Pathological Imitative Behavior and Response Preparation in Schizophrenia

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Editorial Decision 27 March 2017; Accepted 5 April 2017

Abstract

Introduction: Pathological imitative behavior (echopraxia) is occasionally observed in schizophrenia patients. However, only a severe form of echopraxia can be detected with the help of a direct observation. Therefore, our goal was to study a latent form of pathological imitative behavior in this disorder, which is indicated by an increase of imitative tendencies.

Method: In our study, 14 schizophrenia patients and 15 healthy subjects were employed in two tasks: (a) in an imitative task they had to copy a hand action seen on a screen; (b) in a counter-imitative task they had to make a different movement (which involves an inhibition of prepotent imitative tendency that is impaired in case of pathological imitative behavior). Imitative tendencies were assessed by an interference score – a difference between counter-imitative and imitative response parameters. We also studied a response preparation in both groups by employing precueing probabilistic information.

Results: Our results revealed that schizophrenia patients were able to employ probabilistic information to prepare properly not only the imitative, but also the counter-imitative responses, the same as the healthy subjects did. Nevertheless, we detected increased prepotent imitative tendencies in schizophrenia patients, what indicates the latent pathological imitative behavior in case of this disorder.

Conclusions: The obtained results suggest that in the case of schizophrenia problems with pathological imitative behavior more likely occurred in executive rather than in the preparatory stage of response. Our findings can help to detect a latent echopraxia in schizophrenia patients that cannot be revealed by direct observation.

Keywords: Schizophrenia; Imitative behavior; Echopraxia; Response preparation; Stimulus probability; Intra-individual reaction time variability

Introduction

Imitative behavior defines copying of actions performed by another person. This type of behavior is considered to be related to the mirror neuron system and it plays an important role in our social life. For instance, it helps us to understand the intentions and actions of other people as well as to develop different motor skills (Calvo-Merino, Glaser, Grezes, Passingham, & Haggard, 2005; De Lange, Spronk, Willems, Toni, & Bekkering, 2008; Fogassi et al., 2005; Heyes, 2011).

During the observation of another person’s action the activation of the mirror neuron system induces a prepotent imitative tendency to copy it. However, normally this tendency is inhibited if the imitation is not necessary. Nevertheless, in some cases such inhibition is disturbed, resulting in an uncontrolled mimicking of others’ actions that causes many difficulties in the social life. Such pathologic imitative behavior (also known as echopraxia) is occasionally observed in schizophrenia patients (Carluccio, Sours, & Kolb, 1964; Chapman & McGhie, 1964; Ferrara, Freda, Massa, & Carratelli, 2006; Stengel, 1947; Yusin, Nihira, & Mortashed, 1974). However, only a severe form of echopraxia can be detected with the help of a direct observation. Hence, capturing a latent pathological imitative behavior requires a special method, which would enable to assess the augment of the imitative tendency. Such method, known as an interference paradigm, has been proposed by Luria (1966),

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doi:10.1093/arclin/acx034 Advance Access publication on 20 April 2017
who applied it to study the imitative tendencies in frontal lobe patients. This method assesses the imitative tendency by finding the difference between imitative and, so called, counter-imitative responses. The imitative response is simply a repetition of an action shown by an examiner. The counter-imitative response is an execution of an action that is incompatible with the movement performed by the examiner, for instance, in Luria (1966) study when an examiner showed an index finger the patient had to show his fist, and vice versa. It is worth to note, that counter-imitative responses also play an important role in everyday social life (Newman-Norlund, van Schie, van Zuijlen, & Bekkering, 2007).

When counter-imitative responses are to be executed, the prepotent imitative tendency should be inhibited as it interferes with the response. That is why the reaction speed and response accuracy is lower during execution of counter-imitative responses than the imitative ones. This difference is called the interference score and it indicates the strength of imitative tendencies. It was shown that the interference score is larger in frontal lobe patients compared to healthy controls, and that indicates the stronger imitative tendency (a sign of latent echopraxia) in case of frontal lobe lesion subjects (Brass, Derrfuss, Matthes-von Cramon, & von Cramon, 2003). However, according to our knowledge, there were no reported studies of imitative tendencies in people with schizophrenia. Therefore, one of the main purposes of our study is to assess it with the help of interference score.

