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Theory of Mind in schizophrenia: focusing on the role of non-verbal communication and motor function

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ABSTRACT

Theory of Mind, known as the ability to infer mental states of others, is crucial to one's social functioning. Despite Theory of Mind impairment being a well-recognized feature of schizophrenia, precise underlying mechanisms are still unclear. An abundance of cognitive testing methods along with several neurophysiological techniques aiming to evaluate Theory of Mind have been developed, however, there is no universal agreement as to the most accurate way to detect cognitive impairment. Both verbal and non-verbal communication methods are crucial for Theory of Mind function, yet the non-verbal skills develop earlier during childhood and prevail throughout life, which makes them fundamental for social cognitive development. Most of the existing studies evaluate Theory of Mind as a whole entity using a single testing modality, and without differentiating between the components. Therefore, the aim of the current thesis was to establish the significance of the non-verbal aspect of Theory of Mind in schizophrenia using cognitive testing, as well as neurophysiological and autonomic parameters.

Study 1 evaluated both the verbal and the non-verbal testing methods to evaluate Theory of Mind impairment in schizophrenia. As predicted, all schizophrenia patients performed worse than the healthy controls, with the non-verbal test being the most sensitive to Theory of Mind impairment. Furthermore, the severity of psychopathological symptoms inversely correlated with the non-verbal test performance only.

Study 2 investigated the neurophysiological aspect of Theory of Mind in schizophrenia using the EEG mu rhythm analysis during a motor imagery task. EEG mu rhythm suppression has previously been shown to reflect the function of Theory of Mind via the mirror neuron system (Pineda & Hecht, 2009). In our experiment, schizophrenia subjects demonstrated decreased EEG mu rhythm suppression compared to healthy controls.

Study 3 analyzed the association of Theory of Mind test performance with both neurophysiological and autonomic parameters in first episode psychosis, chronic schizophrenia and the healthy subjects. Neither of the parameters differed substantially between the two patient groups. However, implementation of both neurophysiological and autonomic predictors led to a successful classification of subjects into the schizophrenia group and the healthy group.

Our findings indicate that non-verbal communication plays a crucial role in Theory of Mind in schizophrenia. Theory of Mind deficit is detectable throughout the course of disease using both non-verbal cognitive and neurophysiological testing methods, suggesting that Theory of Mind impairment is a trait of schizophrenia. Furthermore, as the brain motor cortex is responsible both for the voluntary movement and the mirror neuron system, schizophrenia-related motor disturbances might be related to the malfunctioning Theory of Mind. All of the above provides further insight into the underlying mechanisms of schizophrenia.

ZUSAMMENFASSUNG

Theory of Mind, auch bekannt als die Fähigkeit sich die mentalen Zustände eines anderen zu erschließen, ist ein entscheidender Teil sozialer Fähigkeiten. Obwohl eine Schädigung dieser Fähigkeit ein allgemein anerkanntes Merkmal der Schizophrenie ist, sind die genauen Mechanismen bislang unbekannt. Eine große Anzahl kognitiver Testmethoden zusammen mit mehreren neurophysiologischen Techniken sind entwickelt worden, um die Theory of Mind beurteilen zu können. Nichtsdestotrotz gibt es keine universell akzeptierte Einigung darüber, was die beste Möglichkeit ist, kognitive Defizite zu erkennen. Sowohl die verbale, als auch die nonverbale Kommunikation sind essentiell für die Theory of Mind. Nonverbale Fähigkeiten entwickeln sich jedoch früher in der Kindheit und spielen das ganze Leben lang eine vorherrschende Rolle. Damit sind sie fundamental für die Entwicklung der sozialen Kognition.

Die meisten existierenden Studien betrachten die Theory of Mind in ihrer Gesamtheit. Hierzu wird ein einzelner Test verwendet, zwischen den verschiedenen Elementen wird nicht differenziert.

Deshalb war das Ziel dieser Arbeit die Signifikanz des nonverbalen Aspekts der Theory of Mind zu etablieren. Hierfür wurden eine kognitive Testung sowie neurophysiologische und autokomische Parameter verwendet.

Die erste Studie verglich sowohl verbale als auch nonverbale Testmethoden um Beeinträchtigungen der Theory of Mind in Patienten mit Schizophrenie zu evaluieren. Wie erwartet waren die Ergebnisse der Patienten schlechter als die der gesunden Kontrollgruppe. Der nonverbale Test war der genaueste darin, Beeinträchtigungen der Theory of Mind aufzuzeigen. Zusätzlich war die Schwere der psychopathologischen Symptome nur mit der Performance im nonverbalen Test invers korreliert.

Die zweite Studie untersuchte den neurophysiologischen Aspekt der Theory of Mind in Schizophrenie mithilfe einer Analyse des Mu-Rhythmus im EEG während die Teilnehmer sich vorstellten eine Bewegung auszuführen. Die Unterdrückung des Mu-Rhythmus im EEG konnte in der Vergangenheit als Reflexion der Theory of Mind Funktion über das Spiegelneuronensystem gezeigt werden (Pineda & Hecht, 2009).

In unserem Experiment konnte gezeigt werden, dass Teilnehmer mit Schizophrenie eine geringere Unterdrückung des Mu-Rhythmus im EEG aufwiesen als die gesunde Kontrollgruppe.

Die dritte Studie analysierte die Assoziationen zwischen der Performance in den Theory of Mind-Tests mit sowohl neurophysiologischen und autokomischen Parametern während einer ersten psychotischen Episode, chronischer Schizophrenie und einer gesunden Kontrollgruppe. Zwischen den beiden Patientengruppen konnte in keinem der Parameter eine große Differenz gezeigt werden. Die Ergebnisse von sowohl den neurophysiologischen als auch den autonomischen Tests konnten genutzt werden um die Teilnehmer in die Schizophrenie-Gruppe und die Gruppe mit Gesunden einzuteilen.

Unsere Ergebnisse zeigen an, dass nicht-verbale Kommunikation eine zentrale Rolle in der Theory of Mind in Schizophrenie spielt. Das Defizit der Theory of Mind kann im Verlauf der Erkrankung mithilfe von nicht-verbalen kognitiven und neurophysiologischen Testmethoden ermittelt werden. Dies ist ein Hinweis darauf, dass ein Defizit der Theory of mind ein Merkmal von Schizophrenie ist.

Da der Motorkortex des Gehirns für sowohl gewollte Bewegung als auch das Spiegelneuronensystem verantwortlich ist, könnten Bewegungsstörungen die mit Schizophrenie assoziiert sind mit einer Dysfunktion der Theory of Mind in Verbindung stehen. All dies bringt weitere Einblicke in die der Schizophrenie zugrundeliegenden Mechanismen.

1. Introduction

1.1. Historical Overview of Schizophrenia

Schizophrenia as a disease concept appeared no earlier than in the middle of the 19th century, although there are case descriptions resembling the disorder that date back a few millennia (Tandon, 2009). It was only then that various European psychiatrists began to describe a group of certain mental diseases with an unknown cause that typically affected the young and often progressed to chronic deterioration (Jablensky, 2010). All those different clinical pictures were nosologically integrated into a single entity by a German psychiatrist Emil Kraepelin under the name of 'dementia praecox'. Kraepelin (1899, 1919) believed that dementia praecox (which is nowadays known as schizophrenia) was caused by anatomical or toxic processes, had a single etiology and a defined pathology (Lehmann & Ban, 1997). Since available methods were not able to identify either of the two, Kraepelin emphasized the 'overall clinical picture': according to him, the disorder could be detected on the basis of its early onset (in adolescence or early adulthood), chronic deteriorating course, and outcome (pervasive impairment in cognitive functions) (Tandon, 2009).

Another researcher, a Swiss psychiatrist Eugen Bleuler, discovered a different approach to understanding schizophrenia. In contrast to Kraepelin, who studied primarily patients' records, Bleuler based his views on careful clinical observations while working in close contact with his patients (Fusar-Poli & Politi, 2008). He believed that all those affected by schizophrenia manifest certain symptoms, now known as Bleuler's 4 As: loosening of association, blunted affect, ambivalence, and autism (Bleuler, 1911). However, it was the splitting of psychological functions leading to a loss of integrity of one's personality that Bleuler considered the most important (Stolz-Ingenlath, 2000). As a result, he took the liberty of employing the word ‘schizophrenia’ by combining the Greek words 'schizo' (split) and 'phrene' (mind) to highlight the discrepancy between perception, behavior, thinking and contact with reality. The term was officially introduced at a meeting of the German Psychiatric Association in Berlin in 1908 (Bleuler, 1908). There, Bleuler emphasized that Kraeplin’s dementia praecox was a term that did not describe the disease, as it was ‘neither a question of an essential dementia nor of a necessary precociousness’ (Kuhn R, 2004). He referred to the condition as a whole group of diseases rather than one disorder (Bleuler, 1950), and believed that it was not invariably incurable, and could manifest not only in the young, nor did it inevitably progress to full dementia (Fusar-Poli & Politi, 2008).

Later on, another influential attempt to define schizophrenia was made by Kurt Schneider (1959), who found features, in his opinion, pathognomic to the disease (Mellor, 1970). He observed and emphasized those symptoms that occur often enough to be useful in differential diagnosis (Andreasen & Carpenter, 1993). In contrast to Kraepelin and Bleuler, who focused mostly on the cognitive processes, Schneider identified a group of first-rank symptoms – delusions and hallucinations that seem bizarre (Andreasen & Carpenter, 1993).

These Schneiderian first-rank symptoms were incorporated into several diagnostic algorithms, including PSE – Present State Examination (Wing, 1970) – a diagnostic mecca in the world of psychiatry for many decades that had a powerful influence on the first comprehensive diagnostic system developed in the United States – SADS (Schedule for Affective Disorders and Schizophrenia, Endicott and Spitzer, 1978), as well as Research Diagnostic Criteria (Spitzer et al, 1975), that subsequently provided the basis for DSM-III (Diagnostic and Statistical Manual of Mental Disorders, third edition published in 1980), the modern version of which is used at the present time (American Psychiatric Association, 2013). Nowadays Schneiderian first-rank symptoms are considered positive symptoms, even though they are no longer found to be specific to schizophrenia (Tandon, 2009; Saddichha, 2010).

Our modern understanding of schizophrenia is based on work of the abovementioned scientists, and current definitions of disease incorporate Kraepelinean chronic course, Bleulerian negative and Schneiderian positive symptoms, although using a modified interpretation of their original concepts (Andreasen, 2007).

1.1.1. Emergence of Cognitive Impairment as a Concept in Schizophrenia

From the very beginning schizophrenia was seen as a disease that manifested with a lasting cognitive deficit leading to functional impairment and inability to maintain social relationships (Falkai et al, 2015). Indeed, in one of his works Eugen Bleuler, being one of the founders of schizophrenia as a disorder concept, divided symptoms of schizophrenia into two groups (see Fig.1): basic (those that always occur) and accessory (those that may or may not be present), each having two subdivisions: primary (directly caused by the neurobiological disturbance) and secondary (seen as a result of the primary disturbance). According to Bleuler, alteration of associations is a symptom affecting both existing mental aspects – cognitive and affective. At the same time, this is the only feature described as both basic and primary, making it the core disturbance in the Bleulerian concept of schizophrenia (Maatz et al, 2015).

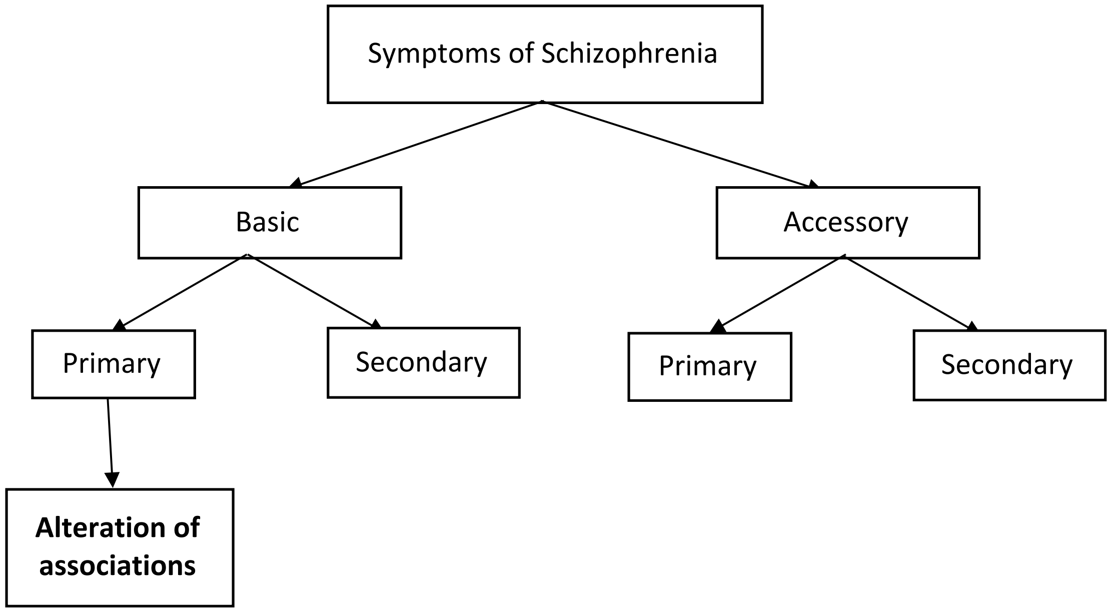

Fig.1. Symptoms of schizophrenia according to Eugen Bleuler (Bleuler, 1911).

Later on, Staehelin noticed highly abnormal social behavior in a group of chronic patients with schizophrenia (Staehelin, 1953). All the participants were observed in naturalistic habitats. Staehelin was surprised by the lack of interpersonal relationships, mutual help, and empathy (Brüne, 2003). All the patients guarded their personal space and escaped any type of bodily contact. According to another study, non-chronic patients also seemed to have problems engaging in social situations and having contact with other people (Grant, 1968). Later on, Troisi (1999) discovered that compromised social functioning of patients was largely independent of positive and negative symptoms prevalence. Therefore, impaired social functioning should be seen as a separate domain of psychiatric disorders (Brüne, 2003). Lately, there has been increasing interest in the field (Billeke & Aboitiz, 2013), with many studies demonstrating social cognitive disturbances manifesting to a various degree in schizophrenia patients (Burns, 2007).

1.2. Social Cognition

Social cognition refers to a variety of neurocognitive processes that are fundamental to one's ability to process behavior of others within social context (Frith & Frith, 2007). It involves several skills, ranging from perceiving and analyzing social information to making decisions and standing by certain behavioral patterns that go in concordance with social norms (Arioli et al, 2018). Social cognition is an important prerequisite for social interactions, which are an integral part of one's everyday life (Frith & Frith, 2007).

1.2.1. Basic Components of Social Cognition

Social cognition can be viewed as a process that comprises several essential components. The first and most basic prerequisite is *perception*, which includes being able to distinguish between objects and living creatures: the behavior of objects is merely attributed to their physical properties and natural laws, while humans' behavioral pattern is more difficult to predict (Fiske & Taylor, 2013). This represents a fundamental difference between non-social perception – perception of objects, and social perception – perception of persons (Heider, 1958). For instance, if one drops a fragile glass on the floor, it will most certainly fall, and possibly break depending on several factors; either way, all these factors can be relatively easily predicted and calculated. Human behavior, on the other hand, is defined by the character, opinions, mood, beliefs, motivation, previous experience – the list is endless, making the art of social cognition so challenging to master.

The second component of social cognition is the *integration and interpretation* of perceived stimuli. Depending on the input, various complex high-level processes are triggered. First of all, each individual perceives social situations in a different way, depending on their attributional style. For instance, one might explain a certain negative experience as mere bad luck, whereas another person is always determined to find a particular reason for the mishap. These interpersonal differences lead to highly diverse further analysis of mental and affective states of others (known as a Theory of Mind), at times including a reflective component to them, which manifests, for example, in the form of empathy (Frith & Frith, 2012).

The third final component of social cognition is the *response* to processed and integrated social input. Appropriate decisions can be made on the basis of thorough understanding of the social context, with plenty of social and non-social contributing factors. According to Ruff and Fehr (2014), there are four principal factors that influence one's decision-making process:

1) The social choices that have already been made by others (if known)

2) Our anticipation of certain decisions we expect others to make
3) Anticipated consequences of a particular social scenario
4) Our awareness of repercussions of certain social behavior

Therefore, the choices each person makes are so individual and occasionally virtually impossible to predict.

1.2.2. Neural Correlates of Social Cognitive Processes

1.2.2.1. Social Perception

Social perception, being the fundamental component of social cognition, involves processing of visual information so as to classify it as an object or a human being (Fiske & Taylor, 2013). In order for that to happen, the initial visual input is decomposed into several parts that are attributed to humans:

1) Facial recognition, which is processed by Occipital Face Area (OFA) in the inferior occipital gyrus, and Fusiform Face Area (FFA) in the fusiform gyrus (Bernstein et al, 2018)
2) Body part/body recognition, performed by Fusiform Body Area (FBA) in the fusiform gyrus, Extrastriate Body Area (EBA) in the lateral occipital-temporal cortex (Peelen & Downing, 2007).

Out of the above-mentioned areas, those located in the fusiform gyrus (FFA and FBA) are responsible for combining the face and body together so as to create a more wholesome image, while OFA and EBA provide the initial representation of separate units (Taylor et al, 2007).

