



More haste less speed: A meta-analysis of thinking latencies during planning in people with psychosis

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ABSTRACT

Cognitive impairment is a core feature of psychosis, with slowed processing speed thought to be a prominent impairment in schizophrenia and first-episode psychosis. However, findings from the Stockings of Cambridge (SOC) planning task suggest changes in processing speed associated with the illness may include faster responses in early stages of planning, though findings are inconsistent. This review uses meta-analytic methods to assess thinking times in psychosis across the available literature. Studies were identified by searching PubMed, Web of Science and Google Scholar. Eligibility criteria: 1) included a sample of people with non-affective psychosis according to DSM III, DSM IV, DSM V or ICD-10 criteria; 2) employed the SOC task; 3) included a healthy control group; and 4) published in English. We identified 11 studies that employed the SOC task. Results show that people with psychosis have significantly faster initial thinking times than non-clinical participants, but significantly slower subsequent thinking times during problem execution. These findings indicate that differences in processing speed are not limited to slower responses in people with psychosis but may reflect a preference for step-by-step processing rather than planning before task execution. We suggest this style of responding is adopted to compensate for working memory impairment.

1. Introduction

People with psychosis show impaired cognitive performance at the time of the first episode of illness (Mesholam-Gately et al., 2009) and after multiple episodes (Dickinson et al., 2007). Compared to healthy controls, the level of impairment is substantial in almost all cognitive domains (Dickinson et al., 2007). This generalised pattern of impairments has been interpreted as reflecting a core impairment of schizophrenia (Dickinson and Harvey, 2009). One of these cognitive domains is processing speed, which can be defined as “the speed with which an individual can perform any cognitive operation” (Salthouse, 1996) and is usually measured as the number of correct responses achieved on a task within a given time. Evidence for slowed information processing has been consistently observed in those with a diagnosis of schizophrenia (Knowles et al., 2010; Nuechterlein, 1977) and non-affective first-episode psychosis (Mesholam-Gately et al., 2009; Mohamed et al., 1999). A prominent quantitative synthesis of the literature concluded that processing speed was the most impaired of all cognitive domains in schizophrenia (Dickinson et al., 2007). Impaired processing speed in

schizophrenia is suggested as one of the “crucial mechanisms of impaired cognitive functioning” (Brebion et al., 2009), and is associated with illness risk (Reichenberg et al., 2010), and clinical (Leeson et al., 2010) and functional outcomes (Brekke et al., 1997; Gold et al., 2002).

Speed of information processing is widely assessed using basic measures such as the Digit Symbol Substitution Test (DSST) and the Trail Making Test (TMT), both of which contribute to the speed of processing domain of the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) battery (Nuechterlein et al., 2008). Morrens et al. (2007) suggest that, whilst these tests are sensitive to psychomotor slowing, they are also sensitive to a wide range of higher level cognitive functions, such as working memory or cognitive flexibility, with deficits in subsets of these functions potentially causing poor performance in these tasks. Indeed, faster response times in people with psychosis have been reported in planning tasks, although other studies have failed to find this. These findings contradict the suggestion that processing speed is central to the cognitive difficulties in people with psychosis, with patients often responding more quickly than healthy controls.

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The aforementioned planning studies employed the computerised Stockings of Cambridge (SOC) planning task, a variation of the classic Tower of London problem (Shallice, 1982). In order to be successful, SOC requires participants to mentally plan their sequence of moves before beginning to complete them. Participants are provided with two different arrangements of 'balls' sitting in 'stockings' hanging from an imagined snooker or pool table; they are asked to plan and execute a series of moves on one arrangement to match the second displayed arrangement, according to a set of rules. This is known as the "plan and move" condition. Key to this task is that participants are asked to solve the problem in the minimum number of moves possible and not to begin until they know which moves to make. The problems vary in difficulty, reflecting the number of planned moves required to solve the problem accurately. The computerised nature of the task also allows a detailed assessment of performance latencies which provide a clue as to how individuals approach the task. For example, there are 'yolked' motor control problems whereby the computer controls for individual motor ability by presenting participants with their own solutions to problems and then asking them to follow the exact same sequence of moves on the lower half of the screen (follow condition); by subtracting these 'motor' times from the 'planning' times, the amount of time a participant spends purely thinking about the task can be derived (discounting that slower responding is solely due to individual differences in motor function). Further, thinking times can be differentiated into 'initial' times (reflecting the length of time participants spend considering the problem solution before attempting it) and 'subsequent' times (reflecting the amount of time thinking about each subsequent move as they execute the solution). Initial thinking times are the difference in time between the participant selecting the first ball in the "plan and move" condition and selecting the first ball in the "follow" condition. Subsequent thinking times are calculated by taking the time between selection of the first ball and the completion of the task, and dividing it by the total number of moves made. This task provides a rigorous means of measuring processing speed impairments in people with psychosis versus healthy controls. The findings in the literature have been inconsistent, so a quantitative synthesis of the literature is warranted to determine if there is evidence of a combination of faster and slower thinking times during planning.