It is important to note that any types of responses are performed more efficiently if they are prepared in advance (Leuthold, Sommer, & Ulrich, 2004). Therefore, another purpose of this research was to study both imitative and counter-imitative response preparation. The precueing paradigm is usually employed in order to study response preparation (e.g. Carnahan, Chua, Elliott, Velamoor, & Carnahan, 1994; Leonard, 1953; Leuthold et al., 2004; Leuthold, Sommer, & Ulrich, 1996; Rosenbaum, 1980). This paradigm relies on two types of stimuli: precue and imperative. Precue provides advance information about subsequent imperative stimulus, and the former requires a certain response. It is documented that reaction time decreases with the increasing amount of information provided by the precue. This particular reduction of response time is related to the response preparation processes occurring in the foreperiod (the time interval between the precue and imperative stimulus) (for review, see Leuthold et al., 2004). Precue can provide many different types of precedent information about imperative stimulus. For instance, it may define its location or time of occurrence (Carnahan et al., 1994; Leuthold et al., 1996).

However, in our study we used another set of precueing information – the probability of upcoming imperative stimulus. In everyday life, prediction of situation is not always exact. Rather, our brain makes predictions of different future events and prepare responses with different probabilities. Therefore, using information about upcoming stimulus probability in precueing paradigm has an advantage of making experiment closer to real life conditions (Bruhn, 2013; Feigenberg, 2008; Hawkins & Blakeslee, 2004; Volz, Schubotz, & von Cramon, 2003). It has been found that response to the more probable imperative stimulus is faster than to the less probable one (e.g. Blackman, 1972; Heuer, 1982; LaBerge, Legrand, & Hobbie, 1969; Miller, 1998). For instance, in Miller’s (1998) study the precue signaled that the probability of one imperative stimulus was 75% and the other – 25%. The results showed that participants reacted faster to the more probable imperative stimulus. Hence, subjects were more prepared to respond to the high-probability stimulus. This was also confirmed with Lateralized Readiness Potential (LRP) – a special electroencephalographic parameter, which serves as an index for movement preparation (Miller, 1998).

Coming back to the imitative behavior topic it is important to note that while expecting to see a certain movement of another person, the subject automatically prepares the same movement (Boyer, Longo, & Bertenthal, 2012). However, if the subject’s aim is to respond with a different movement, he has to suppress automatic preparation of the imitative response and prepare a counter-imitative one (Cross & Iacoboni, 2014). In our study, we hypothesized, that schizophrenia patient could have problems with suppression of automatic imitative response preparation. In such case, it would cause an impaired preparation of counter-imitative response, what could result in increased imitative tendencies.

**Materials and Methods**

**Participants**

Fourteen right handed schizophrenia inpatients (5 males and 9 females) were recruited from the Republican Vilnius Psychiatric Hospital. Diagnosis of schizophrenia was made by clinicians according to the International Classification of Diseases criteria (ICD–10; World Health Association, 1992). The mean age of patients was 37.1 years (SD = 13.9, range 19–63 years). Exclusion criteria for patient group were organic pathology of central nervous system, history of head trauma and substance dependence. At the time of the study, all patients were on neuroleptic medication. All of them received atypical antipsychotic drugs (such as olanzapine, clozapine, quetiapine, or aripiprazole). Six of them were additionally treated with typical antipsychotic drug haloperidol.
The control group comprised fifteen healthy volunteers (6 males and 9 females), mean age 39.9 years (SD = 13.5, range 22–57 years). Exclusion criteria for control subjects were the same as for patient group. Additionally, control subjects had to have no diagnosed psychiatric disorders. No difference in age between the groups was detected by the one-way ANOVA \[F (1, 27) = 0.3, p = .6\]. All individuals were right handed and had normal or corrected-to-normal vision. This study was approved by the local Medical Ethic Committee. An informed consent was obtained from the participants after the procedures had been fully explained.

**Procedure**

Our method was based on Miller’s (1998) study and was modified according to the interference principles. The experiment consisted of two tasks: counter-imitative and imitative one. The stimuli were the same in both tasks. There were two different movements shown on the screen employing the consequence of pictures. Such stimulation was widely used by many investigators who explored the imitative behavior (e.g. Bertenthal, Longo, & Kosobud, 2006; Brass et al., 2003; Brass, Ruby, & Spengler, 2009; Brass, Zysset, & von Cramon, 2001; van Leeuwen, van Baaren, Martin, Dijksterhuis, & Bekkering, 2009). Experimental tasks were developed and performed using E-Prime 2.0 software (Psychology Software Tools, Inc.).

Both counter-imitative and imitative tasks had the same basic design (Fig. 1). Before each task, participants were instructed to place their index finger on the left button and middle finger on the right button of response device. At the beginning of each trial, a precue appeared in the center of the computer screen. It was a picture of left hand in a ready-to-proceed position (mirroring the participant’s right hand). After a period of 1000 ms one of two possible imperative stimuli followed the precue, creating an illusion of moving finger. Imperative stimuli were two images: one picture of a hand pressing left button with an index finger and another image of the same hand pressing the right button with a middle finger.