1.2.2.2. Neural Network of Social Cognition

Since the discovery of neural networks responsible for social cognitive processes (Brothers, 1990), several researchers have studied potential changes in activity of these selected areas, including the temporal cortex, the amygdala, and the orbitofrontal cortex. In order to define the brain areas associated with social cognition, researchers tried to combine one of the imaging methods (fMRI/PET) or EEG with a task that involves social cognition. Studies involving the most widely used paradigms are presented in Table 1.

Table 1: Neural Correlates of Social Cognitive Processes

Reference	**Study Type**	**Paradigm**	**Processes measured**	**Sample Size**	**Brain Structures Involved**
Wolf et al, 2010	fMRI	MASC (Movie for the Assessment of Social Cognition)	Implicit mental state reasoning	HS (n=18)	Bilat: TP, STS, PCC, PC, IOG Left: TPJ, PCG, IC, IPS, CC, SFG Right: FFA
Gallagher et al, 2002	PET	Computerized version of 'rock, paper, scissors'	Intentional stance	HS (n=9)	Bilat: APC
McCabe et al, 2001	fMRI	'Trust and reciprocity' game (both with a human and a computer)	Attribution of intentions	HS (n=12)	APC
Fletcher et al, 1995	PET	'Theory of Mind Stories', 'Physical Stories', 'Unlinked sentences'	Attribution of mental states	HS (n=6)	Bilat: TP Left: STG, PCC, MFG
Goel et al, 1995	PET	'Theory of Mind' task	Inference of function based on the form of objects + inferring whether others would understand the function	HS (n=9)	Left: TP, MFC
Deuse et al, 2016	fMRI	Pictures of naturalistic social interactions	Attribution of mental states	HS (n=38)	MFC
Bowman et al, 2017	EEG	Wellman and Liu (2004) scale, changed-location false-belief tasks	Explicit mental state reasoning	HS (n=26)	Central-parietal mu desynchronization
Vogeley et al, 2001	fMRI	'Theory of Mind Stories', 'Physical Stories',	Attribution of mental states	HS (n=8)	Bilat: ACC Left: TP

		'Unlinked sentences'			
Castelli et al, 2000	PET	Computer presented animations	Attribution of mental states	HS (n=6)	MPC, TPJ, TP, OG
Brunet et al, 2000	PET	Comic strips nonverbal tasks	Attribution of intentions	HS (n=8)	Right: MPC, IPC, ITG Left: STG, cerebellum; Bilat: ACC, MTG
Gallagher et al, 2000	fMRI	ToM stories, non-ToM stories, unlinked sentences	Attribution of mental states	HS (n=6)	Bilat: MPC
Baron-Cohen et al, 1999	fMRI	Gender recognition task, Reading the Mind in the Eyes	Attribution of mental states	HS (n=12), AU (n=6)	Left: DLPC, MFC, supplementary motor area, amygdala, hippocampal gyrus, striatum; Bilat: TPJ, IC

Regardless of the great variety of paradigms, certain brain areas stay active throughout all tests accessing social cognitive functions (Wolf et al, 2010). These areas include temporal poles, superior temporal sulcus, medial prefrontal cortex, temporo-parietal junction, posterior cingulate cortex and precuneus (Frith & Frith, 2003; Gallagher & Frith, 2003).

1.3. Theory of Mind as Part of Social Cognition

Being an integral component of social cognition, Theory of Mind is the ability to sense and acknowledge the difference between one's own and foreign psychological state that leads to certain behavioral patterns and serves as a cornerstone of one's personality. Once the social stimulus is perceived, integration and interpretation take place – which is precisely what Theory of Mind contributes to. The ability to interpret mental states of others, including emotions, desires, and fears, is of utmost importance for successful social interactions. Being able to notice the surrounding social stimuli is simply not enough; one should be able to analyze them in a way other society members would, and that requires being able to attribute mental states to other people. Here is an example from everyday life. One can picture a public bus full of people, where all the seats are taken. An elderly lady gets on the bus and starts looking around. She has a few presumably heavy bags and she seems tired. A young man occupying a seat right in front of her notices her, and she looks back at him. What is his next action? It is certainly clear to everyone, including the young man that the elderly lady wishes to take a seat. Whether or not he is going to let her have it depends on his manners and other circumstances we cannot grasp from the story. However, the fact that he, along with everyone with intact social cognition, understands what the lady desires is the example of a fully functional Theory of Mind.

The term 'Theory of Mind' was first described by David Premack and Guy Woodruff in 1978 (Premack & Woodruff, 1978a,b). The two researchers aimed to determine whether or not a chimpanzee may infer mental states such as belief, thinking, doubt, guessing, pretending and so forth. The chimpanzee was presented with a series of videotaped scenes of a human actor struggling with several problems, either simple, such as trying to reach out for an inaccessible banana, or more complex, for instance, shivering in front of a malfunctioning heater. With each videotape the chimpanzee was given several photos, one of which represented a solution to the problem. The chimpanzee was consistently choosing the correct photograph, which was interpreted by the authors as the evidence of its ability to see the problem, recognize the purpose and choose the best solution. Since then, the term has been used by multiple researchers, and development and function of Theory of Mind became a new area of interest.

1.3.1. Components

Brothers & Ring (1992) described the two main ToM components: cognitive and affective. Cognitive ToM refers to the ability to infer beliefs, intentions, thoughts and desires of other people. Affective ToM, on the other hand, is concerned with other people's feelings and emotions. Cognitive ToM may be further divided into first order and second order. First order includes more simple judgments, for instance ‘I think that Peter finds Susan intelligent’. An example for second order cognitive ToM judgement would be ‘My friend thinks that Peter finds Susan intelligent’. In this case one ascribes second order intentionality to another human being and acknowledges their ability to have mental states about third order individuals.

Shamay-Tsoory et al. (2010) proposed a model of a relationship between cognitive and affective ToM, in which cognitive ToM is a prerequisite for affective ToM. Emotional and cognitive aspects of empathy are required for affective ToM to function (Shamay-Tsoory et al, 2010). Empathy is the ability to feel what another person experiences, to share their emotions, whereas affective ToM refers to understanding the feeling itself. One cannot exist without the other, in order to understand the feeling, one should be able to share it, i.e. show empathy. Indeed, one of antisocial personality disorders – psychopathy – is a great demonstration of the two ToM components. On the one hand, these people show extreme antisocial behavior due to lack of empathy (Richell et al., 2003), meaning that the affective component of ToM is most certainly impaired. On the other hand, psychopaths are excellent deceivers and manipulators, which points towards their ability to infer mental states and understand intentions, beliefs and desires of others (Shamay-Tsoory et al, 2010)., there is increasing neurocognitive proof that the two processes, though interconnected, work as separate functional units (Sebastian et al., 2012, Kalbe et al., 2010). All of the above leads us to believe that Theory of Mind is a multidimensional complex process with several partially independent components.

1.3.2. Impairment in Schizophrenia

Theory of Mind deficit is characteristic of many psychiatric conditions, including schizophrenia. Most of the published studies, including several systematic reviews and meta-analyses have shown stable significant ToM impairment in schizophrenia (Bora et al., 2009, Brüne, 2005, Harrington et al., 2005a,b). Patients in remission manifest less severe deficits, however, they do not return to normally functioning ToM, which suggests that ToM impairment may be seen as a trait marker in schizophrenia (Sprong et al., 2007). Up to date, there is no biomarker for schizophrenia, it is a purely clinical diagnosis based on a number of symptoms and characteristic features described both in International Classification of Diseases (ICD-11) as well as in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) - a classification used in the United States. Therefore, understanding the mechanisms of ToM dysfunction as one of the trait markers in schizophrenia can assist in better understanding of the disease itself.

Christopher Frith (1992) was one of the first researchers to notice intellectual decline and cognitive impairment in schizophrenia patients. They experience difficulties interpreting social signals coming from other people, which leads to confusion and eventually results in formal thought disorder typical for schizophrenia (Brüne, 2005). Moreover, one attributes mental states to other people without realizing that it is their perception they are inferring, which may differ from the actual mental state the other person is in, leading to delusional perception of reality – another characteristic feature of schizophrenia. Such patients are also unable to mentally represent their as well as other people's actions (Hardy-Bayle, 1994).

Another researcher, Abu-Akel (1999) proposed that some schizophrenia patients, especially those with predominant positive symptoms, have excess rather than deficit of ToM. These patients tend to over-attribute mental states to others, which leads to failed expectations of others' behavior.

Whether excessive or deficient, ToM impairment stays one of the prominent features in schizophrenia. Distorted perception of almost every aspect of the social environment leads to patients' inability to adapt (Gurovich et al., 2016). Therefore, it is crucial to have good diagnostic tools in order to be able to assess the extent of ToM impairment with the aim to improve non-pharmacological management of the disorder.

1.3.2.1. Neural Correlates of ToM in Schizophrenia

Since ToM is integral to social cognitive processes, we may presume that neural networks responsible for social cognition would include those that get affected in schizophrenia as a reflection of impaired ToM characteristic for the disease. Indeed, most existing studies on ToM in schizophrenia reveal decreased activation of the temporo-parietal junction in such patients (Vucurovic et al. 2020), which is known for being a crucial part of the social cognitive network (Frith & Frith, 2003). Other areas that are specifically known to be involved in ToM functioning in schizophrenia include the middle and inferior frontal gyrus, the insula, superior temporal sulcus, as well as the prefrontal cortex (Russell et al, 2000; Brunet et al, 2003; Lee & Siegle, 2012). Additionally, a recent meta-analysis by Vucurovic et al. (2020) concluded that it is the dysfunctional connectivity between the ventrolateral prefrontal cortex and the temporo-parietal junction that is responsible for ToM impairment in the disease.

1.4. Evaluation of Theory of Mind in Schizophrenia

ToM deficit is known to be strongly associated with social functioning in schizophrenia patients (Fett et al, 2011). Therefore, thorough evaluation methods are crucial, as they lead to more targeted treatment methods with easier follow-up – such as cognitive remediation therapy, which has been shown to improve the functional outcome in schizophrenia (Thibaudeau et al, 2017). Multiple ways to evaluate ToM have been developed, but up to date there is no universal agreement as to which test is the most precise and suitable for patients with schizophrenia. There are several reasons for that. First of all, schizophrenia can have a number of clinical presentations, with positive or negative symptoms being prevalent, meaning that in each case cognitive functions may be affected in a different manner. However, existing methodological approaches evaluate ToM with variable thoroughness and inadvertently focus on specific sub-components without considering the background processes (Apperly, 2008). Together with varying sample size, age and diagnostic features of the patients, these discrepancies lead to substantial contradictions between existing studies (Kettle et al, 2008).

1.4.1. Types of Tests

A range of tests is commonly used in order to reveal ToM impairment in schizophrenia. These tests can be divided into verbal and non-verbal, the former referring to symbolic speech, while the latter including comprehension of gestures, signs and facial expressions.

1.4.1.1. Verbal Tests

Verbal tests examine a subject's ability to infer mental states of other people through spoken language.

1.4.1.1.1. Hinting Task

One of the first tests ever developed is 'Hinting Task' (Corcoran et al., 1995), which was designed specifically to see whether schizophrenia patients can understand and infer mental states of other people. R. Corcoran together with another famous researcher C. Frith believed that impaired ToM was the underlying cause for some negative and positive behavioral signs in schizophrenia, therefore they designed a series of studies trying to test their proposed hypothesis (Corcoran et al, 1995; Frith and Corcoran, 1996; Corcoran, Cahill and Frith, 1997). All of their studies were a success, confirming the researchers' hypothesis on ToM role in schizophrenia patients. Several modifications of their testing methods have been applied since, yet it is the original test version that is implemented the most nowadays.

In the original Hinting Task, the subject is presented with 10 separate cards describing short stories followed by a question at the end to assess how well the situation is understood. The subject is instructed to read each situation one by one and answer the question proposed below. All the 10 stories merely describe ordinary day-to-day situations, and the task tests one's ability to fully understand intentions, thoughts and feelings behind the words and actions of other people in the context of social interactions. One of the examples includes a mini-story describing a young man who is in a very good relationship with his parents, although they do not communicate on a regular basis. This young man just called to tell them he is planning to get married. The question is: how would the parents react to his words? The satisfactory answer should include some sort of a positive response provided the subject understands the nature of relationship within the family. In the case of a non-satisfactory reply, the subject is asked to flip the card and read the extra sentence and another question regarding the story. This serves as an additional hint to guide the subject towards the right conclusion. The subject is not limited in time.

The maximum number of points for this task is 20. If the subject gives the right answer after reading the first part of the story, he/she gets 2 points and proceeds to the next card. However, in case the subject cannot give the correct answer to the first question, he/she is instructed to continue reading the additional sentence on the other side of the card and answer the question that follows. If the subject gives the right answer after this additional hint, he/she is assigned 1 point for the card, whereas if no correct answer is given the subject automatically gets 0 points and moves onto the next card.

1.4.1.1.2. Faux Pas

'Faux Pas' (Stone et al., 1998) literally translates from French as a 'false step'. This test reveals comprehension of more complex social situations with several people being involved and requires the ability to attribute second-order mental states to other people.

The test was originally developed in 1998 by Valerie Stone, Simon Baron-Cohen and Robert Knight, while working with autism patients. The authors noticed that individuals with Asperger's syndrome, which is a mild form of autism, performed well on the existing ToM tasks, however, they suspected that such patients might manifest more subtle impairments. Therefore, a new sophisticated test – Faux Pas – was developed and tested on Asperger's syndrome subjects, healthy controls and neurological patients with bilateral orbitofrontal cortical lesions as well those with unilateral damage in the left dorsolateral prefrontal cortex. As predicted, Asperger's syndrome and bilateral orbitofrontal cortical lesions led to impaired ToM detected with the new method, as opposed to healthy controls and the second group of neurological patients.

As it became clear that schizophrenia patients show detectable ToM impairment (Giannakou et al, 2019), multiple researchers started applying Faux Pas in order to reveal ToM deficits in schizophrenia patients (Martino et al, 2007; Shur et al, 2008; Zhu et al., 2007).

The task tests one's ability to reveal social missteps and differentiate them from ordinary social setups. The task consists of 20 short stories, half of which describe normal situations, whereas the other 10 contain a 'faux pas' – a seemingly innocent phrase or a comment that unintentionally creates an awkward situation.

The subject is instructed to listen to the stories being read out loud one by one and answer the questions that follow. All the stories are supposed to be printed out and put in front of the subject to ensure he/she can follow and read each story again if necessary. The subject is not limited in time. At the end of each story the subject is asked whether they think any character said something they should not have said. In case the answer is yes, more detailed questions follow in order to determine who exactly was inappropriate and why. In case the answer is no, the instructor skips straight to two control questions that ensure the subject understands the general setting of the situation. For instance, one of the stories describes a situation where the neighbor comes by Carol's place for a quick visit. Once the neighbor sees Carol's 3-year-old niece Sally, who happens to have short hair and a round face, he says 'I do not think I have met this boy before! What is your name?'. The subject is supposed to recognize the faux pas in this case, as the neighbor could not have known the gender of the child for sure, nor did he intend to insult or hurt anyone. The questions that follow specify precisely who said something inappropriate (the neighbor in this case) and why they said it. The subject is also asked to analyze how Sally, the 3-year-old, feels in this situation and whether the neighbor actually knew that Sally was a girl. The two follow-up questions referring to this story ask the subject where Sally was, and who exactly came by for a visit. Another story describes a guy called Oliver having a conversation with a girl at a party. A friend of his, Vicky, comes up to Oliver, and the girl he was talking to introduces herself. Oliver offers to bring both girls a drink. The subject's task is to acknowledge that nobody said anything inappropriate in this case, as the story does not contain a faux pas.

Overall, the subject can get 80 points: 60 on faux pas-related stories and 20 on control stories. All 10 stories containing a faux pas are given 6 points maximum per story. The first point is given in case the subject says 'yes' to first question asking whether anyone said anything they should not have. The five more questions that follow, specify as to who exactly said something wrong, why they said it and so on. It is important to ask two control questions proposed at the end to ensure the subject followed the story. For example, control questions for the story with Oliver, Vicky and another girl would be as follows: 'Where was Vicky?' and 'Did Vicky know the other girl?'. If the subject gets these questions wrong, objective evaluation of other answers is not possible, therefore the question can be excluded from the final evaluation of this test. This concerns all stories regardless of whether control questions follow a faux pas-related or a control story. In case the subject does not notice anything wrong with the story, they are given 0 points and proceed to control questions right away.

As for control stories, the subject is given 2 points in case he/she says there is no faux pas in the story provided he/she answers control questions correctly. However, if the subject thinks one of the characters did say something inappropriate, the instructor asks more questions to specify who exactly said it and why, followed by control questions at the end.

1.4.1.2. Non-Verbal Tests – Reading the Mind in the Eyes

Non-verbal tests include the ability to comprehend social information other than that given via speech. The most known test used for this purpose is ‘Reading the Mind in the Eyes’ (Baron-Cohen et al, 2001), which tests the non-verbal ToM component via the ability to recognize emotions of another person through their facial expression, more specifically the eyes, the eyebrows and the mimic muscles in the periocular area of the face. The subject is presented one by one 36 grayscale photographs of human eyes portraying various emotions, and the task is to either choose one of the four simultaneously presented adjectives describing the emotion the eyes are conveying or suggest their own. The subject is not limited in time. There is a glossary available to be used at any point during the test in case the subject has any doubts as to the meaning of any of the adjectives used in the task. Evaluation of ‘Reading the Mind in the Eyes’ is rather straightforward, with each correct answer being given 1 point. In case the subject suggests their own adjective that has a similar meaning to the one considered correct, they get zero points anyway, since they failed to recognize the one amongst the 4 proposed words. Maximum number of points for this task is 36.