1.1. Aims of the study

We carried out a systematic review and meta-analysis of the literature on the SOC task to 1) examine the overall impairment in planning accuracy and 2) establish if this is accompanied by group differences in initial and subsequent thinking times.

2. Method

2.1. Search strategy

Studies were identified by searching PubMed, Web of Science and Google Scholar using the following search terms: (Cambridge Neuropsychological Test Automated Battery OR Stockings of Cambridge OR Tower of London OR Tower of Hanoi OR CANTAB OR TOL OR TOH OR SOC) AND (Psychosis OR Schizophrenia). We included the search terms of other planning tasks – Tower of London and Tower of Hanoi – to establish if the SOC task had been employed in any of these studies or if there was the possibility of mislabelling of the SOC task. This search was conducted for studies published until March 2016 and included congress abstracts.

2.2. Eligibility criteria

Studies were included if they 1) included a sample of people with schizophrenia or non-affective psychosis according to DSM III or DSM IV American Psychiatric Association (2000), DSM V American

Psychiatric Association (2013) or ICD-10 (1992) criteria., 2) employed the CANTAB SOC task, 3) included a healthy (non-psychiatric) control group, and 4) were published in the English language. Two reviewers (VH and AW) independently screened and determined eligibility for included studies. Disagreements were resolved by discussion, with arbitration via third reviewer (EMJ) planned but not needed. To ensure the highest standard of reporting, we adopted "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) guidelines (Moher et al., 2009).

2.3. Data extraction and recorded variables

Two reviewers used standardised forms to independently extract data. We collected data on demographic variables reported in studies, including date of publication, sample size, age of participants and sex ratio. We also gathered data on the IQ of the psychosis and healthy control groups. Disagreements were dealt with as described above.

2.4. Risk of bias

The CANTAB is a standardised computerised assessment tool, designed to minimise assessor bias. A remaining area of potential bias was inadequate matching of the two participant groups on demographic variables. For this reason, coded individual study variables that would enable the matching of clinical and healthy control groups to be assessed.

2.5. Calculating of standardised effect sizes

The SOC task has four conditions of problem complexity ranging from two to five moves required for perfect problem execution. There was inconsistency in how the variables were reported, with some studies reporting all four complexity levels, some fewer than four and with others reporting only an average – or composite – across conditions. We report the number of perfect solutions, the initial, and the subsequent thinking times for the lower difficulty level (3 move), higher difficulty level (5 move) and composite (2–5 move) conditions. These were the most commonly reported variables in the studies that were reviewed. Based on the data reported in the selected studies we estimated standardised effect size (SMD) as Hedges' g (Hedges, 1981): the difference between the test performance (accuracy or response time) divided by the pooled standard deviation. The estimate for one study (Braw et al., 2008) revealed an SMD that was extremely large. We were unable to confirm with the authors if this was an error, so we used a 'leave one out' analysis (see below) that tests for undue influence of individual studies. A small number of effect sizes were obtained from statistics reported in studies following methods described by Thalheimer and Cook (2002). Better performance and longer thinking times are indicated by positive effect sizes.

2.6. Meta analytical procedure

We conducted 9 individual meta-analyses on the difference between people with psychosis and healthy controls on the following variables: number of perfect solutions, initial thinking time and subsequent thinking time. Random effects models were estimated using the metafor package (Viechtbauer, 2010) in R version 3.1.0 (R-Core-Team, 2014) (<http://www.R-project.org/>). Heterogeneity of effects was estimated with the Q statistic (Hedges and Olkin, 1985) and I^2 (Higgins et al., 2003). We used guidance by Deeks, Higgins, and Altman (Deeks et al., 2011) to determine the presence of substantial heterogeneity. Finally, we used funnel plots and trim-and-fill analyses to assess publication bias (Duval and Tweedie, 2000).

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