The probability of imperative stimulus showing movement of the index finger was 75%, middle finger – 25%. Participants were not informed about the probabilities of stimuli. Subjects were instructed to respond as fast and as correct as possible with a time limit of 2000 ms. Each response was followed by a short feedback message that appeared in the center of the screen for 2000 ms, informing about response correctness. Both tasks consisted of six series of 32 trials occurring in a random order.

In order to minimize fatigue, participants started experiment with the more difficult counter-imitative task. In this task participants had to respond to imperative stimuli in an incongruent manner: they had to press the button with the middle finger to the shown movement of index finger, and vice versa. In the consequent imitative task, participants had to press the button with congruent finger copying the movement shown by imperative stimulus. Subjects were allowed a short (around 5 min) resting time between the tasks. Therefore, participants learned to respond more often with the middle finger during the first counter-imitative task. However, this learning did not affect the results of the consequent imitative task, because they had to retrain to respond more often with the middle finger in order to perform it efficiently.

**Fig. 1.** Experiment design. Both imitative and counter-imitative tasks started with the precue stimulus – hand in a ready-to-proceed position exposed for 1000 ms during response preparation period. Afterwards, one of two possible imperative stimuli appeared creating an image of moving down finger and pressing the button. Imperative stimulus of index finger movement appeared with 75% probability, while the movement of middle finger was shown with probability of 25%. The sort of response depended on experiment task. In imitative task participants had to repeat the movement shown by imperative stimulus. In counter-imitative task, the opposite movement had to be performed.
Data Analysis

Every first series of each task were considered as a practice and were not counted in the final analysis. We have eliminated all trials containing wrong key responses. Following Triviño, Correa, Arnedo, and Lupiáñez (2010), all remaining trials, which had reaction times 2.5 \(SD\) slower or faster than the mean for each participant in each task were considered to be outliers and were eliminated out of the result analysis. There were eliminated 2.69% of trials in schizophrenia patients and 1.96% of trials in the control group. All remained trials were considered as accurate and were employed in further analysis.

For the statistical analysis we used the one-way ANOVA to compare the data between the subjects of different group. For the comparison of the data within the same group, the one-way repeated measures ANOVA analysis has been employed in our study.

Results

The imitative tendencies were assessed by the comparing the interference score between clinical and control groups (Brass et al., 2003). Interference score was counted by subtraction of imitative response parameters from the parameters of counter-imitative response. We counted interference scores of all total trials responses separately for schizophrenia and control group subjects (Table 1). In the counting of interference score we employed data form three parameters: response accuracy, reaction time and intra-individual reaction time variability (IIV). IIV is the standard deviation of an individual’s reaction time and it reflects the stability of response performance, providing useful predictive information about cognitive functioning (MacDonald, Nyberg, & Bäckman, 2006; Roalf et al., 2013; Shin et al., 2013).

It was found that schizophrenia patients had significantly greater interference score in response accuracy, reaction time and intra-individual reaction time variability. Therefore, all three parameters revealed that the differences between counter-imitative and imitative responses were reliably larger in the schizophrenia group than in healthy subjects.

To investigate the ability to prepare imitative and counter-imitative responses using the probabilistic precueing information we compared reaction times separately to the high- and low-probability stimuli (Table 2). The presence of statistically significant difference between response times to the high- and low-probability stimuli was an indicator of the ability to make appropriate response preparation in controls and schizophrenia patients.

Our results showed that schizophrenia patients were responding faster to the high probability stimulus than to the low-probability one in imitative and, in particular, in counter-imitative task. Analogous results were detected in control group subjects for the imitative and counter-imitative responses. The probability \(×\) group interaction suggested that schizophrenia patients were able to prepare both imitative \([F (1, 27) = 0.72, \ p = .79]\) and counter-imitative response \([F (1, 27) = 0.38, \ p = .54]\) at the same level, as the healthy subjects did.

Additionally, we analyzed the response execution in both groups. In order to achieve this purpose, we compared reaction time results of each group subjects in both tasks. In healthy subjects, imitative responses were faster than the counter-imitative

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<th>Table 1. Comparison of interference scores between the groups</th>
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<tr>
<td>Interference score:</td>
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<td>Response accuracy (SD), %</td>
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<td>Reaction time (SD), ms</td>
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<td>Intra-individual reaction time variability (SD), ms</td>
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Interference score is a difference between counter-imitative and imitative responses, counted with the three different parameters: response accuracy, reaction time and intra-individual reaction time variability.