This test was first developed in 1997 (Baron-Cohen et al, 1997) to detect cognitive dysfunction in people with Asperger syndrome and high-functioning autism and differentiate them from the control group. Since then, various modifications have been implemented in the attempts to increase the sensitivity of the test, including the latest version used nowadays (Baron-Cohen et al, 2001). This new version is more sophisticated than the original task, as it includes more complex emotions like playfulness and arrogance, instead of basic emotions such as fear, happiness, anger and so on. These elaborate emotions are crucial elements of social cognition, and the ability to recognize them signifies advanced functional ToM that normally develops around adolescence (Baron-Cohen et al, 1999). Since it was discovered that deficits in social cognition are present not only in patients with autism spectrum disorders, but also in other conditions (Brüne, 2005), the test started being used to detect ToM dysfunction in patients with other pathologies, including schizophrenia (Bora et al, 2009).

Up to date, there are several studies where schizophrenia patients' ToM was tested using 'Reading the Mind in the Eyes', and the vast majority of researchers discovered significant ToM impairments in these patients in comparison to healthy people.

1.4.2. Other ToM Tests

Since ToM in schizophrenia became a topic of interest, a wide array of tasks was developed to serve the testing purpose. The three tests mentioned above – Hinting Task, Faux Pas, and Reading the Mind in the Eyes are more commonly encountered in the scientific literature; however, multiple researchers developed their own ToM tests based on the same principle. Langdon et al. (2002) implemented tasks based on understanding irony and metaphors, while Safrati et al. (1997) invented Character Intention-Inferencing Task, which tests the comprehension of intentions of non-verbal comic strip characters. In his review, Harrington et al. (Harrington et al., 2005) divided all existing tasks into three main categories: false belief and deception tests, pragmatic comprehension of speech, and others. The first group comprises all the tasks aimed at 1st and 2nd order mental state attribution, including Faux Pas test, which is believed to be impaired in schizophrenia (Corcoran et al, 2008). The second group includes all the verbal tasks that focus on the comprehension of irony, metaphors and the ability to read between the lines – Hinting Task is the most commonly used test in the group. The last group includes the tests that do not belong to the first two categories, such as the Fact and Value Belief task that checks one's ability to differentiate between one's own and others' values, and Reading the Mind in the Eyes.

1.4.3. Studies Comparison

Up to date, there are two meta-analyses covering ToM in schizophrenia. Sprong et al. (Sprong et al, 2007) analyzed 29 studies that used various mentalizing testing methods, including Hinting Task. The researchers confirmed the validity of the test, as most studies showed significant impairment in patients compared to healthy subjects. Furthermore, schizophrenia patients performed poorly in all ToM test types with the impairment staying significant even in remission phase, indicating that ToM impairment is a trait marker in schizophrenia (Sprong et al, 2007). Bora et al. (2009) published another meta-analysis with similar results, which included, amongst others, studies with both Hinting Task and RME, all showing significant impairment in schizophrenia patients as opposed to controls, with remitted patients performing better than those in the symptomatic phase of schizophrenia, yet worse than the healthy subjects (Bora et al, 2009).

Selected studies investigating ToM test performance in schizophrenia patients and healthy controls by the means of Hinting Task, Faux Pas, and Reading the Mind in the Eyes tests published within the last 15 years are presented in Table 2.

Table 2: Tasks Related to Theory of Mind

Reference	Test	Sample (n, type of patients)	Results	Comments (correlations with pathology)
Betrand et al, 2007	HT	FEP (n=36) HC (n=25)	FEP performed worse than HC (p=0.013)	
Pinkham et al, 2015	HT RME	SCH (n=96) SAD (n=83) HC (n=104)	Patients performed worse than HC on both tasks (both p<0.001)	
Pinkham et al, 2017	HT RME	SCH (n=112) SAD (n=106) HC (n=154)	Patients performed worse than HC on both tasks (both p<0.001)	
Montreuil et al, 2010	HT	FEP (n=45) HC (n=26)	FEP performed worse than HC (p<0.003)	Patients were subdivided into either good outcome or poor outcome group, with no difference in test performance
Kanie et al, 2014	HT	SCH (n=52) HC (n=53)	SCH performed worse than HC (p<0.001)	
Hagiya et al, 2015	HT	SCH (n=52) HC (n=53)	SCH performed worse than HC (p<0.0001)	
Popolo et al, 2016	HT	SCH (n=37) HC (n=40)	SCH performed worse than HC (p=0.01)	

Smeets-Janssen et al, 2013	HT	E-SCH (n=15) L-SCH (n=15) HC (n=30)	E-SCH performed worse than both L-SCH (p=0.003) and HC (p=0.001); No difference between L-SCH and HC was found	The study was done on geriatric subjects
Lahera et al, 2015	HT	SCH (n=49) HC (n=50)	Patients performed worse than HC (p<0.016)	
Lindgren et al, 2018	HT	SCH-FEP (n=25) Non-SCH-FEP (n=41) HC (n=62)	Patients performed worse than controls (p=0.007); SCH-FEP performed significantly worse than non-SCH-FEP (p=0.016); No difference between non-SCH-FEP and HC was found	
Geraci et al, 2012	FP RME	SCH (n=29) HC (n=20)	SCH performed worse than HC on both tests (p<0.001 for both)	Patients were subdivided into 3 groups – inpatient with negative (n=8), positive (n=13), and outpatient with negative (n=9) symptoms prevailing; no difference in between the groups in either of the tests performance was found
Martino et al, 2007	FP	SCH (n=21) HC (n=15)	SCH performed worse than HC (p=0.0003)	Severity of negative symptoms showed moderate to high correlation with the test performance
Li, Li et al, 2017	FP	SCH (n=35) HC (n=35)	SCH performed poorly on both recognition of faux pas (p=0.041) and understanding of it (p=0.006)	Neither cognitive (faux pas recognition) nor affective (faux pas understanding) ToM components correlated with patients' symptoms, IQ, disease duration, or medication dose
Ho et al, 2015	FP	SCH (n=41) HC (n=42) HS (n=43)[1]	HC performed better on the test in comparison to SCH both in terms of faux pas recognition	HS performed worse than HC on faux pas understanding (p<0.05), but not on faux pas recognition

			(p<0.01) and understanding (p<0.01)	
Huepe et al, 2012	FP	SCH (n=15) HC (n=19) HR (n=14)[1]	SCH performed worse than HC (p<0.001)	HR also showed worse results than HC (p<0.05)
Shur et al, 2008	FP RME	SCH (n=26) HC (n=35)	SCH performed significantly worse than HC both on FP (p=0.039) and RME (p=0.024)	
Hasson-Ohayon et al, 2015	FP	SCH (n=39) HC (n=60)	Patients performed worse than controls (p<0.007)	
Herold et al, 2009	FP	SCH (n=18) HC (n=21)	SCH performed worse than HC (p=0.016)	
Caletti et al, 2013	FP RME	SCH (n=30) HC (n=18) e-BP (n=18)[1]	SCH performed worse than controls on both FP and RME (p<0.0001 for both)	e-BP were statistically close to HC, showing less impairment than SCH
Scherzer et al, 2012	HT FP RME	SCH (n=21) HC (n=29)	SCH performed worse in FP and HT than HC (p<0.01 for both); No difference in RME performance between the groups was found	
Bora et al, 2008	HT RME	SCH (n=91) HC (n=55)	SCH performed worse both on HT and RME (p<0.001)	HT was more impaired in patients with psychotic (p<0.01) and pure negative symptoms (p=0.05)
Balogh et al, 2014	RME	SCH (n=43) HC (n=41)	SCH performed worse than HC both in remission (p=0.001) and relapse state (p<0.0001)	Test performance improved in the same patients in remission compared with relapse disease state (p=0.003)
Navarra-Ventura et al, 2018	RME	SCH (n=40) HC (n=40)	SCH performed worse than HC (p<0.001)	No statistically significant difference in performance between genders was found both in SCH and HC
Zhang et al, 2018	RME	SCH (n=66) HC (n=95) HRP (n=84)[1]	SCH performed worse than HC (p<0.001)	HRP performed better than SCH (p<0.001), but worse than HC (p<0.001); Response time was almost twice as long in

				both HRP and SCH than in HC
Schiffer et al, 2017	RME	SCH (n=34) HC (n=18)	SCH performed worse than HC (p=0.019 for non-violent SCH (n=18) and p=0.023 for patients with violent SCH (n=18))	
Akgül et al, 2017	RME	SCH (n=48) HC (n=48)	SCH performed worse than HC (p=0.001)	No statistically significant difference in performance between genders was found both in SCH and HC
Kelemen et al, 2005	RME	SCH (n=52) HC (n=30)	SCH performed worse than HC (p<0.01)	No difference between remitted (n=17) and non remitted (n=35) patients was found
Hirao et al, 2008	RME	SCH (n=20) HC (n=20)	SCH performed worse than HC (p<0.001)	No correlation with IQ, age, sex and education level was found
Kettle et al, 2008	RME	SCH-FEP (n=13) HC (n=43)	SCH-FEP performed worse than HC (p<0.05)	
Zhang et al, 2016	RME	SCH (n=62) HC (n=42) HRP (n=40)[1]	SCH performed worse than HC (p<0.001)	HRP did better than SCH (p=0.004) but worse than HC (p=0.001)

Most of the existing studies confirm better test performance by healthy controls compared to schizophrenia patients in all three above mentioned tasks. Only one study (Scherzer et al, 2012) found no significant difference in non-verbal Reading the Mind in the Eyes test performance, while Faux Pas and Hinting Task were significantly easier for the unaffected subjects. Hinting Task performance was mostly impaired, apart from a few studies where patients were subdivided into smaller groups; that way, geriatric patients with late onset of schizophrenia did not differ from healthy age-matched controls (Smeets-Janssen et al, 2013), and Lindgren et al, (2018) discovered no difference between non-schizophrenia psychoses and healthy controls, while schizophrenia patients did significantly worse on the test. On the other hand, Faux Pas results seemed stable in all types of patients in comparison to healthy controls.

A few studies included unaffected relatives of patients, who, as a rule, performed worse on RME than healthy subjects, yet better than the patients (Zhang et al., 2016; Zhang et al., 2018). Another study included healthy siblings of schizophrenia patients, who could recognize faux pas just as well as healthy subjects, however, failed to understand it together with the affected

[1] Unrelated to our study directly

patients (Ho et al., 2015). Most studies found no difference in test performance between genders.

1.5. Motor Activity in Schizophrenia

Being a complex disease, schizophrenia comprises several integral features, one of them being motor disturbances. Altered motor function has long been known as a trait in schizophrenia (Bachmann & Schröder, 2018). At the same time, ToM impairment, as mentioned in the previous chapters, has been increasingly referred to as a trait rather than a state in the disease (Ayesa-Arriola et al, 2016). The current chapter puts an emphasis on the connection between the two traits – motor disturbances and ToM dysfunction in schizophrenia.

1.5.1. Motor Disturbances in Schizophrenia

Altered motor function has always been considered one of the core features of schizophrenia (Ungvari et al, 2010). There are a number of clinical symptoms that can be attributed to the disease, including verbal motor disturbances affecting speech, and non-verbal motor disturbances of bodily movements. See Table 3. In the new edition of ICD, all these types of motor dysfunction are stated under 'Psychomotor symptoms' that can be subclassified into mild, moderate, or severe.

Table 3. Motor symptoms of schizophrenia (summarized based on Walther & Strick, 2012; Morrens et al, 2014)

Non-Verbal	
Stupor	Near-unconsciousness and insensibility
Motor stereotypies	Abnormally frequent, repetitive and non-goal-directed movements
Motor perseveration	Purposeless repetition of a goal-directed movement
Echopraxia	A type of motor perseveration where an affected individual repeats someone else's action
Grimacing	Making an odd face for no apparent reason
Posturing	Maintaining a strange pose against gravity
Staring	Looking at the same point intensively for a prolonged period of time
Waxy flexibility	Slight resistance upon being moved, making it possible for the examiner to manipulate with the patient's body position
Catalepsy	Rigidity of posture regardless of external stimuli accompanied by decreased sensitivity to pain
Agitation/excitement	Specifically, with no external stimuli being present

Verbal	
Mutism	Very little verbal response despite the absence of apparent neurological deficit
Echolalia	Repeating someone else's words as they are talking
Verbigeration (verbal stereotypies)	Abnormally frequent repetition of a few words or sentences without an apparent purpose

Table 3 presents the verbal and the non-verbal motor symptoms in schizophrenia – the former being limited to just a few, while the latter are way more variable in their nature. Some of the non-verbal symptoms may manifest in a rather subtle manner, making it more challenging to attribute the symptom to the disease itself – for instance, staring is a feature that is not at all exclusive nor specific to schizophrenia, neither is agitation or excitement. Therefore, highly specific diagnostic tools are required in order to achieve thorough understanding of the non-verbal motor phenomena in schizophrenia.

1.5.1.1. Catatonia

Traditionally, psychomotor abnormalities in schizophrenia have been referred to as 'catatonia' – the term coined by Karl Ludwig Kahlbaum in 1874 (Kahlbaum, 1874). Since then, multiple researchers have addressed various motor phenomena as catatonic, making the definition inconsistent (Ungvari et al, 2010). Nowadays it includes not only purely motor symptoms, but also disturbed affect and volition (Walther & Stirk, 2012). Such patients may manifest either negativism, meaning they do the exact opposite of what they are told, or demonstrate automatic obedience without questioning the examiner's request. Some may also develop mannerisms – ways of accomplishing tasks that are seen as abnormal, odd or grotesque by people of the same culture (Lohr & Wisniewski, 1987). Even though catatonia has been associated with schizophrenia for many decades, it is now classified as a separate entity (according to ICD 10) that appears as a part of other psychiatric conditions (Rasmussen et al, 2016).

1.5.2. Mirror Neuron System

1.5.2.1. Discovery and Function of Mirror Neuron System

The discovery of mirror neurons was undoubtedly amongst the most fascinating achievements in modern neuroscience (Carvalho et al, 2013). A mirror neuron is a neuron that fires both when the animal acts and observes the same action performed by someone else (Rizzolatti &

Craighero, 2004). The phenomenon was accidentally discovered by Di Pellegrino and his colleagues (Di Pellegrino et al, 1992), who studied rostral ventral premotor cortex (F5 area) of monkey's brain in a behavioral situation and found out that the neurons were activated not only during monkey's own previously trained hand movements, but also during the same gestures done by the experimenter. This unexpected neural activity aroused significant interest in the field; therefore, more experiments with monkeys were conducted. It appeared that not only observing the action, but also hearing it (Kohler et al, 2002; Keysers et al, 2003) or knowing that someone else is performing the movement activates mirror neurons (Umilta et al, 2001).

These experiments conducted with monkeys raised the question of whether humans' mirror neurons exist and function in a similar way. Monkeys' F5 premotor area is homologous with Brodmann's area 44 containing Broca's speech center in the human cortex (Binkofski & Buccino, 2006). Therefore, several researchers hypothesized that mirror neurons are related to language development (Rizzolatti & Arbib, 1998; Arbib & Mundhenk, 2005).

Another known function of Brodmann's area 44 is complex hand movements, associative sensorimotor learning and integration (Binkofski & Buccino, 2006). To confirm the homology between the human and the monkey cortical mirror neuron function, the series of studies previously done on monkeys were successfully replicated on humans during performance or observation of a movement that involved hands, feet and mouth (Gazzola et al, 2006; Le Bel et al, 2009).

This discovery led to even more new questions, some of which still remain unanswered. How much do mirror neurons actually reflect? Is it only the movements they react to, or are there more triggers? One thing is known for sure – mirror neurons comprise a complex system, which allows us to understand the behavior of other people through the ability to infer the feelings of others as they perform the movement (Zaytseva, 2015). Mirror neuron system helps us anticipate others' intentions (Rizzolatti et al, 1996; Iacoboni, 2005) and plays a central role in imitation, which requires precise copying of observed actions (Iacoboni, 2005; Rajmohan & Mohandas, 2007).

Another interesting motor-cognitive phenomenon, in which mirror neurons play a key role, is motor imagery (Rizzolatti et al, 2001). It is a cognitive-perceptual process, in which imaginary movement is not accompanied by actual peripheral activity. Motor imagery leads to unconscious activation of the motor system, and is believed to be involved in learning by seeing (Jeannerod & Frak, 1999), emotions and memory along with motor control (Kosslyn et al, 2001).

1.5.2.2. Mirror Neurons and Social Cognition

In humans, mirror neurons are known to play a crucial role in understanding both actions and emotions (Kim, 2013). The way the brain does it can be described as follows: whenever we move, for instance, our hand, the corresponding area in the motor cortex will get activated - that way we are able to perform the movement. However, when we see someone else moving their hand, the same area responsible for hand movement will get activated not only in their but also in our brain, as if we are performing the exact same movement, even though the movement is being merely observed. This can be explained by the brain trying to understand the person in front of us: this partial activation of the same motor areas helps us thoroughly feel the movement someone is performing. Consequently, this leads to better comprehension of the motives that underlie the movement and the emotions the person might be experiencing. Indeed, mirror neurons are now known to be an integral part of ToM (Gabbard, 2005; Siegal & Varley, 2002) – the ability to understand the way someone else feels and being able to differentiate their emotional state from one's own. According to Gallese et al. (2004), the mechanism that underlies understanding of emotions is similar to that involved in understanding others' actions. The only significant difference between the two mechanisms is that the former requires activation of visceromotor centers, unlike the latter, which only needs the visual-motor centers to function (Gallese et al. 2014).

