Schizophrenia Research 210 (2019) 291–293

Contents lists available at ScienceDirect

Schizophrenia Research

journal homepage: www.elsevier.com/locate/schres

Letter to the editor

I do not know whether you did that: Abnormal implicit attribution of social causality in patients with schizophrenia

Dear Editor,

Patients with schizophrenia often experience failures in social interactions that have tremendous consequences on their well-being (Hooley, 2010). This, in turn, might be related to difficulties in attributing the cause of the events to the agents who caused them. This attribution of causality to others requires multiple socio-cognitive processes, such as the ability to discern one's own actions from others' actions (i.e., self-other distinction), as well as the ability of reading others' intentions (van der Weiden et al., 2015). Crucially, such abilities appear to be impaired in these patients (e.g., Daprati et al., 1997; Garbarini et al., 2016).

Here, we capitalized on the Temporal Binding (TB) effect as an implicit measure of causality attribution. This effect refers to the experimental observation that the time interval between an intentional action (self- or other-generated) and its consequence is perceived as compressed, due to a delayed perception of the action and an anticipated perception of its consequence (Moore and Obhi, 2012). Contrariwise, temporal judgements for non-human (machine-generated) actions elicit an "inverse binding", whereby the action is perceived as anticipated and the consequence is perceived as delayed (Limerick et al., 2014). Here, we adapted the TB procedure to get a comprehensive assessment of how patients with schizophrenia implicitly attribute causality to themselves, others, and machines.

Twenty right-handed patients with schizophrenia (9 females; age range = 20–63 years) and twenty right-handed healthy volunteers with no reported history of neurological/psychiatric disease (9 females; age range = 23–57 years) participated in this study (see Supplementary Materials for further details). We used a modified Libet's clock paradigm (Libet et al., 1983) for measuring perceived timing of events. In each trial, participants observed a clock face with a rotating hand on the computer screen. The experiment consisted of six experimental conditions (40 trials each). In four event-judgement conditions, participants were asked to judge the timing of an event (i.e., a tone) that was caused by themselves (i.e., their own button press; *Action-Tone* condition; Fig. 1A), a co-experimenter (*Observation* condition; Fig. 1B), a mechanic lever (*Machine* condition; Fig. 1C), or that appeared without a prior cause (*Tone* baseline; Fig. 1D). In the two remaining action-judgement conditions, participants judged the timing of their button press, which was either followed by a tone (*Action-Move* condition) or did not have a sensory consequence (*Move* baseline).

We calculated a TB index in the *Action-Tone*, *Observation* and *Machine* conditions by subtracting the temporal judgement errors (i.e., the difference between the actual timing and the subjectively reported timing of the tone) in the *Tone* baseline condition from the temporal judgement errors in each experimental condition. The TB index was similarly calculated for the *Action-Move* condition using the *Move* condition as baseline. Negative values of the TB index indicate anticipated temporal perception of the event/action, whereas positive values indicate delayed temporal perception. In patients, we also estimated correlations between the TB index in each condition and positive and negative symptoms of schizophrenia (global SAPS and SANS scores). See details in Supplementary Materials.