<table>
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<th>Table 2. Comparison of reaction time to high- and low-probability stimuli in imitative and counter-imitative tasks</th>
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<td>Response:</td>
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<tr>
<td>Schizophrenia</td>
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\(p < .001\)
in both cases: when responded to the high-probability stimulus \[ F(1, 14) = 54.5, p < .001 \] and when responses were performed to the low-probability one \[ F(1, 14) = 69.39, p < .001 \]. The results of schizophrenia patients showed the analogical regularity. Their imitative responses were also faster than counter-imitative ones either responding to more probable stimulus \[ F(1, 13) = 19.09, p = .001 \], or to less probable one \[ F(1, 13) = 32.12, p < .001 \].

We have also carried out the comparison of reaction times between the subjects. It was found that when reacting to the high-probability stimulus people with schizophrenia were slower than healthy subjects in imitative \[ F(1, 27) = 9.09, p < .01 \] and counter-imitative responses \[ F(1, 27) = 13.12, p < .001 \]. In the case of responding to the low-probability stimulus schizophrenia patients were also slower in both imitative \[ F(1, 27) = 7.21, p = .01 \] and counter-imitative responses \[ F(1, 27) = 12.89, p = .001 \].

Discussion

One of the major purposes of this study was to explore imitation tendencies in schizophrenia patients. It has been found previously that prepotent tendencies to imitate are based on a mechanism matching the observed action onto an internal motor representation of that action (Iacoboni et al., 1999). Such imitative tendencies are normally inhibited when they are inappropriate. Both functional magnetic resonance imaging (fMRI) and cortex lesion studies showed that such inhibitory mechanisms originate at the prefrontal cortex (Brass et al., 2001, 2003). This brain area is found to be impaired in schizophrenia and it is considered to be the cause of pathological imitative behavior (Pridmore, Brüne, Ahmadi, & Dale, 2008; Quintana, Davidson, Kovalik, Marder, & Mazziotta, 2001). However, all previous reports on the pathological imitative behavior (echopraxia) in schizophrenia were based only on direct behavior observation, which enables to detect only overt form of this irregularity (Carluccio et al., 1964; Chapman & McGhie, 1964; Ferrara et al., 2006; Stengel, 1947). Therefore, our research was the first to study the pathological imitative behavior in schizophrenia patients with the help of the interference paradigm. We counted interference score in our study with three different parameters such as reaction time, response accuracy and intra-individual reaction time variability. All three parameters showed a higher interference score in clinical group compared with healthy subjects, what indicates the increase of imitative tendencies in schizophrenia patients. This finding suggests that the method can help to detect pathological imitative behavior in a latent (not directly observable) form in the case of schizophrenia disorder.

Previously Brass and colleagues (2003) also detected increased imitative tendencies; however, not in case schizophrenia, like in our study, but in the patients with frontal lobe damage. In their study researchers applied the interference score, counted with the response accuracy parameter. Kappenman and colleagues (2012) used the same (although differently formulated) method for detecting an increase of spatial prepotent tendencies with the help of reaction time and response accuracy parameters in schizophrenia patients. Their study showed that people with schizophrenia had increased tendencies to respond according to the direction of the stimulus. Their study showed that people with schizophrenia had increased tendencies to respond to the direction of the stimulus. For instance, patients tended to respond by pressing the left button to the stimulus arrow pointing to the left, despite them being instructed to press the right button in that case (Kappenman et al., 2012).

Therefore, our finding of increased imitative tendencies in schizophrenia matches the results of other researchers who detected difficulties resolving competition between prepotent and appropriate responses. Other instances of such impairments in schizophrenia patients were: difficulties suppressing reflexive eye saccades when needed to provide antisaccadic movements (Gooding & Basso, 2008) and problems in performing the Stroop test (Henik & Salo, 2004). However, it is important to note that inhibition of different prepotent tendencies seems to originate in different parts of the frontal lobe. For instance, Brass and colleagues (2003) found that most of subjects with the frontal lobe lesions demonstrated increased imitative or prepotent reading tendencies in Stroop test, but not both. Therefore, previously found problems of inhibitory function performing the Stroop test in case of schizophrenia do not necessarily mean that these patients should automatically have problems with inhibition of imitative tendencies. That is why our study brought new unique information on the inhibitory function impairment in schizophrenia disorder.