1.5.2.3. Detection of Mirror Neuron Activity

The first method ever used by Di Pellegrino and his colleagues on monkey's brain was single cell recordings (Di Pellegrino et al, 1992), which was later reproduced by other researchers in humans (Mukamel et al, 2010). Single cell recordings are the only direct way of mirror neuron activity detection. However, there are more indirect methods that have been used for this purpose, such as Transcranial Magnetic Stimulation (Fadiga et al, 1995), Positron Emission Tomography (Rizzolatti et al, 1996), Magnetoencephalography (Schurmann et al, 2007), and the more recent ones, such as Functional Magnetic Resonance Imaging detecting the brain areas involved according to changes in blood oxygenation levels under certain conditions (Iacoboni et al, 2005; Chong et al, 2008; De la Rosa et al, 2016), as well as Electroencephalography, which works by recording mu rhythm suppression (McCormick et al, 2012).

All these methods provided neurophysiological proof of mirror neuron activity, making it possible to investigate their role in social cognitive processes and their potential dysfunction in certain psychiatric conditions.

1.5.2.4. Mirror Neuron System Dysfunction in Schizophrenia

Schizophrenia patients commonly manifest with social and cognitive deficits, which significantly affect the functional outcome of disease (Couture et al, 2006). As mentioned before (see ToM evaluation chapter), there are a number of ways to test the ToM component of social cognition; however, all these methods are based on a patient's verbal and non-verbal communicative skills. The association between schizophrenia, ToM and the mirror neuron system dysfunction has recently become well-recognized (Jeon and Lee, 2018), providing us with the opportunity to estimate expected social cognitive deficits using not only pure clinical, but also neurophysiological methods.

Up to date, there are a limited number of neurophysiological studies investigating mirror neuron activity in schizophrenia. In their review, Mehta et al. (2014) analyzed 14 most relevant studies covering the topic. All the papers comprised both a schizophrenia spectrum group and healthy controls, and used one of the following neurophysiological methods: fMRI and EEG being the most common ones, as well as MEG, TMS, EMG, and PET. Mirror neuron activity was decreased in most of the studies (n=9), 4 of the rest showed mixed results (either increased or decreased activity of mirror neurons), while 1 research team did not find any significant differences between the patient and control groups. The brain regions associated with the changes in mirror neuron activity are inferior frontal gyrus, inferior parietal lobule, premotor and motor cortices, and posterior superior temporal gyrus.

Another recent study by Bagewadi et al. (2018) found a significant difference in mirror neuron activity between context-based hand action observation and neutral hand action observation both in patients and healthy controls. Schizophrenia subjects demonstrated significantly decreased mirror neuron activity compared to the healthy group when shown context-based hand action, signifying impaired social cognitive functioning. In other words, potentially disturbed perception of biological motion by schizophrenia patients leads to impaired comprehension of non-verbal communication with the others. As a result, social interactions pose a real challenge for these patients and make a substantial negative impact on their daily lives.

Study Rationale

Despite the recent scientific progress that has significantly improved our understanding of the mirror neuron system in schizophrenia (Mehta, 2020), there are still a few knowledge gaps remaining to be filled. As seen in the previous chapters, ToM impairment is a well-established feature of schizophrenia, as well as the motor disturbances. The discovery of the mirror neuron system was a major breakthrough suggesting that the two processes might be of a similar, if not the same, nature, as both cover the non-verbal functional aspects of the brain. However, the actual link between the two processes is still poorly understood in spite of the improved knowledge of the brain regions involved in social cognitive processes (Walbrin et al, 2020). Therefore, **the aim** of the current research was to establish the significance of non-verbal communication for ToM in schizophrenia patients evaluated by cognitive testing, electrophysiological and autonomic parameters.

The following hypotheses were proposed:

1. **Schizophrenia subjects perform worse on ToM tests than the healthy subjects.** Schizophrenia patients have been known to manifest impairments in ToM leading to poorer cognitive test performance in comparison to healthy subjects, as shown by the vast majority of previously published research on the topic (Baron-Cohen et al, 2001; Scherzer et al, 2012; Sullivan et al, 2012).
2. **The non-verbal test for ToM evaluation is more sensitive than the verbal tests.** We hypothesize that the non-verbal tests are more sensitive to ToM evaluation based both on the neurodevelopmental aspect, since the non-verbal ToM becomes established earlier during childhood than the verbal ToM (Kreifelts et al, 2013), as well as the fact that the non-verbal communication prevails in our day-to-day life, conveying the vast majority of the conversation (Mehrabian, 1972).
3. **The severity of psychopathological symptoms correlates with test performance both in verbal and in non-verbal tests.**
   The severity of psychopathological symptoms has previously been shown to correlate with ToM test performance (Craig et al, 2004). Despite potential differences between the verbal and the non-verbal tests, both types are known to detect ToM impairment in

schizophrenia patients (Scherzer et al, 2012), therefore, we hypothesize that the severity of symptoms will correlate with test performance in all the tests applied.

4. **Schizophrenia subjects show less EEG mu rhythm suppression during the motor imagery task than the healthy subjects.**

   Mirror neurons are known to play a key role during motor imagery (Rizzolatti et al, 2001), while schizophrenia patients manifest decreased activity in the mirror neuron areas (Enticott et al, 2008). Based on these two facts, we hypothesize that the EEG mu rhythm suppression during the motor imagery task will be decreased in schizophrenia subjects as a reflection of impaired mirror neuron activity.

5. **In patients with substantial motor disturbances in schizophrenia, the mu rhythm suppression is less pronounced.**

   Mu rhythm suppression index is inversely correlated to the motor cortex excitability (Yin et al, 2016). Out of all schizophrenia subtypes, patients with catatonic schizophrenia are characterized by the predominance of motor symptoms (ICD-10). Therefore, we expect to see the more pronounced motor disturbances (i.e. in catatonic schizophrenia patients) being associated with the least mu rhythm suppression.

6. **Disease duration has no impact on ToM test performance in schizophrenia patients.**

   Since ToM impairment is more and more readily recognized as a trait rather than a state in schizophrenia (Brüne, 2005), we hypothesize that test performance should be consistent regardless of disease duration. A number of studies that have been published comparing ToM test performance in patients with the chronic vs newly diagnosed schizophrenia show no intergroup differences (Mazza et al, 2012; McGlade et al, 2008).

7. **Psychological and physiological predictors can assist in classifying subjects into the schizophrenia group and the healthy group.**

   Previous research has shown that considering several cognitive as well as neurophysiological parameters together may lead to successful classification of subjects into several diagnostic categories (Johnnesen et al, 2016). Therefore, we hypothesize that combining psychological and physiological predictors enables classification of subjects into the healthy controls and the schizophrenia group.

2. Methods & Results

2.1. Study 1. Comparative Analysis of Theory of Mind Tests in First Episode Psychosis Patients

ToM impairment is recognized as a characteristic feature of schizophrenia (Brüne, 2005; Corcoran, 2003) with all patients manifesting the deficit to a various degree, which complicates proper perception of most social environmental components and leads to inability to adapt. A range of tests, either verbal or non-verbal, is commonly used in order to evaluate ToM impairment and track performance patterns throughout the course of disease. Being able to detect social cognitive deficit may facilitate timely diagnosis and intervention, which, in turn, potentiates improved disease management (Seeber & Cadenhead, 2005). **The aim** of this study was to compare and contrast verbal cognitive tests of variable difficulty and a non-verbal cognitive test so as to define their sensitivity to ToM deficit detection in the first psychotic episode patients with schizophrenia and schizoaffective spectrum disorders.

Despite being separate diagnostic entities, schizophrenia and schizoaffective spectrum disorders show remarkably similar cognitive, social cognitive and neural profiles (Hartman et al, 2019). Both groups have been shown to have detectable ToM impairment before, and including other schizophrenia spectrum disorders into the study provides crucial insight into their common etiology as well as the neuropathological events that precede it and continue throughout the course of disease (Seeber & Cadenhead, 2005).

2.1.1. Methods

The study included 20 patients with the first psychotic episode undergoing treatment in the Department of Outpatient Psychiatry and Organization of Psychiatric Care, Moscow Research Institute of Psychiatry. 65% of patients had schizotypal disorder, 25% of patients suffered from schizoaffective disorder, while 10% were diagnosed with schizophrenia. All the patients were treated with atypical antipsychotics. The average age of the patients was 26.1±7 years. 13 out of 20 subjects were male (65%), 7 were female (35%). 35% of patients had higher education, 30% had incomplete higher education, 35% had secondary and secondary specialized education.

The severity of psychopathological symptoms was assessed with the PANSS scale. The average sum was 76.8±15.0 (15.9±8.0 according to the positive symptoms scale, 18.9±6.0 according to the negative symptoms scale, 41.9±8.0 according to the general psychopathology scale).

The study was approved by an ethical committee, and all participants gave their informed consent once the nature of the study had been fully explained to them.

During the Faux Pas task, the specialist read 20 small paragraphs one by one out loud, while the subject was instructed to listen to it carefully and answer the questions that followed. Each paragraph described a social situation, such as neighbors running into each other in the street, or a group of friends having a discussion at a house party. The first question that followed each test was whether the subject reckons someone's response was inappropriate in the situation described. In case the patient said yes, more detailed questions followed so as to discover who exactly, according to the subject, was out of place with what they said and why. In case the patient said no, the specialist skipped straight to control questions, which were asked regardless of the patient's initial response, as they were aimed at revealing the general understanding of the situation. Thus, the specialist was able to exclude accidental correct answers to maximize the test's objectivity. The task consisted of 20 situations: 10 with irrelevant verbal or non-verbal behavior, and 10 control situations. The maximum number of points for the 10 Faux Pas-containing situations was 60 (6 per each), whereas correctly answered control questions were evaluated as 20 points altogether (2 per each). Each situation was read once only. There was no time limit established.

During the other verbal test called 'Hinting Task' the patient was required to read the situations from the card in front of them and to establish what exactly the main character meant in each of them. In case the subject struggled to give the right answer, they were instructed to flip the card and read the additional sentence with another hint. Each correct answer was evaluated as 2 points. If the patient got it right from the second attempt, 1 point was given. The total maximum result was 20 points. No time limit was established for the subjects.

The non-verbal task 'Reading the Mind in the Eyes' consisted of 36 photos of human eyes expressing an emotion, which was presented one after another for an unlimited time. The subject's task was to pick the adjective describing it best out of the 4 options available or suggest their own in case none of the options were suitable in their opinion. There was a dictionary available to ensure the greater accuracy of results.

The statistical analysis was carried out using nonparametric criteria. Correlation analysis was applied to explore the associations between ToM test scores and PANSS scales.

2.1.2. Results

The analysis showed that the least difficulties occurred in 'Hinting Task' performance. 7 out of 20 subjects achieved the maximum result, while the rest scored close to maximum. The average for the group was 91.6%. Most of the mistakes were made without a traceable pattern. In contrast, nobody achieved the maximum score in 'Faux Pas' and 'Reading the Mind in the Eyes'. Only 3 patients got over 90% in 'Faux Pas' (the same who got maximum points on the 'Hinting Task'). The total average for this task was 73.4%. If the patient had difficulties fulfilling the test, it manifested equally in at least 50% of the stories (10 out of 20).

'Reading the Mind in the Eyes' test revealed a substantially greater ToM deficit (total average for this task was 59.6%). The patients were struggling with this task, and only 1 patient scored over 80%. Many incorrect answers of each patient had a traceable emotional or psychopathological pattern, which allowed exploring some of their paranoid tendencies. For instance, some patients kept choosing the answer 'suspicious' as correct, or selected the adjectives with a predominantly negative sense. Correlation of the test results for each subject is presented in Fig.2.

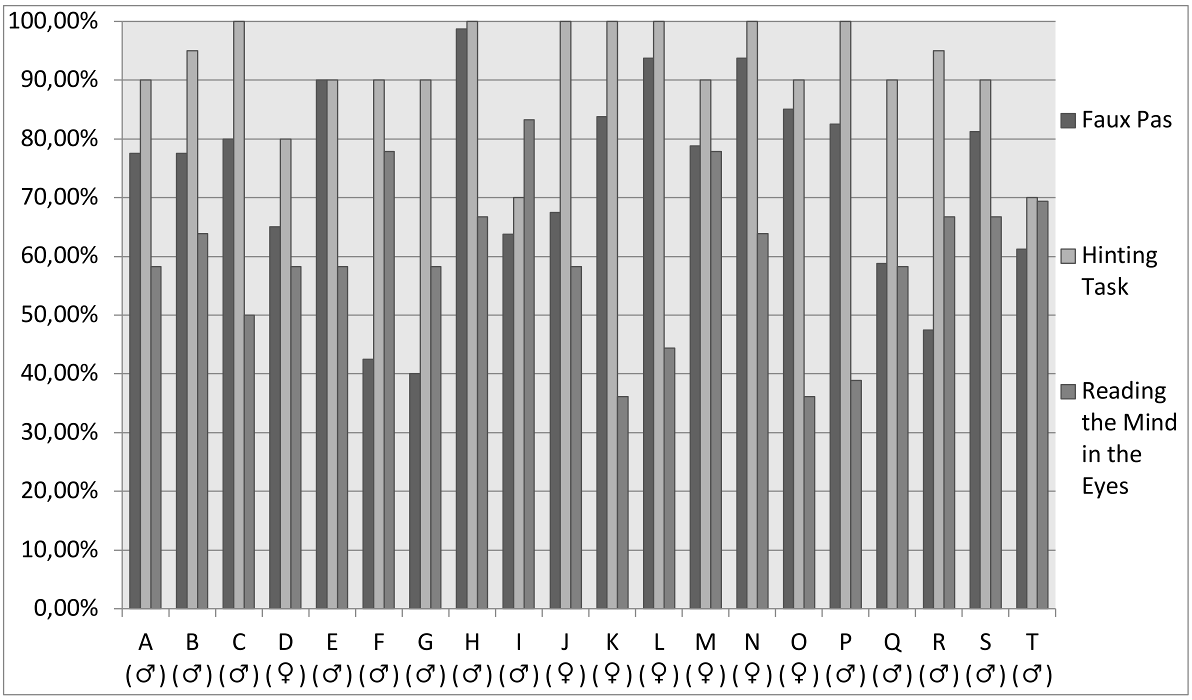

Fig.2. ToM test results in first episode psychosis patients

For statistical analysis, the percentage results achieved by the subjects were coded as follows: ≥ 80% - 5 points, 60-79% - 4 points, 46-59% -3 points, ≤ 45% - 2 points. The scores of the three tests used varied significantly: ANOVA Chi Sqr. (N=19, df=2) =20.37, p=0.00004. A pairwise comparison of ToM test scores was performed using the Wilcoxon test. 'Faux Pas' vs 'Hinting Task': p=0.012; 'Faux Pas' vs 'Reading the Mind in the Eyes': p=0.023; 'Hinting Task' vs 'Reading the Mind in the Eyes': p=0.0004.

Correlation analysis (according to Spearman's test) revealed credible associations between the severity of psychopathological symptoms and the score of the 'Reading the Mind in the Eyes' test only. The following negative correlations between this ToM test scores and PANSS scales were found with positive symptoms P1 (r= -0.628, p=0.005), P3 (r= -0.609, p=0.007), negative symptoms - N1 (r= -0.636, p=0.005) and general symptoms- O6 (r= -0.497, p=0.036), O9 (r= -0.625, p=0.006) as well as with the total score of the psychopathological symptoms (r= -0.510, p=0.030).

Thus, the analysis showed that first episode psychosis subjects show poorer test performance than healthy controls on ToM tests, with the non-verbal 'Reading the Mind in the Eyes' being the most challenging out of the three. At the same time, only these non-verbal test scores correlated with the PANSS. Therefore, the only non-verbal test - 'Reading the Mind in the Eyes' – was the most sensitive to ToM impairment in first episode psychosis patients.

The current study was published in Psychiatria Danubina (Morozova A, Garakh Z, Bendova M, Zaytseva Y: 'Comparative Analysis of Theory of Mind Tests in First Episode Psychosis Patients'. Psychiatr Danub. 2017 Sep;29(Suppl 3):285-288). Being the first author of the study, I contributed to the data collection and analysis, wrote the manuscript with valuable input and revisions from co-authors.

2.2. Study 2. Motor Imagery in Schizophrenia: an EEG study

Motor imagery is a mental execution of a movement that is not accompanied by peripheral activity. It is widely used in a number of different contexts, including cognitive neuroscience, in order to research the neural processes that precede action performance (Decety & Ingvar, 1990). Mirror neurons, known as an integral ToM component (Siegal & Varley, 2002), are also crucial for motor imagery (Rizzolatti et al. 2001). The basic concept of mirror neuron activity is trying to understand someone in front of us by mentally mimicking their actions, leading to comprehension of their mental state. Motor imagery, on the other hand, uses one's own psychological resources rather than a 'mirror' with a similar effect (Goldman, 2002). The underlying neurophysiological mechanisms can be investigated using the analysis of EEG mu rhythm suppression (Pfurtscheller et al, 2006). It is believed that mu rhythm with the oscillation frequency of 8-13 Hz reflects the activity of the sensorimotor cortex. Synchronized mu waves are registered at rest, while their desynchronization occurs while performing, observing, or imagining the movement (Pineda, 2005). Mu rhythm EEG investigations are usually limited to its suppression in sensorimotor areas only (C3, C4, Cz). Up to date, very few studies have attempted to explore neuronal activity of the frontal cortical areas (F3, F4, Fz) (Zhu et al, 2011). Neuroimaging methods demonstrate the activation of the frontoparietal neuronal network during motor imagery (Hetu et al, 2013), which is at the same time highly sensitive to cognitive and affective influences (Pineda, 2005).