Within-group comparisons (Wilcoxon signed-rank) for the event-judgement conditions revealed that controls perceived the tone as happening earlier in the *Action-Tone* (median = −32.62; IQR = 89.31) compared to the *Machine* condition (median = 42.97; IQR = 32.76): $n = 20$, $Z = 3.77$, $p < .001$, $r = -0.60$. A similar pattern was present for the *Observation* (median = −3.25; IQR = 94.76) compared to the *Machine* condition: $n = 20$, $Z = 3.47$, $p < .001$, $r = -0.55$, while *Action-Tone* and *Observation* conditions did not differ significantly ($n = 20$, $Z = 2.31$, $p = .02$; N.S. after Bonferroni correction; alpha level: $p = .017$). Patients perceived the tone significantly earlier in the *Action-Tone* condition (median = −14.59; IQR = 149.62) relative to the *Observation* (median = 49.48; IQR = 45.91; $n = 20$, $Z = 2.43$, $p = .015$, $r = -0.38$) and *Machine* (median = 45.14; IQR = 45.74; $n = 20$, $Z = 2.73$, $p = .006$, $r = -0.43$) conditions. No significant difference was observed between *Observation* and *Machine* conditions ($n = 20$, $Z = 0.75$, $p = .46$). Crucially, between-group comparisons (Mann-Whitney U) showed a significant difference for the *Observation* condition, whereby controls perceived the tones as happening earlier compared to patients: $n = 20$, $Z = 2.42$, $p = .015$, $r = -0.39$ (Fig. 1E). The between-group comparison for the other event-judgement conditions (*Action-Tone*: $n = 20$, $Z = 0.42$, $p = .68$; *Machine*: $n = 20$, $Z = 0.37$, $p = .71$) and the action judgements ($n = 20$, $Z = -0.78$, $p = .43$) did not yield significant differences. Finally, the correlation analysis showed a positive correlation between the TB index in the *Observation* condition and positive symptoms (SAPS global): $\rho = 0.58$, $n = 20$, $p = .008$ (other conditions: $0.12 < p < .90$; Fig. 1F).

In summary, controls perceived self- and other-generated events as anticipated and machine-generated events as delayed. On the contrary, patients perceived only self-generated events as anticipated, and both other- and machine-generated events as delayed. In patients, increased severity of positive symptoms was correlated to decreased implicit attribution of causality during other-generated actions. Together, our data indicate that patients showed an abnormal pattern in the attribution of causality to others and that the magnitude of this impairment was associated with the severity of their illness.

This novel finding is consistent with previous research suggesting that mechanisms of *motor resonance* (i.e., the spontaneous generation of a motor representation that reflects observed actions) is impaired in these patients (Mehta et al., 2014). As TB for others' actions is hypothesized to rely on this resonance, such a deficit might explain the impaired attribution of social causality observed in the present data. Intriguingly, our data also indicate that patients with schizophrenia might have intact abilities in recognizing physical causes, as both