However, the intra-individual reaction time variability has never been used for counting the interference score before. According to MacDonald and colleagues (2006) measurements of response stability have been largely overshadowed in neuropsychological studies. These authors argue that this is a serious theoretical and a practical oversight because response stability indicates unique predictive information about cognitive functioning (MacDonald et al., 2006). However, during the last decades the assessing of response stability has been widely used in different disorders of the nervous system. For instance, response stability reductions were found in case of frontal lobe lesions (Picton et al., 2007; Stuss, Murphy, Binns, & Alexander, 2003), schizophrenia (Cole, Weinberger, & Dickinson, 2011; Kaiser et al., 2008; Roalb et al., 2013; Shin et al., 2013; Winterer et al., 2004), dementia (Hultsch, MacDonald, & Dixon, 2002; Tales et al., 2012), attention deficit...
hyperactivity disorder (ADHD) (Henríquez-Henríquez et al., 2014; Rubia, Smith, Brammer, & Taylor, 2007; van Belle et al., 2015; Westerberg, Hirvikoski, Forssberg, & Klingberg, 2004) and Parkinson’s disease (Camicioli, Wieler, de Frias, & Martin, 2008). It has been found that in case of some cognitive tasks response stability parameter showed better discriminative abilities than classical behavioral measurements between the nervous system disorder patients and healthy subjects (Collins & Long, 1996; Hultsch, MacDonald, Hunter, Levy-Bencheton, & Strauss, 2000; Klein, Wendling, Huetter, Ruder, & Peper, 2006). Moreover, in some cases, patients differed from healthy subjects only in response stability but not in classical behavioral test results (Picton et al. 2007; Rentrop et al. 2010; Shin et al. 2013). This evidence shows an important advantage of intra-individual reaction time variability because it might detect more subtle cognitive impairments than standard measures of task performance and it might be helpful in differentiating between patients and controls (Kaiser et al. 2008). Therefore, in general, our data coincides with previous findings of response stability, demonstrating that pathological imitative tendencies could be detected in schizophrenia patients not only with response accuracy and reaction time, but also with intra-individual reaction time variability.

Another purpose of our study was exploring if schizophrenia patients are able to use precue information about stimuli probability in order to prepare imitative and counter-imitative responses. Previous results demonstrated that people with schizophrenia are able to use different types of precue information (for instance, information about hand of response, distance to target button and spatial position of a stimulus) to prepare response in case of neutral imperative stimuli (Carnahan et al., 1994; Fuller & Jahanshahi, 1999). The stimuli considered to be neutral if they do not share the common features with the responses. For instance, neutral stimulus can be geometric figure in the case of the response requiring to press the right or left button (Kappenman et al., 2012). It was also found that schizophrenia patients are able to employ probabilistic information about neutral imperative stimuli and react faster to high-probability neutral stimulus than to the low-probability one (Elvevåg, Weinberger, Suter, & Goldberg, 2000; Luck et al., 2009).

Note that in the tasks which employ the probabilistic information about neutral stimuli, participants have to learn not only stimulus probability but also stimulus-response mapping. Nevertheless, in the probabilistic information tasks, which use imitative responses, subjects do not have to learn stimulus-response mapping because we already have a prepotent mapping in our brain providing to repetition of observed imitative stimulus (Boyer et al., 2012). Therefore, preparation of imitative responses should be easier processed than the preparation of neutral responses and should not be impaired in schizophrenia patients. Our reaction time results confirmed this hypothesis and showed that both the control and clinical subjects were able to use probabilistic information to make the appropriate imitative response preparation.

In the probabilistic tasks of counter-imitative response preparation, participants had to learn not only the stimulus probability, but also to reprogram their natural stimulus-response mapping of copying actions. In order to prepare counter-imitative response the subjects have to inhibit preparation of imitative one. Previous findings of inhibitory deficit in schizophrenia let us hypothesize that preparation of counter-imitative response could be impaired in schizophrenia patients. Unexpectedly, our results showed that according to significant difference of reaction times to high- and low-probability stimuli people with schizophrenia were able to use probabilistic information to prepare appropriate counter-imitative response, same as the control subjects did.

Conclusions

Summarizing main results of our study, we have detected that schizophrenia patients expose increase of imitative tendencies, what indicates the latent pathological imitative behavior in case of this disorder. Such tendencies were detected not only with the help of standard response parameters (reaction time, response accuracy), but also employing a new one – intra-individual reaction time variability. However, we have also found that schizophrenia patients are able to use precueing probabilistic information to prepare appropriately not only the imitative, but also the counter-imitative response. Therefore, problems with inhibition of prepotent imitative tendency more likely occurred in executive rather than in the preparatory stage of response performance in the case of schizophrenia disorder.

Acknowledgment

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

All authors declare that they have no conflict of interest.
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