Motor imagery is known to pose a challenge for schizophrenia patients (Dankert et al, 2004). At the same time, both motor and social cognitive functions are increasingly recognized as one developmental domain (Kenny et al, 2016), suggesting a correlation between ToM and motor activity. According to ICD-10 classification (World Health Organization, 2004), catatonic schizophrenia (diagnosis code F20.2) is the subtype of disease predominantly characterized by psychomotor disturbances. Another subtype – paranoid schizophrenia (ICD-10 diagnosis code F20.0) is primarily characterized by prominent delusions.

The aim of this study was to investigate whether the patients with catatonic schizophrenia, the subtype with the most pronounced motor disturbances, would show less mu rhythm suppression during motor imagery than paranoid schizophrenia patients and healthy controls. The current study was designed so as to contribute to our understanding of the neurophysiological mechanisms underlying schizophrenia, discover correlations between the severity of motor symptoms and the mirror neuron system detectable by the EEG mu rhythm, and examine the recently established connection between ToM and motor disturbances (Kenny et al, 2016) in the disease.

2.2.1. Methods

Two subjects with catatonic schizophrenia (F.D., aged 23 years, and S.A., 22 years) were recruited for the current study. They were asked to do a motor imagery task while their EEG mu rhythm suppression was being recorded.

Patient F.D. was admitted to the psychiatric clinic having been found motionless in a bathroom. The mental disorder manifested with hallucinations of grandeur – the patient thought he was Jesus, and his purpose was to die for the sake of humanity. His catatonic symptoms included waxy flexibility and immobility without any reaction to the surroundings for prolonged periods of time while being apparently awake.

Patient S.A. presented with stereotypy, negativism and grimacing; he was convinced he was hearing voices coming from the devil that he had to follow against his own will. Other catatonic symptoms included stupor, freezing and speechlessness.

Control groups were selected matching the age and the sex of the patients: a group of patients with first-episode paranoid schizophrenia (n = 9, all males aged 22.1 ± 1.2 years), and a group of healthy volunteers (n = 32, all males aged 23.0 ± 0.8 years).

Subjects with paranoid schizophrenia manifested with persecutory delusions, verbal hallucinations and different types of automatisms.

All the patients were receiving atypical antipsychotic therapy from the beginning of admission to the clinic (for 3–20 days prior to the EEG investigation). The diagnoses were made in accordance with the *ICD-10* (10th rev., World Health Organization, 1992–1994): paranoid schizophrenia (diagnosis code F20.0) and catatonic schizophrenia (diagnosis code F20.2).

The experimental task included an imaginary representation of one's own movement, namely, the subjects were asked to imagine walking on a familiar street. This task lasted 2 minutes, followed by the subjects' self-reports, where everyone was able to elaborate on the imaginary route. Electrophysiological parameters were synchronously registered in the resting state and during the performance of the experimental task with the subjects' eyes closed. The experiment took place in a dark room in a comfortable seated position.

The 19-channel EEG was recorded according to the international 10-20 system: Fp1, Fp2, F3, F4, F7, F8, C3, C4, T3, T4, T5, T6, P3, P4, O1, O2, Fz, Cz and Pz on an installation comprising a 19-channel amplifier and a personal computer. The recording was monopolar, and the reference electrodes were placed on the linked earlobes. The EEG was recorded for 120 seconds in each functional state. Averaging the data of 10-15 periods analyses lasting 5 seconds each was applied for the calculation of spectral parameters.

The mu rhythm was isolated by a special software (Garakh et al, 2020) on the basis of spatial-frequency EEG filtering and characteristic reaction to eye opening. The software was used to define mu rhythm location and power.

In order to isolate mu rhythm (6-14 Hz) band was filtered and the difference between the covariance matrices was calculated during both conditions: with the eyes open and during motor imagery. Since the covariances reflect the energy rather than the power of each state (their results are proportional to recording length), each matrix was normalized to the appropriate recording length before subtraction. The difference matrix was subjected to factor analysis, and the original EEG recordings were laid out in accordance with the factors derived. Then comparative analysis of the factor power spectra during both conditions was performed. The mu rhythm was isolated based on the factors that had maximum power difference between the two experimental conditions. The fact that the maximum power is localized in the central channels was taken into account (C3, C4, Cz).

The spectral power of mu rhythm suppression was analyzed in the frontal channels F3, F4 and in the sensorimotor cortex projections – C3, C4. The index of mu rhythm suppression was calculated as the difference of the spectral power during motor imagery and at rest in the appropriate cortical areas. For the data normalization, the natural logarithm in spectral power (ln sp. power, ln mcV^2/Hz) was used.

Student t-test was applied to compare mu rhythm suppression in paranoid schizophrenia patients with the healthy subjects.

2.2.2. Results

Mu rhythm suppression during motor imagery was decreased in all subjects (healthy individuals and patients) in frontal and central locations. The degree of the suppression was higher in healthy controls and substantially decreased in both schizophrenia patient groups (See Table 4).

Location **Subject**	**F3**	**F4**	**C3**	**C4**
F.D.	-0.139	-0.117	-0.172	-0.041
S.A.	-0.071	-0.1	-0.041	-0.068
P-SCH (n=9)	**-0.191±0.05****	-0.292±0.07	**-0.243±0.06***	**-0.203±0.04****
NORM (n=32)	-0.536±0.09	-0.407±0.07	-0.499±0.05	-0.583±0.08

Table 4. Mu rhythm suppression in schizophrenia patients and healthy individuals (ln spectral power).

* - $p<0.05$, ** - $p<0.01$ – differences from the NORM group.

P-SCH – paranoid schizophrenia

NORM – healthy controls

In the Table 4, overall mu rhythm suppression was significantly higher in the healthy subjects (NORM) when compared to schizophrenia patients (P-SCH and the catatonic patients) in the frontal lead F3, and the central leads C3 and C4. Although both catatonic and paranoid schizophrenia patients showed less mu rhythm suppression than the healthy subjects, the difference in suppression between the two patient groups did not reach statistical significance but was rather represented as a tendency to less suppression in catatonic schizophrenia.

Patients F.D. and S.A. showed less mu rhythm suppression than the P-SCH group. Subject S.A. demonstrated a lower result than subject F.D. Interestingly, the clinical catatonic symptoms of S.A. were more pronounced, and he has been having the mental disorder for a longer period of time.

According to the distribution of mu rhythm spectral power, catatonic patients persistently had a lower value indicating less mu rhythm suppression, especially in the right hemisphere (F4 and C4). (See Fig.3.)

Being a co-author of the current study, I did a comprehensive literature review on the topic as well as participated in writing and finalizing the manuscript.

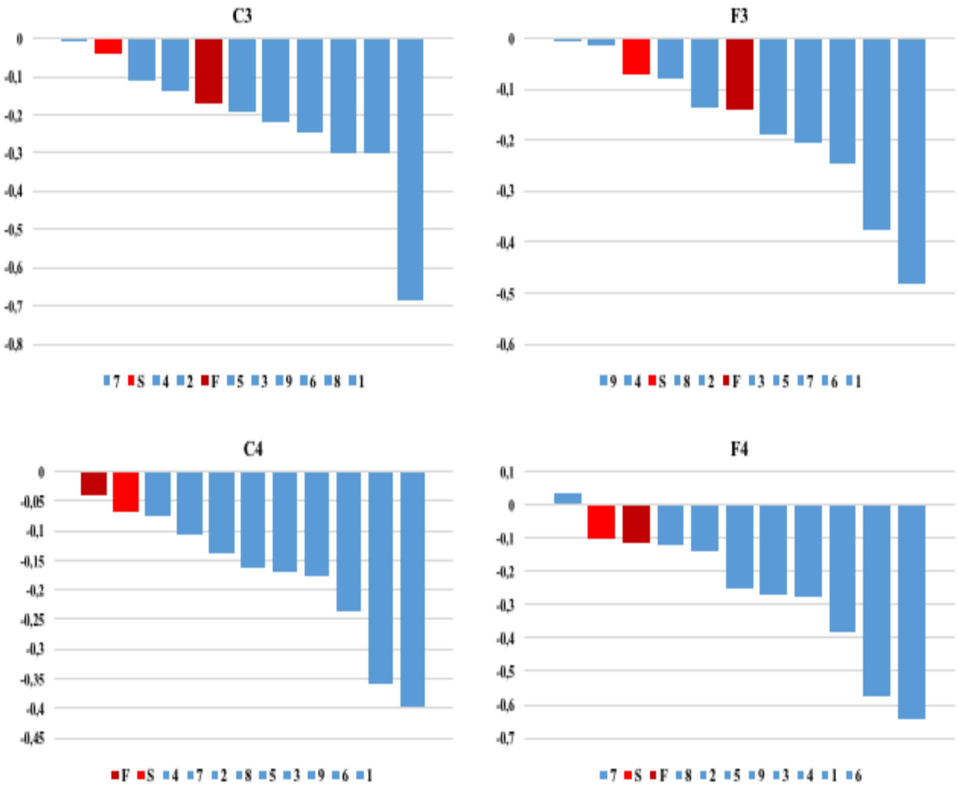

Fig.3. Distribution of the Max spectral power in the group of patients with paranoid and catatonic schizophrenia.

Fig.3. Spectral power of mu rhythm suppression in the patients with paranoid schizophrenia (blue) and catatonic schizophrenia (red). The graph demonstrates that patients with catatonia show less mu rhythm suppression than the majority of paranoid schizophrenia patients, especially in the lead C4 located in the right hemisphere. The suppression of the frontal lead F4 on the same side was also remarkably lower in catatonic schizophrenia patients.

Overall, mu rhythm suppression was shown to be significantly lower in schizophrenia patients in comparison to healthy subjects. Catatonic patients with predominant motor disturbances tend to show even less EEG mu rhythm suppression as opposed to those suffering from paranoid schizophrenia.

2.3. Study 3. Association of Theory of Mind Test Performance with Neurophysiological and Autonomic Parameters in Schizophrenia Patients and Healthy Subjects

Cognitive decline is a well-known feature of schizophrenia occurring after disease onset (Zanelli et al, 2019), making it crucial to take duration of disorder into account when assessing one's mentalizing abilities. Theory of Mind deficit in schizophrenia is commonly investigated with a wide range of psychological and neurobiological methods, including the verbal test 'Hinting Task'. However, it remains unclear whether there is a connection between ToM performance and the physiological parameters in norm and pathology and whether a distinction between the stages of disease can be found based on these criteria. The modern approach to assessment of mental disorders requires taking into consideration multiple contributing factors, therefore, the integration method was recognized as the most promising for that purpose (Mahy et al, 2014). The primary aim of the current study was to compare ToM test performance in chronic schizophrenia, first episode psychosis patients and healthy controls in order to assess the possible changes throughout the course of disease. After that, analysis of correlations between 'Hinting Task' performance with physiological parameters was carried out, followed by the discriminant analysis so as to classify subject groups according to several predictors, including the psychological and physiological parameters.

2.3.1. Methods

The first part of the study included comparative analysis of 'Hinting Task' test performance. Overall, 167 subjects were recruited. All participants were divided into the following groups:

- Group 1 included 50 first episode psychosis patients (28 males and 22 females) aged 27.28±0.74;
- Group 2 included 43 patients with chronic schizophrenia lasting longer than 5 years (28 males and 15 females) aged 31.46±1.61;
- Group 3 included 74 healthy subjects (44 males and 30 females) aged 27.44±0.80.

Groups 1 and 3 did not differ in age; however, group 2 participants were older than groups 1 and 3 ($p < 0.05$). There were no significant gender differences between the groups. All the subjects were physically healthy right-handed individuals and gave their written consent to participate. The project was approved by the local ethical committee.

Each subject with schizophrenia underwent the initial psychopathological symptom assessment according to PANSS scale (Kay et al,1987). The average sum for Group 1 was 73.26±1.84

(16.43±0.7 according to the positive symptoms scale, 16.68±0.64 according to the negative symptoms scale, and 40.15±1.02 according to the general psychopathology scale). The average sum for Group 2 according to PANSS scale was 71.95±2.23 (13.84±0.78 according to the positive symptoms scale, 19.86±0.63 according to the negative symptoms scale, and 37.85±1.44 according to the general psychopathology scale). All the patients were treated with atypical antipsychotics.

During the 'Hinting Task' the subjects were asked to read the situations from the card in front of them and to establish what exactly the main character meant in each of them. In case the subject struggled to give the right answer, they were instructed to flip the card over and read the additional sentence with another hint. Each correct answer was evaluated as 2 points. If the subject got it right from the second attempt, 1 point was given. The total maximum result was 20 points. There was no time limit established.

Comparative analysis of test results was carried out using nonparametric criteria (Mann-Whitney U Test and the Kruskal-Wallis Test). Correlation coefficients between the scores in the 'Hinting Task' and the severity of psychopathological symptoms according to PANSS scale were additionally calculated for Groups 1 and 2 using the Spearman criterion.

In the second part of the study, the relationship between the quality of 'Hinting Task' performance and the electrophysiological and autonomic parameters was analyzed. Consequently, the possibility of classifying the three groups of subjects by the set of predictors, namely, the psychological, electrophysiological and autonomic parameters was tested. The 114 subjects that, along with performing the ToM test, had their physiological parameters recorded both at rest and during a motor imagery task were included in this part of the study. Group 1 consisted of 29 patients (16 males, 13 females), Group 2 – 23 patients (14 males, 9 females), while Group 3 included 62 healthy subjects (37 males, 25 females). This experimental task required the subjects to imagine walking on a familiar street for 2 minutes. The subjects were seated in a dark room with their eyes closed. At the same time, the autonomic and electrophysiological parameters were recorded both during the motor imagery task and at rest.

The 19-channel EEG was recorded according to the international 10-20 system: Fp1, Fp2, F3, F4, F7, F8, C3, C4, T3, T4, T5, T6, P3, P4, O1, O2, Fz, Cz and Pz on an installation comprising a 19-channel amplifier and a personal computer. The recording was monopolar, and the reference electrodes were placed on the linked earlobes. The EEG was recorded for 120 seconds in each functional state. The averaging the data of 10-15 periods analyses lasting 5 seconds each was applied for the calculation of spectral parameters.

Cardiovascular bodily reactions are often used in motor imagery research (Collet et al, 2013), therefore, heart rate was selected as the studied autonomic parameter. It was recorded using an electrode located on the forearm of the left hand, and the grounding electrode was used as a reference. Heart rate (beats per minute) was derived from averaging the R-R interval during the recording time.

The mu rhythm was isolated by an in-house software (Garakh et al, 2020). For the data normalization, the natural logarithm of spectral power (ln sp. power, ln mcV^2/Hz) was used. First, inter-group differences in the mu rhythm suppression value (the difference between the spectral power during motor imagery and at rest) in sensorimotor areas C3 and C4 were revealed. For this purpose, analysis of variance (ANOVA RM) with the categorical factor 'group' (three levels) and the factor 'hemisphere' (left and right) was applied. A posteriori analysis was done using Fisher's Least Significant Difference test.

To identify the relationship between the quality of 'Hinting Task' performance and the physiological parameters, a multiple linear regression analysis was used with stepwise inclusion of predictors in each group of subjects separately. Twenty-four indicators served as independent variables: sociodemographic information (such as the age and the gender of subjects), the spectral power of mu rhythm and its suppression during motor imagery in the leads Fp1, Fp2, F3, F4, F7, F8, C3, C4, Fz, Cz; changes in heart rate at rest and during the motor imagery experiment. Multiple correlation coefficients, regression analyses were done.

In order to assess the possibility of classifying the healthy subjects and the patients with schizophrenia, a classical discriminant analysis with stepwise inclusion of predictors was applied. The 'Hinting Task' scores were used as predictors. Statistical processing of the indicators obtained was performed using the STATISTICA 10.0 software package.

2.3.2. Results

2.3.2.1. Comparative analysis of 'Hinting Task' performance (Fig.4)

The total average score of Group 1 was 18.92 ± 0.26, Group 2 obtained 18.56 ± 0.33, while Group 3 got 19.49 ± 0.12 on average. Kruskal-Wallis non-parametric test revealed differences in 'Hinting Task' performance between the three groups of subjects: $H (2, N = 167) = 8.517$, $p = 0.0141$. Pairwise comparison using Mann-Whitney U Test demonstrated that Group 3 did better than Group 2 ($p = 0.004$) and better than Group 1 at the trend level ($p = 0.07$). There was no difference in the quality of test performance between Groups 1 and 2 ($p = 0.29$).

