henik, 2003; Cañas, 1990). One way to further elucidate the nature of the semantic priming effect in schizophrenia and to help explain the discrepancies observed in the literature is to study the effect of associative strength on priming in schizophrenia patients. An examination of several studies on semantic priming in schizophrenia carried out over the last decade shows that, in many cases, prime-target associative strength was not controlled and was not even reported (e.g. Kreher et al., 2006; Kreher et al., 2008; Kuperberg et al., 2007; Laurent et al., 2010; Lecardeur et al., 2007; Mathalon et al., 2010; Niznikiewicz et al., 2010; Pfeifer et al., 2012). Of the studies performed, only a few (e.g. Chenery et al., 2004; Kiang et al., 2008; Kiang et al., 2012; Neill and Rossell, 2013) report association values.

The main goal of the present work was to establish if the association strength effect observed in healthy subjects occurs in schizophrenia. To achieve this objective, we have manipulated semantic association strength between prime and target in a lexical decision task. Secondly, we have explored the association strength effect in automatic and controlled conditions. Under automatic semantic priming conditions (short stimulus-onset asynchrony) we have examined if schizophrenia is in fact characterized by a dysfunction in the automatic spreading activation process. In addition, we have included a long stimulus-onset asynchrony condition to explore if the commonly observed reduction in semantic priming in schizophrenia under controlled semantic priming conditions -hypothesized to be due to difficulties with the use of controlled semantic processing strategies (the context) – is moderated by associative strength conditions. Furthermore, we have investigated in patients, whether the priming observed in the different association strength and SOA conditions is related with duration of illness and symptoms.

The mixed data in the literature and the absence of studies manipulating the associative strength between prime and target in schizophrenia do not allow to make any specific hypothesis for each of the associative and stimulus-onset asynchrony conditions. However, in line with the main accounts that have been proposed to explain impairment in semantic priming in schizophrenia, some predictions can be made: under automatic processing conditions the overactivation account would predict the same amount of priming for strong than for weak related pairs. The spreading activation wave will not decay as it moves away from the prime, producing the hyperpriming results observed in the literature. Under controlled conditions, the inadequate use of context account would expect poorer priming effects in the weak than in the strong associative condition. If schizophrenia patients can't use the context (start expectancy or semantic matching processes) they will not show priming effects or will appear only in the strong associative condition, a condition in which the semantic relation between prime and target could be more evident. At the same time, these predictions concerning weak associations will fit in the disorganized structure hypothesis proposed to explain semantic processing deficits in schizophrenia. If the semantic structure is disorganized, impairments in semantic priming are expected to be more apparent in conditions more sensible to disruptions in the semantic network. We hope that the manipulation of associative strength helps to interpret semantic priming data in literature.

2. Method

2.1. Participants

Thirty outpatients and twenty-nine healthy controls participated in the study. Patients were recruited at an outpatient psychiatric facility (Miguel Servet Hospital in Valencia, Spain) and fulfilled the DSM-IV Axis I Disorder criteria for schizophrenia (SCID-I; First et al., 2001). Patients' symptoms were rated using the Brief Psychiatric Rating Scale (BPRS) (Ventura et al., 1993). The severity of symptoms of each item was assessed using a five-point Likert rating scale (with 0 indicating "absent" and 4 indicating "very severe"). Furthermore, scores for item 4 of the BPRS were used to assess the state of current disorganized thinking. Patients had scores ranging from 0 (not present) to 2 (doubtful or very mild), indicating that they did not have formal thought disorder. All patients were on stable doses of anti-psychotic medication and were screened for previous traumatic brain injury and current substance abuse (over the previous year). The group of healthy controls was matched to patients in gender, age and education, and had no history of neurological or psychiatric illness or drug abuse. All participants gave their written informed consent to take part in the study, and the study was in line with the Helsinki Declaration. Demographic and clinical characteristics are shown in Table 2.

2.2. Word stimuli and task

Stimuli were 120 critical word prime-target pairs, and 120 word prime-nonword target pairs. The critical pairs were selected from the University of Valencia Spanish word association norms (Algarabel et al., 1986). Of the 120 critical pairs, 30 were strongly associated pairs with an association mean of 0.45 (e.g. forest-tree), 30 were weakly associated pairs with an association mean of 0.09 (e.g. letter-stamp),