https://doi.org/10.1016/j.schres.2018.12.030

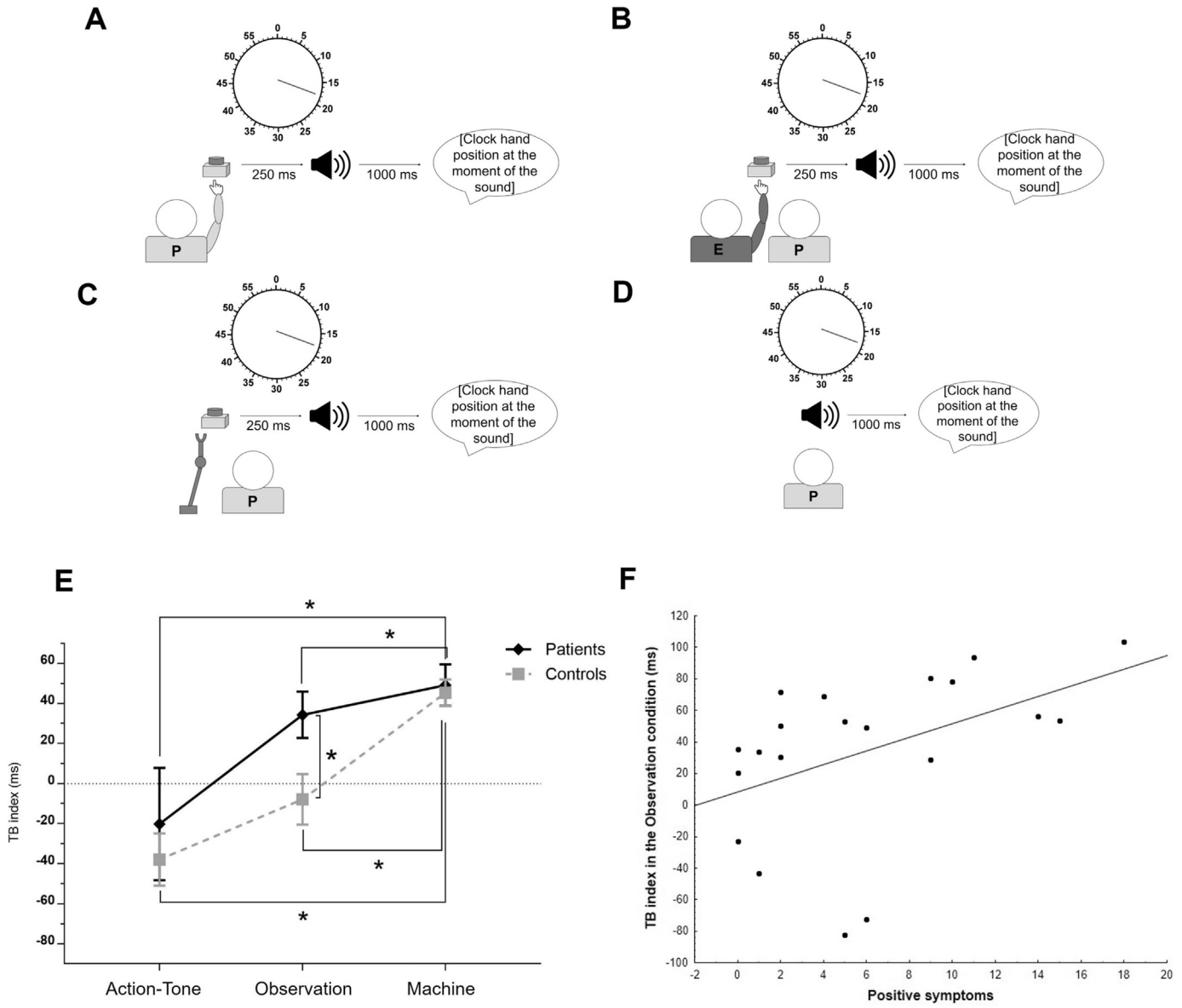

Fig. 1. Experiment setup and results. Panels A–D show experiment setup and procedure: A – *Action-Tone* condition (participant (P) observes the rotating clock hand and presses the button, the button press is followed by a tone, the participant (P) is asked to report the timing of the tone); B – *Observation* condition (participant observes the rotating clock hand; the co-experimenter (E) presses the button, the button press is followed by a tone, the participant is asked to report the timing of the tone); C – *Machine* condition (participant observes the rotating clock hand; a mechanic lever presses the button, the button press is followed by a tone, the participant is asked to report the timing of the tone); D – *Tone* condition (participant observes the rotating clock hand; the tone is presented without any button press, the participant is asked to report the timing of the tone); Panel E shows temporal judgement errors standardized for the baseline (*Tone*) in the group of patients and the control group; ms. TB = Temporal binding. Error bars represent standard error of means; * = significant differences; Panel F shows the correlation between the TB index in *Observation* condition (ms) and positive symptoms of schizophrenia (SAPS). The data are available in the Supplementary Material.

controls and patients showed a delayed perception of machine-generated events. This "inverse binding" might reflect a mechanism to discriminate human-generated events from other events in the environment (Capozzi et al., 2016) and our data extend this functional role to patients with schizophrenia. Finally, whereas some research has suggested that schizophrenia might be associated with an excessive TB for self-generated actions (Voss et al., 2010), our results instead support the notion that altered attribution of self-causality might be contextually modulated (van der Weiden et al., 2015).

In conclusion, we report an intriguing finding showing that patients with schizophrenia have a specific impairment in recognizing other human beings as causes of external events. Future studies are needed to validate and further qualify this preliminary finding that may have important clinical and theoretical implications.

Conflict of interest

The authors declare no conflicts of interest.

Contributors

MP, FC, LP and FG designed the study and wrote the protocol. MP performed the data collection and analysis. MS, SC and PR performed patient recruitment and psychiatric evaluation. MP, FC and FG wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Acknowledgements

The authors are grateful to the patients and healthy volunteers involved in the study. The authors would also like to thank Eleonora Bilardo (University of Turin) for assisting with the data collection.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.schres.2018.12.030.

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18 October 2018

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