

Short Communication

Positive symptoms and time perception in schizophrenia: A meta-analysis

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ABSTRACT

Positive symptoms of schizophrenia may be related to distortions in time perception. To examine this issue, we conducted a meta-analysis to determine whether positive symptoms are associated with deficits in time processing performance. MEDLINE and Web of Science were searched from January 1980 through March 2017, and all related articles and their references were scrutinized to find relevant studies. Studies were selected if they included participants with a diagnosis of schizophrenia, and reported data from behavioral measures of interval timing (e.g. duration discrimination and temporal order judgement). The results indicated that positive symptoms of schizophrenia are related with overestimation of interval timing (i.e., acceleration of the “internal clock”), and suggest that time perception may be associated with psychosis.

1. Introduction

There have been many attempts to identify cognitive/behavioral indicators linked to positive symptoms (delusions, hallucinations, and etc.) of schizophrenia (Bark et al., 2003; Bear et al., 2017; Graham-Schmidt et al., 2016; Giersch et al., 2016; Horga et al., 2014). Specifically, temporal information processes are essential to all aspects of behavior, such as walking, speaking and engaging in physical activity. Recently, disturbances of temporal information processes have been suggested to contribute to the generation of positive symptoms (Carroll et al., 2009; Gómez et al., 2014; Lošák et al., 2016; Stevenson et al., 2017; Ward et al., 2012). Therefore, attempts to integrate these behavioral manifestations deserve considerations.

The nature of time perception is different from that of the other sensory modalities, e.g. visual and auditory processing, in that it is not paired to specific receptors, e.g. eyes and ears. It is generally agreed that attention and arousal may be important in temporal information processes (Merchant et al., 2013). Specifically, the pacemaker-accumulator model has been proposed as one of the main internal timing models (Treisman, 1963). This model is based on a multi-process theory that assumes three levels of timing processes common to animals and humans (Fig. 1; modified from Hartcher-O'Brien et al., 2016). The first level consists of a pacemaker and accumulator. The pacemaker generates pulses that are gated via a switch controlled by attention. In this level, a lack of attention leads to a deficiency in pulses in the

accumulator. In the second level, the pulses reach the working memory module. The final level represents the decision mechanism. During this stage, the contents of the working memory module are compared to those of the reference memory of the pulse-duration on previous occasions, to which the subject responds accordingly (e.g., see Carroll et al., 2008; Hartcher-O'Brien et al., 2016).

There are also some indications that altered time perception may be present in schizophrenia. Traditionally, the pathophysiology of schizophrenia has been associated with abnormalities in dopamine (DA) transmissions (e.g., Seeman et al., 2006), which in turn, have been linked to the speed of the internal clock (Cheng et al., 2007). In fact, several studies have demonstrated DA receptor agonists accelerate the internal clock, while antagonists decelerate it (e.g., Frederick and Allen, 1996; Meck, 2006).

Indeed, behavioral studies have reported overestimation (e.g. participants estimate the interval longer than objective time) in temporal durations ranging from milliseconds to several minutes in patients with schizophrenia (Jonson and Petzel, 1971; Volz et al., 2001; Carroll et al., 2009). The overestimation of time has been suggested to be caused by accelerated time processing (Droit-Volet and Meck, 2007).

Acceleration of the internal clock may be linked to the hypervigilance state that has been implicated in positive symptoms of schizophrenia (Lošák et al., 2016; Peterburs et al., 2013). Specifically, Dodgson and Gordon (2009) proposed that hypervigilance enhances responding biases and produces errors in cognitive processing, leading

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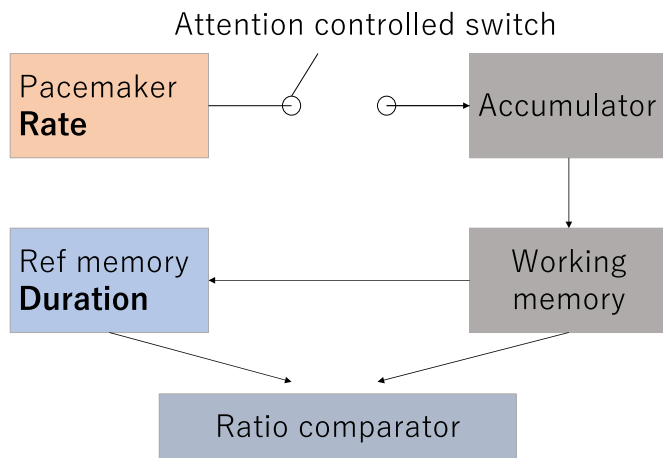


