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# Implicit memory functioning in schizophrenia: Explaining inconsistent findings of word stem completion tasks

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ABSTRACT

The definitive implicit memory profile of schizophrenia is yet to be clarified. Methodological differences between studies could be the reason for the inconsistent findings reported. In this study, we have examined implicit memory functioning using a word stem completion task. In addition, we have addressed methodological issues related with lexical and perceptual stimuli characteristics, and with the strategy used to calculate priming scores. Our data show similar performance values in schizophrenic patients and healthy controls. Furthermore, we have not detected significant differences in priming between the two groups, even when this parameter was calculated using three different procedures. These results are in line with those we have reported previously using the same stimuli in a word fragment completion task. Considered as a whole, our research suggests that implicit memory functioning in schizophrenia is unimpaired when assessed using word fragment or stem completion tasks. In light of this, future studies should follow standardized criteria to assess implicit memory when the sensitivity of the task employed is essential for identifying potential memory deficits in schizophrenia.



## 1. Introduction

Memory has been identified as one of the areas of impaired cognitive skills that characterize schizophrenia (Heinrichs and Zakzanis, 1998; Fiovaranty et al., 2005; Reichenberg and Harvey, 2007; Gold et al., 2009). However, memory is a complex domain, and, although areas of impairment have been identified over the last decades, the full pattern of deficits is still unclear. This uncertainty is particularly evident with respect to implicit memory.

Theories of memory establish that the long-term memory system is divided into explicit and implicit memory (Graf and Schacter, 1985; Squire, 2004). Explicit memory requires an intentional retrieval of the encoded information of prior events, whereas implicit memory does not require this conscious access to encoded information. Explicit memory is usually assessed using recall and recognition tasks and is well known to be impaired in schizophrenic patients (Aleman et al., 1999; Mckenna et al., 2002; Schaefer et al., 2013). Research on procedural and implicit memory is not very extensive. Procedural memory has been explored using prototypical tests of motor skill learning, such as the pursuit rotor, and results show that it is unimpaired in schizophrenia (Clare et al., 1993; Kern et al., 2010). Implicit memory has been measured through the priming effect (greater accuracy or faster performance when items have been studied previously) (Gabrieli, 1998), using tasks such as word stem completion or lexical decision (see Toth, 2000 for a complete list of implicit tests of memory), and results have been more inconsistent.

The character of the priming effect has led to the classification of implicit tasks in different categories according to the nature of the target-dependent variable used in the task – accuracy or reaction time measures – and the nature of the processes involved in the tasks – conceptual or perceptual processes (see Toth, 2000 and Spataro et al., 2011 for more classification options and a detailed discussion of inconsistencies in the categorization of some tasks). Results obtained with perceptual tasks using reaction time measures (e.g. lexical decision) are mixed. The studies in question have focused on the semantic priming effect: the reduction in reaction time to the processing of a stimulus if a semantically related word is presented previous to its appearance, in comparison to when the word is not semantically related to the stimulus (Meyer and Schvaneveldt, 1971; Neely, 1991). Results have shown an absence of priming, normal priming or hyperpriming (Kiang et al., 2008; Pomarol-Clotet et al., 2008; Kreher et al., 2009; Niznikiewicz et al., 2010; Kiang et al., 2012; Pfeifel et al., 2012; Neil and Rossell, 2013).

Studies using perceptual tasks with accuracy measures (word fragment completion or word stem completion) have also explored

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priming, but in these tasks priming is defined as the improvement in task performance when the subject has previously and unconsciously processed the stimuli involved in the task (in contrast to not having previously processed the stimuli). Research regarding this is also contradictory, with some authors reporting impaired implicit memory (Randolf et al., 1993; Kern et al., 2010) and others reporting preserved implicit memory in schizophrenia (Bazin and Perruchet, 1996; Perry et al., 2000). In a review by our group of studies employing perceptual tasks (Soler et al., 2011) we observed that all used a word stem completion (WSC) task and that the discrepancies in their results could have been due to differences in the methodology used, the criteria used in stimuli selection, how "priming" was defined, and participant characteristics such as IQ. Consequently, we designed a study to overcome the methodological problems of previous studies, and the results showed there were no differences between schizophrenic patients and controls in implicit memory evaluated using a WFC task. However, we used a word fragment completion (WFC) task, because, according to Bruss and Mitchell (2009), it involves only perceptual mechanisms, and so the results obtained can be considered a measure of perceptual implicit memory.

The purpose of the present article is to extend the study of implicit memory functioning in schizophrenia by employing the commonly used task of WSC using standardized stimuli and defining priming according to Graf and Schacter (1985). In this way, we aim to avoid inconsistencies due to lexical and perceptual stimuli characteristics like frequency and familiarity, the number of possible solutions for a stem, or the baseline performance used to measure priming. To do this, we have: (1) designed a WSC task with stimuli selected from a normative database; (2) defined priming using an unambiguous definition; and (3) used three different criteria to assess priming.