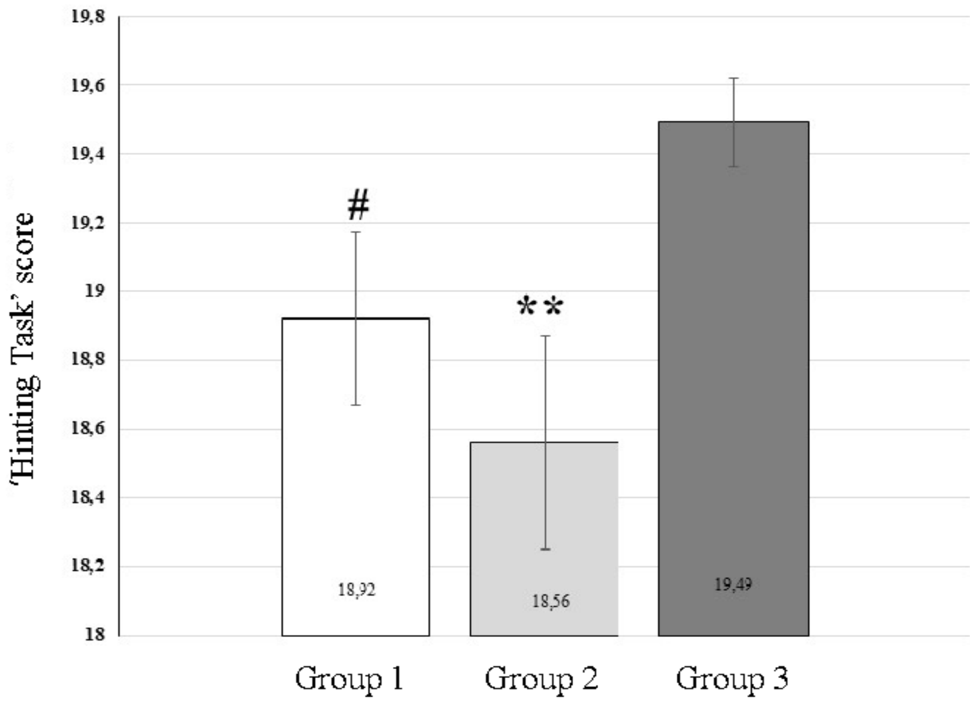

Fig.4. 'Hinting Task' Success Rate. Group 1 (white) represents first episode psychosis patients, Group 2 (light grey) is chronic schizophrenia patients, Group 3 (dark grey) is healthy controls. Group 1 is compared to Group 3: # - $p<0.08$; group 2 is compared to Group 3: ** - $p<0.01$.

2.3.2.2. Correlation analysis of 'Hinting Task' performance quality in relation to the psychopathological symptoms

Spearman criterion correlation analysis did not reveal any reliable associations between the ToM test performance quality and the severity of psychopathological symptoms in any of the groups.

2.3.2.3. Intergroup comparison of mu rhythm suppression during motor imagery (Fig. 5)

Mu rhythm suppression was evaluated in C3 and C4 sensorimotor areas in all three groups of subjects. Analysis of variance showed that the factor 'group' was significant: $F(2,111) = 3.37$, $p = 0.038$. Fisher's LSD posteriori analysis discovered that mu rhythm suppression in lead C4 was more pronounced in Group 3 than in Group 1 ($p = 0.01$) and Group 2 ($p = 0.03$). No mu rhythm suppression differences between Group 1 and Group 2 were detected.

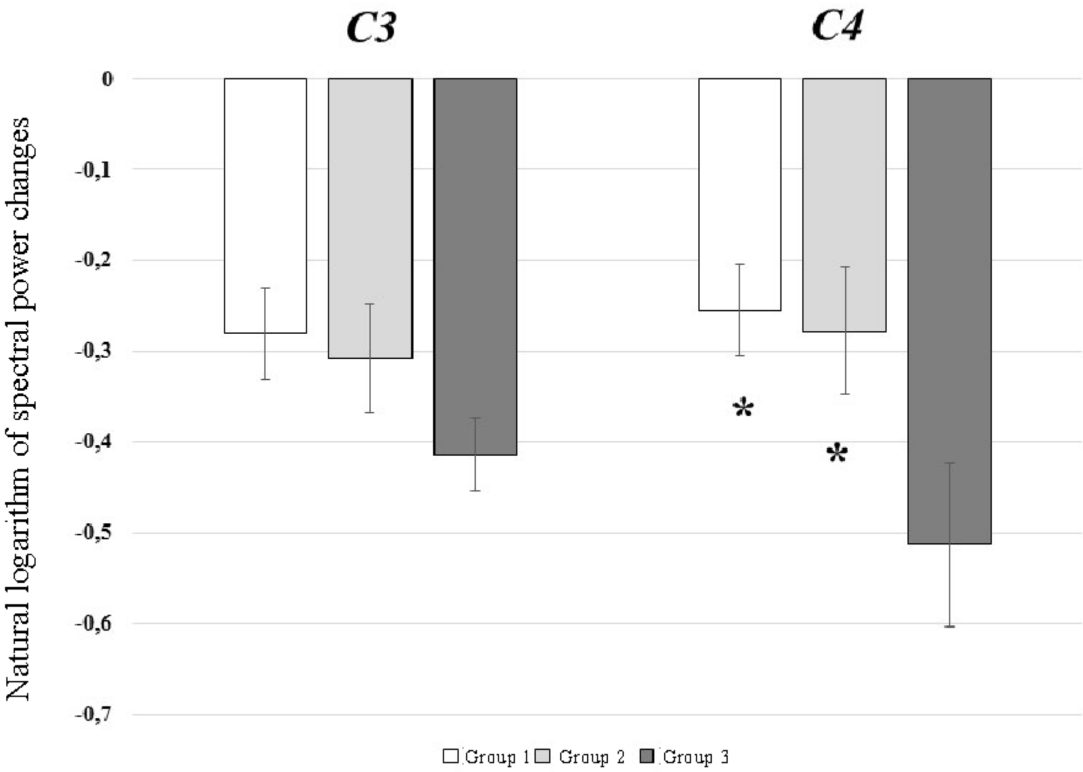

Fig.5. Mu rhythm suppression during motor imagery in comparison to resting conditions. Group 1 (white) represents first episode psychosis patients, Group 2 (light grey) is chronic schizophrenia patients, Group 3 (dark grey) is healthy controls. Group 1 compared to Group 2 and Group 3: * - $p<0.05$.

2.3.2.4. Analysis of the 'Hinting Task' score in relation to electrophysiological and autonomic parameters

In order to detect the combination of physiological factors that had the greatest influence on 'Hinting Task' score, Multiple Regression Analysis was applied. The optimal regression model was created with the 'Hinting Task' being a dependent variable, and the physiological parameters at rest being the independent variables (see Table 5).

Independent variables (at rest)	Standardised β-coefficient	Regression coefficient	t value (25)	p value
Mu rhythm spectral power in lead F7	0.582962	0.61365	4.64334	0.000094
Heart rate (bpm)	0.373012	0.03810	2.99517	0.006109
Mu rhythm spectral power in lead F4	0.319010	0.30524	2.53222	0.017990

Table 5: Optimal Group 1 Regression Model

In the optimal regression model of Group 1, the dependent variable ('Hinting Task') was reliably predicted by three independent variables of physiological parameters at rest (see Table 5): mu rhythm spectral power in leads F4 (factor 1) and F7 (factor 2), as well as heart rate (factor 3).

The greatest contribution to the regression model was made by the factor of mu rhythm spectral power in lead F7. The multiple correlation coefficient R between the 'Hinting Task' score and the physiological parameters described above was 0.784, while the determination coefficient R^2 equaled 0.615 ($F (3, 25) = 13.31$, $p = 0.000022$). That is, 62% of 'Hinting Task' score variations in this subject group are due to the influence of resting electrophysiological and autonomic parameters. To describe this relationship, a regression equation was composed: 'Hinting Task' score = 18.48848 + 0,61365 * factor 1 + 0,30524 * factor 2 + 0,03810 * factor 3. Sociodemographic characteristics did not affect the 'Hinting Task' score.

The most optimal multiple regression models for linking physiological parameters and 'Hinting Task' scores in Group 2 and Group 3 (control group) did not reach the level of statistical significance. Group 2: $R^2 = 0.239$ ($F (3, 19) = 1.997$, $p = 0.149$), Group 3: $R^2 = 0.192$ ($F (6,55) = 2.172$, $p = 0.06$).

2.3.2.5. Discriminant analysis

The first step included searching for a combination of psychological and physiological characteristics, according to which the three groups of subjects could be classified. The method included stepwise inclusion of variables. Once the optimal model was constructed (Wilks'-

Lambda criterion = 0.56802, F (20,204) = 3.3338, p < 0.0000), only Group 3 (control group) was effectively classified (90.3%). Group 1 was classified by 44.8%, and Group 2 was classified by 43.5%. Only the resting values of mu rhythm spectral power in leads C3, C4 and F7, along with resting heart rate, were significant in this model. Since Groups 1 and 2 were classified by less than 50%, the classification results of the three groups were not studied in further detail.

The second step was to test the possibility of an effective classification of healthy subjects and the total sample of schizophrenia patients. The optimal model (Wilks'-Lambda criterion = 0.68147, F (7,106) = 7.0779, p < 0.0000) consisted of six predictors, including the 'Hinting Task' score. The most significant ones were resting mu rhythm spectral power in the sensorimotor areas (C4 and C4), resting heart rate and mu rhythm suppression value in lead C3 (Fig.2). According to the set of predictors, the healthy subjects were correctly classified by 88.7% (55 out of 62 people), and schizophrenia patients by 71.2% (37 out of 52).

Being a co-author of the current study, I did a comprehensive literature review on the topic as well as participated in finalizing the manuscript.

3. Discussion

3.1. ToM Test Performance

All the three ToM tests – the verbal 'Hinting Task' and 'Faux Pas' along with the non-verbal 'Reading the Mind in the Eyes' are commonly used in patients with a number of different mental disorders in order to evaluate their ability to infer mental states of others (Baron-Cohen et al, 2001; Scherzer et al, 2012).

3.1.1. Verbal vs Non-Verbal Tests

All the three tests posed a challenge for first episode psychosis patients, however, the non-verbal 'Reading the Mind in the Eyes' test was the most difficult out of the three. To date, only one study examined the same group of patients' performances in all three tests (Scherzer et al, 2012). Scherzer et al. revealed impaired 'Hinting Task' and 'Faux Pas' performance in schizophrenia subjects, with 'Hinting Task' being less challenging for both groups, which is consistent with our findings. At the same time, the authors did not reveal any significant differences between the groups in 'Reading the Mind in the Eyes' test performance, contrary to our findings.

According to the existing data, schizophrenia patients perform worse than the healthy subjects in all three tests (Baron-Cohen et al, 2001; Sullivan et al, 2012). Specifically, patients with schizophrenia show significantly poorer performance in 'Faux Pas' and 'Hinting Task' than healthy controls (Scherzer et al, 2012). The success rate of 'Reading the Mind in the Eyes' test performance, on the other hand, is rather heterogeneous, with some sources showing worse performance by the patients (Kettle et al, 2008; Hirao et al, 2008), while others demonstrating results comparable with the healthy subjects (Scherzer et al, 2012; Wexler et al, 1998).

Being the only non-verbal test out of the three, 'Reading the Mind in the Eyes' examines one's theory of mind in a substantially different manner. The ability to understand the non-verbal cues is acquired during early childhood, while verbal communication skills develop later (Kreifelts et al, 2013). Therefore, non-verbal communication is more involuntary, more ambiguous yet often more credible than speech. According to different sources, up to 93% of conversation meaning is conveyed nonverbally (Mehrabian, 1972) making it fundamental to any social cognitive skills. In this light, it is not surprising that this test is the most challenging out of the three not only for the patients, but also for the healthy controls (Wexler et al, 1998), which possibly results in comparable test scores in both healthy and schizophrenia subject groups as mentioned above.

3.1.2. Correlations to Symptom Severity

Correlation analysis revealed no reliable associations between verbal test performance and the severity of psychopathological symptoms both in Study 1 and Study 3. Davidson et al. (2019) obtained similar results. However, contrary to our research, they found no correlations between 'Reading the Mind in the Eyes' test performance and PANSS scale. The existing literature shows inconsistent findings, with several studies emphasizing the importance of negative symptoms in relation to ToM test performance (Harrington et al, 2005; Andrzejewska et al, 2017), while others finding an association between positive symptoms and social cognitive skills (Craig et al, 2004). Such discrepancies may be attributed to the differences in methodology, as there is a great variety of cognitive tests and yet no universal agreement upon which one has the highest sensitivity in the context of schizophrenia patients. Another explanation to this divergence in the existing literature is deducible from a recent study by Bliksted et al. (2017), who discovered that the effect of positive symptoms on ToM is heavily influenced by the presence of negative symptoms, meaning that those with milder negative symptomatology may not show correlations with the test performance.

In Study 1, the non-verbal 'Reading the Mind in the Eyes' was the most sensitive and at the same time the only test which correlated with the PANSS scale, making it potentially appropriate for symptom severity estimation in schizophrenia. Here, test performance correlations were found in all three aspects of PANSS – the positive, negative and the general psychopathology scale. Geraci et al. (2012) recorded no significant difference in test performance between the patients with positive symptoms and negative symptoms predominating in the clinical picture, with both groups demonstrating worse test scores than the healthy subjects on the test. According to our data, the worse the patient performed, the higher the positive symptom scale, indicating more pronounced psychopathological symptoms, such as delusions and hallucinations. These findings are consistent with Craig et al. (2004), who found negative correlations between positive symptoms and 'Reading the Mind in the Eyes' test performance. Besides, our results showed a negative correlation between the current test score and the negative symptoms, more specifically, the blunted affect, which is confirmed by Kelemen et al. (2005). Furthermore, several correlations in the general psychopathology scale were discovered, such as depression and bizarre thoughts. These impairments detected in all PANSS scale aspects imply that ToM in schizophrenia is state-independent, confirmed by Bertrand et al. (2007).

3.1.3. Correlations to Disease Duration

Study 3 included both chronic schizophrenia and first episode psychosis groups and revealed no difference in 'Hinting Task' performance between the patients, while healthy subjects performed significantly better. McGlade et al. (2008) indirectly obtained similar results by finding no correlations between 'Reading the Mind in the Eyes' and 'Hinting Task' performance with the age, gender, disease duration and the medication doses. Another study (Mazza et al, 2012) compared 'False Belief Task' performance in the first episode psychosis patients and the chronic patients, and discovered no significant intergroup differences. This may be explained by a pre-existing deficit in schizophrenia patients, since their unaffected first-degree relatives perform better than them yet worse than the healthy controls (Janssen et al, 2003). Wykes et al. (2001) discovered no differences in test performance between the patients and their unaffected siblings. The existing data go in accordance with our findings, and allow us to regard ToM impairment as a trait of the disease (Brüne, 2005).

3.1.4. Correlations to Physiological Parameters

In Study 3, 'Hinting Task' score correlated with the physiological parameters in first episode psychosis patients. Neither chronic schizophrenia patients nor the healthy subjects showed any reliable correlation between 'Hinting Task' performance and physiological parameters. The physiological predictors of test performance included autonomic and electrophysiological parameters at rest, which leads us to the assumption that these parameters may represent the special psychophysiological state of the first episode patients. In particular, in the current group of patients this may be regarded as a stress reaction in response to the changing homeostatic conditions, whereas the chronic patients may be able to compensate for this specific state due to adaptation to their lasting disease. No correlations between 'Hinting Task' performance and the physiological markers of motor imagery were found. No associations between the test score and the age and/or gender of the subjects were found either, which was previously confirmed in another study (McGlade et al, 2008).

3.2. Mu Rhythm and ToM

The mirror neuron system gets activated both when someone performs a motor action and observes the same action, hence it is considered to be part of social cognitive processes (Gallese et al, 1996). One of the ways to study this phenomenon is using electrophysiological parameters, namely, the EEG mu rhythm. In our study, we measured mu rhythm suppression during a motor imagery task. Mu rhythm suppression is a normal event that occurs during movement execution as well as motor imagery in healthy subjects. Although the former is followed by muscle movement, while the latter is not, both require thorough motor planning that occurs in the frontal cortex. The areas involved include the mirror neuron system (Molenberghs et al, 2009), therefore, impaired motor planning detected by insufficient EEG mu rhythm suppression indicates mirror neuron dysfunction, known to be present in schizophrenia.

Several neuroimaging studies performed in the last few years offer a possible explanation of this impairment. Neuroimaging data on catatonia subjects show significant alterations in the neural network of the right hemisphere, specifically in the medial and lateral orbitofrontal networks as well as posterior parietal cortex (Northoff, 2000). The function of this particular network may be altered due to dysfunctional GABAergic transmission caused by the decreased density of GABA receptors, which results in insufficient inhibition and decreased top-down control (Ellul & Choucha, 2015). This may be the possible explanation of the motor and behavioural disturbances observed in clinical practice as well as altered cognitive processing in such patients.

3.2.1. Schizophrenia vs Healthy Subjects

Both Study 2 and Study 3 included schizophrenia and healthy subjects, with those unaffected by the disease showing higher mu rhythm suppression index. Absence of adequate mu rhythm suppression indicates parietal and frontal cortical dysfunction, leading to decreased motor control (Danckert et al, 2002) and impaired voluntary movement planning (Danckert et al, 2004) as well as being an indirect indicator of malfunctioning mirror neuron system. In the previous brain imaging studies schizophrenia patients exhibited a lack of activity in mirror neuron areas (Enticott et al, 2008) associated with the inability to fully comprehend the actions of self and others (Schurmann et al, 2007). Our results go in line with the behavioural experiment performed by Lallart et al. (2012), who studied motor imagery by asking the subjects to imagine walking on a familiar street. The patients were substantially slower in creating the internal representation of their own walk due to increased sensitivity to the external stimuli and executive functioning deficit (Lallart et al, 2012), which is characteristic for the disease (Orellana & Slachevsky, 2013).

3.2.2. Paranoid vs Catatonic Schizophrenia

Study 2 included subjects with catatonic and paranoid schizophrenia. Despite the absence of statistically significant intergroup differences, the more pronounced motor deficits in schizophrenia were associated with less mu suppression on the EEG. Therefore, catatonic schizophrenia subjects show the least mu rhythm suppression. To the best of our knowledge, no studies have investigated catatonic schizophrenia in the given context so far, most probably due to the fact that this subtype of disease is rather rare. Such patients are characterised by predominant motor symptoms, and mu rhythm suppression index is inversely related to excitability of motor cortex (Yin et al. 2016). In other words, one may expect less mu rhythm suppression in schizophrenia subjects with more pronounced motor symptoms, which is to a limited extent consistent with our findings. The lack of intergroup statistical significance may be explained by a small sample group, although obtaining a larger sample for future research may be challenging due to catatonic schizophrenia being an uncommon diagnosis (McGlashan & Fenton, 1991).