Fig. 1. The pacemaker accumulator model. Pulses are produced by the pacemaker and are gated via an attention-controlled switch. In this stage, the lack of attention leads to deficiency of pulses in the accumulator. The pulses reach working memory (or short term memory). The contents of working memory are compared with the reference memory (long term memory) which acquired pulse-duration in previous occasion and made decision how to respond.

Modified from [Hartcher-O'Brien et al., 2016](#) with permission from ELSEVIER LISENCE (License number: 4242350830031).

to the perception of a vague signal as a distinct one. Taken together, it is hypothesized that there is an association between positive symptoms and accelerated time perception, both linked to hypervigilance. Therefore, we conducted a meta-analysis to determine if severity of positive symptoms would be correlated with degree of acceleration of time perception in patients with schizophrenia.

2. Methods

2.1. Data sources

We conducted a literature review to search for articles that investigated timing abilities in schizophrenia. MEDLINE and Web of Science were searched through January 1980 to May 2017. We used two key words *schizophrenia* and *positive symptoms* in combination with any of the following terms: *time discrimination*, *interval timing*, and *time perception*. The reference list of identified studies was also hand-searched to obtain additional articles. Inclusion criteria were as follows: (1) published in English in a peer-reviewed journal; (2) included subjects with a primary diagnosis of schizophrenia on the basis of ICD (International Statistical Classification of Diseases and Related Health Problems) or DSM (Diagnostic and Statistical Manual of Mental Disorders) classification criteria; (3) reported behavioral measures of interval timing; and (4) conducted a correlation analysis between behavioral data and measures of positive symptom severity. Studies were excluded if correlational data concerning the timing ability of patients and positive symptom severity could not be extracted from the reported information.

The literature search yielded 100 < studies, 5 of which fulfilled the inclusion/exclusion criteria. Two articles reported on acceleration or deceleration in time perception ([Waters and Jablensky, 2009](#); [Peterburs et al., 2013](#)), while three reported on the ability to detect temporal precision of duration discrimination ([Carroll et al., 2008](#); [Carroll et al., 2009](#); [Stevenson et al., 2017](#)). Multiple publications from the same investigators were examined to exclude duplication of subjects ([Carroll et al., 2008](#)). Finally, four studies ([Carroll et al., 2009](#); [Peterburs et al., 2013](#); [Stevenson et al., 2017](#); [Waters and Jablensky, 2009](#)), containing a total of 101 individuals with schizophrenia, were included in the meta-analysis (See [Table 1](#)).

Table 1
Overview of studies on timing deficits in schizophrenia.

Study	Sample size	Symptom scale	Task	Modality	Duration of the task	Findings
Carroll et al. (2009)	28	PANSS	Temporal bisection task	Audio	3–6 s	Correlation between severity positive symptoms and temporal precision was slight almost negligible or low.
Peterburs et al. (2013)	22	PANSS	Anticipation movement task (AMT)	Visual	3000 or 18,000 ms	Severity positive symptoms were associated with over estimation/under production of movement object time.
Stevenson et al. (2017)	16	SAPS	Simultaneity judgement task	Audio/visual	0, ± 10, ± 20, ± 50, ± 80, and ± 100 to 300 ms in 50 ms	Temporal precision associates with severity of hallucinations.
Waters and Jablensky. (2009)	35	FRS	Duration discrimination task	Audio	1260–1440 ms	Subjects prone to overestimate were related to higher First Rank Symptoms scores.

Note. PANSS = The Positive and Negative Syndrome Scale. SAPS = The Scale for the Assessment of Positive Symptoms. FRS = First Rank Symptom scale.

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