In a WSC task participants initially process a group of words with no explicit learning instructions. Next, after a short distraction task, participants have to complete a list of stems (e.g. mon _ _ -"money"). Half of the stems in the list are built from the group of previously processed words and the other half are built from new ones. All the stems include the three first letters of the word. The difference between the proportion of completed stems from processed and new words is the priming or implicit memory measure. However, variations in this standard procedure are common in the previous literature, particularly in the way performance is calculated, and, as a consequence, in the priming scores obtained. Kern et al. (2010) reported priming scores of 10.7% for patients and 18.7% for controls, which contrasted considerably from those of Randolf et al. (1993), who reported a priming of 30% for patients and 53% for controls. However, neither study indicated the number of possible solutions for the stems, which is necessary information for calculating priming. Perry et al. (2000) used stems that could be completed with at least 10 different words and found no differences between patients and controls, reporting priming values of around 50%. Indeed, most previous studies do not indicate how priming scores were calculated (e.g. Bazin and Perruchet, 1996).

In summary, it should be underlined that previous studies have not specified what constituted a correct solution for the stem, which makes the comparison of their results and the measurement of priming difficult, thus hindering a definitive characterization of implicit memory in schizophrenia. When priming values are calculated the criterion used to define a hit is relevant, as the magnitude of the priming depends on it. Stems usually have more than one solution; indeed, they can be considered to be correctly completed according to any one of three criteria: 1) when it is completed with an expected word (usually that from which the stem was constructed); 2) when it is completed with any alternative that fits the stem; and 3), when an item-based baseline is used (following the suggestion of Shaw (1997)). Priming for a stimulus is determined by comparing the probability of completion when it has been previously processed vs. when it has not been previously processed. This difference reflects the effect of implicit memory or the advantage that a stimulus has due to its unconscious processing.

With the present study, we also set out to extend the data reported in our previous work (Soler et al., 2011), which we obtained using a word fragment completion task, by setting a word stem completion task. In this way, we have sought to improve the description of implicit memory functioning in schizophrenic patients in relation to healthy controls.

## 2. Method

### 2.1. Participants

The study included 19 outpatients diagnosed with schizophrenia and 19 healthy controls, all of them native Spanish speakers. All patients were recruited from the Center for Rehabilitation and Social Integration-General Barroso in Valencia, Spain, and met the DSM-IV criteria for schizophrenia according to the Structured Clinical Interview for DSM-IV Axis I Disorder (SCID-I) (First et al., 2001), which was carried out by a trained psychiatrist. All were clinically stable, with an IQ above 85, no organic cerebral disease, no substance abuse or dependence, and no formal thought disorder. Antipsychotic medication type and dose had been stable in the previous 3 months in all patients. Subjects underwent the reduced version of the WAIS-III (Fuentes et al., 2010) to assess intellectual functioning and the Brief Psychiatric Rating Scale (BPRS) (Ventura et al., 1993) to evaluate symptomatology. An experienced, specifically trained psychologist rated the subjects' performance.

Healthy control participants were recruited via advertisements in the community and were screened for exclusion criteria: history of psychotic or affective disorder; IQ below 85; substance abuse or dependence; and organic cerebral disease. Controls were matched with patients in age, gender and education. The demographic and clinical characteristics of all participants are summarized in Table 1. All participants gave their written informed consent prior to participation, after having the procedures explained to them. The study was in line with the Helsinki Declaration.

### 2.2. Experimental procedure

The stimuli were 56 word stems selected from the Soler et al. (2009) norms, with a frequency over 0 and a familiarity range from 2.06 to 6.60 (in a 7-point scale). This database of Spanish verbal stimuli includes information relative to the target words corresponding to the stems (e.g. familiarity, frequency, number of meanings, activation and valence). This initial list was randomly divided into two lists (A and B). Both lists were statistically equivalent in frequency (list A: 11.12 (7.83); list B: 11.14 (7.02)), in familiarity (list A: 4.50 (1.16); list B: 4.90 (1.19)), in number of meanings (list A: 4.50 (1.99); list B: 3.71 (2.27)), in valence (list A: 5.383 (1.42); list B: 4.95 (1.42)), in activation (list A: 4.71 (1.08); list B: 4.87 (1.08)), and word length (list A: 6.18 (0.77); list B: 5.96 (0.88)). The stems were the three first letters of the words.

The WSC task was administered individually in a quiet room. In the first phase of the task, 28 words in lowercase letters appeared one at a time in the center of a computer screen for 8 s. Participants were required to judge their knowledge on a scale of 1 (known) to 3 (unknown) using a rating sheet. Half of the participants received list A as a rated list (studied word stems) and the other half received list B. Afterwards, participants performed a 5-minute filler task in which they were asked to write the names of European countries. After the filler task, in the second phase of the task, participants had to complete 56 word stems and 2 initial fillers. The word stems were presented one at a time in the center of a computer screen for 12 s. each, in lowercase letters, with the missing letters indicated by underscores (e.g. ani _ _ _ -"animal"). Participants were instructed to write on a sheet the

**Table 1**
Demographic and clinical characteristics of patients and healthy controls.

| | Schizophrenia ($n=19$) | Controls ($n=19$) | $t/\chi^2$ | $P$ |
|---|---|---|---|---|
| Age (years) | 42.26 (S.D.=6.64) | 44.37 (S.D.=6.93) | 0.96 | 0.345 |
| Years of education | 10.84 (S.D.=2.81) | 11.05 (S.D.=3.14) | 0.22 | 0.830 |
| IQ | 92.26 (S.D.=8.73) | 98.58 (S.D.=11.73) | 1.88 | 0.068 |
| Female/Male ratio | 7/12 | 7/12 | | |
| Illness onset (years) | 17.89 (S.D.=7.51) | | | |
| BPRS | 20.27 (S.D.=6.55) | | | |