Catatonic patients are known to have functional disbalance between the ventromedial prefrontal cortex and the dorsolateral prefrontal cortex, making cognitive control of emotions as well as the associative function of the dorsolateral prefrontal cortex more challenging (Ellul & Choucha, 2015). The cognitive impairments are connected with the parietal lobe and the motor cortex, resulting in motor symptoms of schizophrenia (Ellul & Choucha, 2015). This highlights the connection between the motor and cognitive impairment in catatonia, and supports our findings.

3.2.3. Correlations of the index of the mu rhythm suppression and the disease duration

Study 3 included both chronic schizophrenia as well as first episode psychosis patients. Our data showed decreased mu rhythm suppression index in both patient groups in comparison to healthy subjects in the right sensorimotor area. At the same time, the two patient groups had comparable results. Similar data was obtained by Mitra et al. (2014) and one more study that noted the tendency for decreased mu rhythm suppression (Brown et al, 2016). However, there are several studies that did not reveal any mu rhythm suppression differences between schizophrenia patients and healthy subjects (Horan et al, 2014; McCormick et al, 2012; Singh et al, 2011). The discrepancies in findings are to be expected, since this area of research is relatively new and the methods applied may differ substantially.

3.3. Group Classification Based on Multiple Parameters

An approach that incorporates several aspects of ToM evaluation has been increasingly applied in order to find the characteristics that differentiate between schizophrenia patients and healthy subjects. Combining several cognitive and social cognitive psychometric parameters led to a rather successful classification of the subjects into the patient group, their unaffected relatives as well as the healthy control group (Huepe et al, 2012). In their study, Johannesen et al. (2013) attempted to classify the patients into schizophrenia and bipolar disorder by combining P50 and P300 event related potentials, which was unsuccessful. Later on, the same authors (Johannesen et al, 2016) concluded that in order to classify patients not only neurophysiological, but also psychometric parameters, i.e. testing of cognitive functions, need to be used. Indeed, Lin et al. (Lin et al. 2012) demonstrated that using either one of the parameters leads to less successful classification than combining both the neurophysiological and psychometric parameters. In Study 3, the most successful selection of parameters to classify schizophrenia patients and healthy subjects included 'Hinting Task' score, electrophysiological and autonomic parameters at rest and their alterations during motor imagery. Classification success averaged 81%. Therefore, healthy subjects and schizophrenia patients can be classified with the help of psychometric and physiological parameters, which combine several aspects of ToM.

4. Conclusions

The current research was aimed at establishing the significance of non-verbal communication for ToM in schizophrenia patients evaluated by cognitive testing, electrophysiological and autonomic parameters.

The major findings of this research were as follows:

1. **Subjects with schizophrenia show poorer performance on ToM tests than the healthy controls.**

   All the three ToM tests applied were more challenging for the patients than for the healthy subjects. Indeed, ToM impairment in schizophrenia is detectable by cognitive testing, which is well documented in literature (Baron-Cohen et al, 2001; Harrington et al, 2005; Sprong et al, 2007) and was repeatedly confirmed in our studies.

2. **The non-verbal tests evaluate ToM deficit in schizophrenia patients with higher accuracy than the verbal tests.**

   The non-verbal test applied was more sensitive than the verbal ones. Non-verbal cognition is first to develop in life, and it serves as the cornerstone of one's social cognitive development later on, as children with impaired non-verbal communication skills grow up demonstrating a whole different communication profile (Chiang et al, 2008), leading to impairments in social cognition. Therefore, non-verbal tests are aimed at detecting the fundamental deficit, making them potentially more accurate than the verbal tests as they target the primary impairment.

3. **The severity of psychopathological symptoms correlates with non-verbal test performance in schizophrenia patients.**

   Out of the three tests applied, only the non-verbal test performance correlated with the psychopathological symptoms evaluated by PANSS scale. In other words, the more severe the symptoms, the worse the subject scored. Our results were confirmed by Okruszek et al. (2017), who found similar correlations in schizophrenia patients, but not in patients with temporal lobe epilepsy, suggesting that ToM impairment is likely to be a trait of schizophrenia.

4. **Disease duration does not impact ToM test performance in schizophrenia, i.e. the deficit is state-independent.**

   ToM test performance is rather consistent throughout the course of disease (Sprong et al, 2007). This was also confirmed in our research, meaning that the impairment is state-independent, most likely present from early childhood and does not fluctuate throughout the course of disease (Mazza et al, 2012; McGlade et al, 2008).

5. **Schizophrenia subjects show less EEG mu rhythm suppression during the motor imagery task than the healthy subjects.**
   Mu rhythm suppression is a method used to investigate the activity of the mirror neuron system, known to be dysfunctional in schizophrenia (Hobson & Bishop, 2017). Decreased mu rhythm suppression reflects the mirror neuron system impairment, and goes in accordance with the previous research (Singh et al, 2011).
6. **The degree of mu rhythm suppression is inversely related to severity of motor deficits in schizophrenia patients.**
   Being a characteristic feature of schizophrenia, motor deficits vary in severity, with catatonic schizophrenia being characterized by the predominance of motor disturbances (ICD-10). The mirror neuron system overlaps with the motor cortex (Molenberghs et al, 2009), therefore, the degree of mu rhythm suppression is inversely related to severity of motor deficits, confirmed by our study, as catatonic patients showed a tendency to less mu rhythm suppression than the paranoid schizophrenia patients.
7. **Psychological and physiological predictors can assist in classifying the subjects into the schizophrenia group and the healthy group.**
   Using a combination of both physiological parameters and predictors based on ToM test performance can lead to a rather successful classification of subjects (Huepe et al, 2012). Since the mirror neuron system deficit is a complex issue that includes both motor dysfunction detected primarily by the EEG as well as social cognitive impairment, implementing both kinds of predictors leads to a possibility to classify the subjects into a healthy group and a schizophrenia group.

Overall, our research confirms the importance of non-verbal communication and motor function in schizophrenia. Both can be detected in several ways, including electrophysiological and autonomic methods as well as cognitive testing, and both have been shown to be related to the Theory of Mind function. This highlights the nature of the non-verbal cognitive impairment, which appears to be a trait of schizophrenia.

Limitations and Suggestions for Further Research

The findings of the current research have to be seen in the light of some limitations. The sample size for the comparative analysis of ToM tests was rather small, and even more so in the study with catatonic schizophrenia – the limitation is present due to the diagnosis being rare. Control groups were matched by age and gender, but not by IQ or the level of education. All the patients were treated with atypical antipsychotic medications, which in different doses could have potentially had an impact on the results obtained – a limitation that ethically could not have been avoided. One of the predictors used for patient classification was a verbal test 'Hinting Task', which is not the most sensitive to ToM deficit, as discovered by us in the process.

All of the above should be taken into consideration when conducting further research. Potential improvements can be made by implementing a non-verbal test, increasing the number of subjects and matching them by their IQ level and education in the future.

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Appendix 1: Positive and Negative Symptom Scale (PANSS)

Positive and Negative Symptom Scale (PANSS) was first developed by Kay et al. (1987) and tested on over 100 patients with schizophrenia (Kay et al, 1987). The scale comprises 30 items – 7 on the positive scale, 7 on the negative scale and 16 on the general psychopathology scale:

Positive Scale (minimum score = 7, maximum score = 49)

P1. Delusions

P2. Conceptual disorganization

P3. Hallucinatory behaviour

P4. Excitement

P5. Grandiosity

P6. Suspiciousness

P7. Hostility

Negative Scale (minimum score = 7, maximum score = 49)

N1. Blunted affect

N2. Emotional withdrawal

N3. Poor rapport

N4. Passive/apathetic social withdrawal

NS. Difficulty in abstract thinking

N6. Lack of spontaneity and flow of conversation

N7. Stereotyped thinking

General Psychopathology Scale (minimum score = 16, maximum score = 112)

G1. Somatic concern

G2. Anxiety

G3. Guilt feelings

G4. Tension

G5. Mannerisms & posturing

G6. Depression

G7. Motor retardation

G8. Uncooperativeness

G9. Unusual thought content

G10. Disorientation

G11. Poor attention

G12. Lack of judgment and insight

G13. Disturbance of volition

G14. Poor impulse control

G15. Preoccupation

G16. Active social avoidance

As shown above, each symptom is clearly defined, and there are a maximum of seven points that may be attributed to each item: 1 = absent, 2 = minimal, 3 = mild, 4 = moderate, 5 = moderate–severe, 6 = severe, 7 = extreme. In order to obtain the total score, the points for each subscale are to be added up. The minimum total score is 30, while the maximum is 210.

Appendix 2: Reading the Mind in the Eyes Test (Baron-Cohen et al, 2001)

Test Instructions (Adult Version):

Here is a booklet with a set of photographs of people's eyes. Beside each photo there are 4 words describing the feelings or thoughts of the person depicted in the photo.

For each page of the test, select and mark on the answer sheet the best description of what the person in the photo thinks or feels. You only need to choose one word that best describes the feelings or thoughts of the person in the photograph.

Before you make a choice, please read all 4 description words. If you don't know what one of the words means, you can look up the meaning of that word in the glossary (below). If it seems to you that none of the 4 words-descriptions are suitable for the correct answer, please write what, in your opinion, the person depicted in the photo thinks or feels in the special column in the answer form.

The test execution time is unlimited.

GLOSSARY

ACCUSING — blaming
The policeman was accusing the man of stealing a wallet.

AFFECTIONATE — showing fondness towards someone
Most mothers are affectionate to their babies by giving them lots of kisses and cuddles.

AGHAST — horrified, astonished, alarmed
Jane was aghast when she discovered her house had been burgled.

ALARMED — fearful, worried, filled with anxiety
Claire was alarmed when she thought she was being followed home.

AMUSED — finding something funny
I was amused by a funny joke someone told me.

ANNOYED — irritated, displeased
Jack was annoyed when he found out he had missed the last bus home.

ANTICIPATING	expecting At the start of the football match, the fans were anticipating a quick goal.
ANXIOUS	worried, tense, uneasy The student was feeling anxious before taking her final exams.
APOLOGETIC	feeling sorry The waiter was very apologetic when he spilt soup all over the customer.
ARROGANT	conceited, self-important, having a big opinion of oneself The arrogant man thought he knew more about politics than everyone else in the room.
ASHAMED	overcome with shame or guilt The boy felt ashamed when his mother discovered him stealing money from her purse.
ASSERTIVE	confident, dominant, sure of oneself The assertive woman demanded that the shop give her a refund.
BAFFLED	confused, puzzled, dumbfounded The detectives were completely baffled by the murder case.
BEWILDERED	utterly confused, puzzled, dazed The child was bewildered when visiting the big city for the first time.
CAUTIOUS	careful, wary Sarah was always a bit cautious when talking to someone she did not know.
COMFORTING	consoling, compassionate The nurse was comforting the wounded soldier.
CONCERNED	worried, troubled The doctor was concerned when his patient took a turn for the worse.
CONFIDENT	self-assured, believing in oneself The tennis player was feeling very confident about winning his match.

CONFUSED puzzled, perplexed
Lizzie was so confused by the directions given to her, she got lost.

CONTEMPLATIVE reflective, thoughtful, considering
John was in a contemplative mood on the eve of his 60th birthday.

CONTENTED satisfied
After a nice walk and a good meal, David felt very contented.

CONVINCED certain, absolutely positive
Richard was convinced he had come to the right decision.

CURIOUS inquisitive, inquiring, prying
Louise was curious about the strange shaped parcel.

DECIDING making your mind up
The man was deciding whom to vote for in the election.

DECISIVE already made your mind up
Jane looked very decisive as she walked into the polling station.

DEFIANT insolent, bold, don’t care what anyone else thinks
The animal protester remained defiant even after being sent to prison.

DEPRESSED miserable
George was depressed when he didn't receive any birthday cards.

DESIRE passion, lust, longing for
Kate had a strong desire for chocolate.

DESPONDENT gloomy, despairing, without hope
Gary was despondent when he did not get the job he wanted.

DISAPPOINTED displeased, disgruntled
Manchester United fans were disappointed not to win the Championship.

DISPIRITED glum, miserable, low
Adam was dispirited when he failed his exams.

DISTRUSTFUL suspicious, doubtful, wary
The old woman was distrustful of the stranger at her door.

DOMINANT commanding, bossy
The sergeant major looked dominant as he inspected the new recruits.

DOUBTFUL dubious, suspicious, not really believing
Mary was doubtful that her son was telling the truth.

DUBIOUS doubtful, suspicious
Peter was dubious when offered a surprisingly cheap television in a pub.

EAGER keen
On Christmas morning, the children were eager to open their presents.

EARNEST having a serious intention
Harry was very earnest about his religious beliefs.

EMBARRASSED ashamed
After forgetting a colleague's name, Jenny felt very embarrassed.

ENCOURAGING hopeful, heartening, supporting
All the parents were encouraging their children in the school sports day.

ENTERTAINED absorbed and amused or pleased by something
I was very entertained by the magician.

ENTHUSIASTIC very eager, keen
Susan felt very enthusiastic about her new fitness plan.

FANTASIZING daydreaming
Emma was fantasizing about being a film star.

FASCINATED captivated, really interested
At the seaside, the children were fascinated by the creatures in the rock pools.

FEARFUL terrified, worried
In the dark streets, the women felt fearful.

FLIRTATIOUS brazen, saucy, teasing, playful

Connie was accused of being flirtatious when she winked at a stranger at a party.

FLUSTERED — confused, nervous and upset
Sarah felt a bit flustered when she realised how late she was for the meeting and that she had forgotten an important document.

FRIENDLY — sociable, amiable
The friendly girl showed the tourists the way to the town centre.

GRATEFUL — thankful
Kelly was very grateful for the kindness shown by the stranger.

GUILTY — feeling sorry for doing something wrong
Charlie felt guilty about having an affair.

HATEFUL — showing intense dislike
The two sisters were hateful to each other and always fighting.

HOPEFUL — optimistic
Larry was hopeful that the post would bring good news.

HORRIFIED — terrified, appalled
The man was horrified to discover that his new wife was already married.

HOSTILE — unfriendly
The two neighbours were hostile towards each other because of an argument about loud music.

IMPATIENT — restless, wanting something to happen soon
Jane grew increasingly impatient as she waited for her friend who was already 20 minutes late.

IMPLORING — begging, pleading
Nicola looked imploring as she tried to persuade her dad to lend her the car.

INCREDULOUS — not believing
Simon was incredulous when he heard that he had won the lottery.

INDECISIVE	unsure, hesitant, unable to make your mind up Tammy was so indecisive that she couldn't even decide what to have for lunch.
INDIFFERENT	disinterested, unresponsive, don't care Terry was completely indifferent as to whether they went to the cinema or the pub.
INSISTING	demanding, persisting, maintaining After a work outing, Frank was insisting he paid the bill for everyone.
INSULTING	rude, offensive The football crowd was insulting the referee after he gave a penalty.
INTERESTED	inquiring, curious After seeing Jurassic Park, Hugh grew very interested in dinosaurs.
INTRIGUED	very curious, very interested A mystery phone call intrigued Zoe.
IRRITATED	exasperated, annoyed Frances was irritated by all the junk mail she received.
JEALOUS	envious Tony was jealous of all the taller, better-looking boys in his class.
JOKING	being funny, playful Gary was always joking with his friends.
NERVOUS	apprehensive, tense, worried Just before her job interview, Alice felt very nervous.
OFFENDED	insulted, wounded, having hurt feelings When someone made a joke about her weight, Martha felt very offended.
PANICKED	distraught, feeling of terror or anxiety On waking to find the house on fire, the whole family was panicked.
PENSIVE	thinking about something slightly worrying

Susie looked pensive on the way to meeting her boyfriend's parents for the first time.

PERPLEXED	bewildered, puzzled, confused Frank was perplexed by the disappearance of his garden gnomes.
PLAYFUL	full of high spirits and fun Neil was feeling playful at his birthday party.
PREOCCUPIED	absorbed, engrossed in one's own thoughts Worrying about her mother's illness made Debbie preoccupied at work
PUZZLED	perplexed, bewildered, confused After doing the crossword for an hour, June was still puzzled by one clue.
REASSURING	supporting, encouraging, giving someone confidence Andy tried to look reassuring as he told his wife that her new dress did suit her.
REFLECTIVE	contemplative, thoughtful George was in a reflective mood as he thought about what he'd done with his life.
REGRETFUL	sorry Lee was always regretful that he had never travelled when he was younger.
RELAXED	taking it easy, calm, carefree On holiday, Pam felt happy and relaxed.
RELIEVED	freed from worry or anxiety At the restaurant, Ray was relieved to find that he had not forgotten his wallet.
RESENTFUL	bitter, hostile The businessman felt very resentful towards his younger colleague who had been promoted above him.
SARCASTIC	cynical, mocking, scornful The comedian made a sarcastic comment when someone came into the theatre late.

SATISFIED	content, fulfilled Steve felt very satisfied after he had got his new flat just how he wanted it.
SCEPTICAL	doubtful, suspicious, mistrusting Patrick looked sceptical as someone read out his horoscope to him.
SERIOUS	solemn, grave The bank manager looked serious as he refused Nigel an overdraft.
STERN	severe, strict, firm The teacher looked very stern as he told the class off.
SUSPICIOUS	disbelieving, suspecting, doubting After Sam had lost his wallet for the second time at work, he grew suspicious of one of his colleagues.
SYMPATHETIC	kind, compassionate The nurse looked sympathetic as she told the patient the bad news.
TENTATIVE	hesitant, uncertain, cautious Andrew felt a bit tentative as he went into the room full of strangers.
TERRIFIED	alarmed, fearful The boy was terrified when he thought he saw a ghost.
THOUGHTFUL	thinking about something Phil looked thoughtful as he sat waiting for the girlfriend he was about to finish with.
THREATENING	menacing, intimidating The large, drunken man was acting in a very threatening way.
UNEASY	unsettled, apprehensive, troubled Karen felt slightly uneasy about accepting a lift from the man she had only met that day.
UPSET	agitated, worried, uneasy The man was very upset when his mother died.
WORRIED	anxious, fretful, troubled When her cat went missing, the girl was very worried.

ANSWER SHEET

Date of Birth: Today's Date: Occupation:

P	jealous	panicked	arrogant	hateful
1	playful	comforting	irritated	bored
2	terrified	upset	arrogant	annoyed
3	joking	flustered	desire	convinced
4	joking	insisting	amused	relaxed
5	irritated	sarcastic	worried	friendly
6	aghast	fantasizing	impatient	alarmed
7	apologetic	friendly	uneasy	dispirited
8	despondent	relieved	shy	excited
9	annoyed	hostile	horrified	preoccupied
10	cautious	insisting	bored	aghast
11	terrified	amused	regretful	flirtatious
12	indifferent	embarrassed	sceptical	dispirited
13	decisive	anticipating	threatening	shy
14	irritated	disappointed	depressed	accusing
15	contemplative	flustered	encouraging	amused
16	irritated	thoughtful	encouraging	sympathetic

17	doubtful	affectionate	playful	aghast
18	decisive	amused	aghast	bored
19	arrogant	grateful	sarcastic	tentative
20	dominant	friendly	guilty	horrified
21	embarrassed	fantasizing	confused	panicked
22	preoccupied	grateful	insisting	imploring
23	contented	apologetic	defiant	curious
24	pensive	irritated	excited	hostile
25	panicked	incredulous	despondent	interested
26	alarmed	shy	hostile	anxious
27	joking	cautious	arrogant	reassuring
28	interested	joking	affectionate	contented
29	impatient	aghast	irritated	reflective
30	grateful	flirtatious	hostile	disappointed
31	ashamed	confident	joking	dispirited
32	serious	ashamed	bewildered	alarmed
33	embarrassed	guilty	fantasizing	concerned
34	aghast	baffled	distrustful	terrified
35	puzzled	nervous	insisting	contemplative

36	ashamed	nervous	suspicious	indecisive

Practice

jealous panicked

arrogant hateful

1

playful comforting

irritated bored

2

terrified upset

arrogant annoyed

3

joking flustered

desire convinced

4

joking insisting

amused relaxed

5

irritated sarcastic

worried friendly

6

aghast fantasizing

impatient alarmed

7

apologetic friendly

uneasy dispirited

8

despondent relieved

shy excited

9

annoyed hostile

horrified preoccupied

10

cautious

insisting

bored

aghast

11

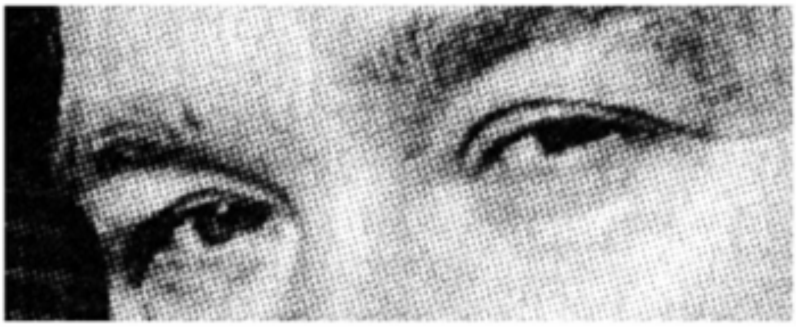
terrified amused

regretful flirtatious

12

indifferent

embarrassed



sceptical

dispirited

13

decisive anticipating

threatening shy

14

irritated disappointed

depressed accusing

15

contemplative flustered

encouraging amused

16

irritated thoughtful

encouraging sympathetic

17

doubtful affectionate

playful aghast

18

decisive amused

aghast bored

19

arrogant grateful

sarcastic tentative

20

dominant friendly

guilty horrified

21

embarrassed fantasizing

confused panicked

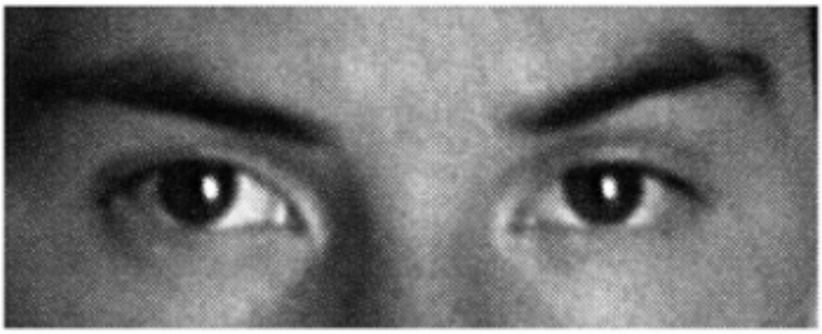
22

preoccupied grateful

insisting imploring

23

contented apologetic



defiant curious

24

pensive irritated

excited hostile

25

panicked incredulous

despondent interested

26

alarmed shy

hostile anxious

27

joking cautious

arrogant reassuring

28

interested joking

affectionate contented

29

impatient aghast

irritated reflective

30

grateful flirtatious

hostile disappointed

31

ashamed confident

joking dispirited

32

serious ashamed

bewildered alarmed

33

embarrassed guilty

fantasizing concerned

34

aghast baffled

distrustful terrified

35

puzzled nervous

insisting contemplative

36

ashamed nervous

suspicious indecisive

Appendix 3: Hinting Task (Corcoran et al, 1995)

Instructions:

‘Read the description of each situation carefully, and answer the question to your best understanding’.

If the subject does not cope with the task the first time, the instructions are as follows:

‘Flip the card. The continuation of the situation is written on the reverse side - answer the question presented there’

Processing: 2 points per situation are awarded in case the subject completes the task from the first attempt; 1 point per situation is awarded in case the subject completes the task after flipping the card; if no correct answer was given the subject is awarded 0 points. The points for each individual situation are then added up to achieve the total score. The maximum score is 20 points, while the minimum is 0.

The current version of the test contains slight modifications for the Russian-speaking subjects.

Card 1

Oksana's birthday is approaching. She says to her father:

‘You know, I love animals, and especially dogs so much!

What does Oksana really mean?

(2nd attempt)

Oksana continues to talk and asks if her favourite store is open on her birthday.

What does Oksana want from her father?

Card 2

Oleg has 5 cigarettes left in his cigarette pack. He leaves the room, leaving the pack on the table.

Sergei comes up to the table and takes two cigarettes out of the pack.

How many cigarettes does Oleg expect to see in his pack when he comes back to the room?

(2nd attempt)

Before leaving the room Oleg asked Sergei not to touch his cigarettes.

How many cigarettes, according to Oleg, are left in the pack?

Card 3

A husband and his wife have just finished having dinner. The wife puts the dishes into the sink, then turns to her husband and says:

‘Honey, I'm so tired ...’

What does the wife mean?

(2nd attempt)

The wife tells her husband that she is pleased when he takes care of her and helps her around the house.

What does she want her husband to do?

Card 4

Dmitry is going to buy a DVD as a gift for his friend. He finds a suitable one in the store, but discovers that he does not have enough money with him. Dmitry goes home to pick up the money. During his absence, another person buys this DVD.

What does Dmitry expect to see when he returns to the store?

(2nd attempt)

Dmitry checks to make sure he has enough money now, and approaches the seller.

What is he going to ask?

Card 5

Three friends (Irina, Sergey and Olga) are sitting in a cafe. It's getting pretty late. Olga keeps looking at her watch from time to time. Then she says to her friends: ‘I’ve got so many things to do tomorrow ...’

What kind of reaction does she expect from them?

(2nd attempt)

Her friends suggest ordering another cup of tea. Olga refuses to have one and says that she has to get up early tomorrow, and the cafe is closing soon.

What does Olga mean?

Card 6

Alexander takes the last free seat on the bus. At the next stop, an elderly woman walks in with heavy bags. She stops next to Alexander and sighs heavily several times.
What does she expect from him?
(2nd attempt)
An elderly woman complains to Alexander about what a difficult day she had and that she is very tired.
What does the elderly woman expect Alexander to do?

Card 7
Maxim is a student at school. He studied a lot and is very well prepared for the upcoming test. During the test he finds all tasks to be easy.
How should the teacher evaluate his work, according to Maxim?
(2nd attempt)
Maxim checks his answers several times and is sure that he solved everything correctly.
What grade does Maxim expect for his work?

Card 8
Igor invites Julia, whom he really likes, to a pizzeria. When the bill comes Julia looks at Igor and smiles.
What actions does she expect from him?
(2nd attempt)
Julia looks at the bill and says: ‘What a huge sum! I’m afraid I don’t have enough money…’
What does Julia want from Igor?

Card 9
Marina has a cat that suddenly gets very sick. Marina's parents put the cat down during her absence.
What will be Marina's reaction to this news?
(2nd attempt)
Marina loved her cat very much and her parents were going to tell her the news very carefully.
How will Marina feel when she finds out about the death of her pet?

Card 10

Victor lives separately from his parents; he is busy and works full time, yet he maintains a good relationship with both his mother and father. One day he calls them and says that he is going to get married.

What kind of reaction does Victor expect from his parents?

(2nd attempt)

Victor's parents are always happy for his achievements, and therefore he really wanted to share the news with them.

Appendix 4: Faux Pas (Stone et al, 1998)

Instructions:

All the stories are printed out and placed in front of the subject.

'I will read these short stories out loud to you and ask you questions about them. The stories are also placed in front of you, so you can read them again at any point'. The instructor reads the stories and asks questions about whether anyone said anything inappropriate in the story, and if so, then who said it and why. The last question after each story is a control question that ensures the subject's understanding of the story.

Scoring the Faux Pas task:

For each story containing a faux pas (2, 4, 7, 11-16, 18) the subject gets one point for each correct answer.

Question 1: Has anyone said anything inappropriate they should not have said?

The right answer is 'Yes' for the faux pas-containing stories (2, 4, 7, 11-16, 18); the right answer is 'No' for control stories.

Question 2: Who exactly said something inappropriate?

Story 2 (Surprise Party) – Sasha (the woman who spilled the coffee)

Story 4 (The Curtain Story) – Lisa (the girlfriend)

Story 7 (Calling a Girl a Boy) – Maria (the neighbour)

Story 11 (The Cancer Patient Story) – Maxim (the guy who came late)

Story 12 (A New Boy at School) – Vanya (Vanya and Petya)

Story 13 (The Pie Story) – Seryozha (Stacy's cousin)

Story 14 (The Crystal Vase Story) – Anya (the hostess, or the married woman)

Story 15 (The Story Contest) – Fedya (the guy who won)

Story 16 (The Spilled Coffee Story) – Gena (the guy who spilled coffee)

The subjects who answered 'No' to the first question are automatically awarded 0 points here.

Question 3: Why should they not have said it or why was it inappropriate?

Any reasonable answer is acceptable without going into details – the subject does not get a point here only if their answer does not reflect an understanding of faux pas.

The subjects who answered 'No' to the first question are automatically awarded 0 points here.

Question 4: Why do you think they said it?

Any reasonable answer is acceptable – the subject does not get a point here only if their answer does not reflect an understanding of faux pas.
The subjects who answered 'No' to the first question are automatically awarded 0 points here.
Question 5: Did XXX know that YYY?
If the subject demonstrates an understanding of faux pas, a point is awarded.
Question 6: How do you think XXX felt?
This question evaluates the subject's empathy for the story characters. The subject's response should reflect the character's perceived emotions.
Question 7 & 8: These two questions reflect how well the subject remembers the story and its details.

The maximum score for the 10 faux pas-containing stories is 60 points. The maximum score for control stories is 20 points (2 points are awarded if the subject answers 'No' to the first question). All the points need to be evaluated separately. If the answers to control questions are incorrect, you should carefully interpret the errors in the questions associated with false beliefs in these stories. It seems advisable to exclude points for this story and calculate the total percentage of correct answers not from 60, but from 54, 48, etc.
The current version of the test contains slight modifications for the Russian-speaking subjects.

STORY 1
Vika was at a party at her friend Dima's house. She was talking to Dima as another girl approached them. It was one of Dima's neighbours. The woman said: 'Hello', then turned to Vika and said: 'It seems to me that we haven't met before. I am Maria, what is your name?' 'My name is Vika' – Vika replied. 'Does anyone want anything to drink?' – says Dima.

STORY 2
Elena's husband was throwing a surprise party for his wife's birthday. He invited Sasha, Elena's friend, and told her: 'Don't tell anyone about the party, especially Elena'. The day before the party, Elena was visiting Sasha's house and Sasha spilled coffee on her new dress hanging on the back of the chair. 'Oh!', - Sasha said, - 'I was going to wear it to your party!' 'What party?' – Elena asked. 'Let's go!' - said Sasha, - 'Let's try to remove this stain!'

STORY 3

Dima went shopping in search of a shirt that would match his suit. The salesman showed him some shirts. Dima looked at them and eventually found one of the right colour. But when he went to try it on in the dressing room, turned out that it did not fit. ‘I'm afraid it’s too small for me,’ – he said to the salesman. ‘Don't worry,’ – said the salesman, ‘we are expecting a shipping of larger shirts next week’. ‘Great! I'll come later then’, - said Dima.

STORY 4

Lena has just moved into a new apartment. She went to the store and bought curtains for her new bedroom. Lena had just finished furnishing her new apartment when her best friend Lisa arrived. Lena took her on a tour of the apartment and asked: ‘How do you like my bedroom?’ ‘These curtains are awful!’- said Lisa, - ‘I hope you buy new ones!’

STORY 5

Gosha went to get a haircut at the hairdressers. ‘What haircut would you like?’ – asked the hairdresser. ‘I would like the same one that I have now, only a couple of centimetres shorter,’ – Gosha replied. It turned out a little uneven in the front and the hairdresser had to cut it shorter to get it straight. ‘I'm afraid this is a little shorter than you wanted,’ – said the hairdresser. ‘Well, no worries, it will grow back,’ – said Gosha.

STORY 6

Zhenya stopped by a gas station to fill the tank on his way home. He gave the cashier his credit card. The cashier swiped it through the cash register. ‘I’m sorry,’ – the cashier said, ‘the machine doesn’t accept your card.’ ‘Hmm, that's strange,’ – said Zhenya, ‘I'll pay in cash then’. He gave the cashier a thousand roubles and said ‘Full tank, diesel fuel please’.

STORY 7

Sonya is a three-year-old girl with a round face and short blond hair. She was visiting her aunt Nina. The doorbell rang and Aunt Nina opened the door. It was her neighbour Maria. ‘Hello!’ Aunt Nina said – ‘It's so good you dropped by!’. Maria said: ‘Hello!’, then she saw Sonya and exclaimed: ‘Ah! It seems to me that I haven’t met this little boy yet. What’s your name?’

STORY 8

Zhanna went for a walk in the park with her dog Jim. She threw a stick for him to fetch. After some time, they were approached by Polina, Jeanne's neighbour, who was passing by. They talked for a couple of minutes, then Polina asked: ‘Are you going home? We could walk together’. ‘Of course,’ - said Zhanna. She called Jim, but he was chasing pigeons and did not pay attention to the owner. ‘It seems he hasn't had enough of this walk yet. I think we will stay out a little longer,’ – said Zhanna. ‘Okay then, I’ll see you later,’ – said Polina.

STORY 9

Valeria had the main role in last year's school play and she wants to have it again this year. She took acting classes and auditioned for a musical in the spring. On the day the results were posted, she got to school early. She was not selected for the main role, but for a supporting role only. She ran to her boyfriend and told him what had happened. ‘I am sorry to hear that,’ - he said, - ‘you must be very upset’. ‘Yes,’ - said Valeria, - ‘now I have to decide whether to take this role or not."

STORY 10

Andrey was at the library. He found the book he was looking for on walking routes along the Golden Circle and walked over to the librarian's desk. When he looked into his wallet, he saw that he had forgotten his library card at home. ‘Sorry,’ he said to the librarian. ‘I must have left my library card at home’. ‘No worries,’ she replied, ‘tell me your name, and if you are in the computer's database, you can borrow the book after showing me your passport’.

STORY 11

Olga, the manager of Chrom Design company, gathered all employees for a meeting. ‘I have something to tell you,’ – Olga said - ‘One of our employees, Dmitry, is very sick, he has cancer and he is in the hospital.’ Everyone was sitting still, trying to take in the news, when the Maksim, the system administrator, arrived late. ‘Hello everyone! I heard a funny joke last night!’- Maxim shouted – ‘What did the terminally ill say to his doctor?’ – Olga interrupted him, ‘Okay, let's move on to discussing business.’

STORY 12

Misha, a nine-year-old boy, started attending a new school. He was sitting on one of the benches in the dressing room. Vanya and Petya passed by and talked. ‘Do you know this new guy from our class? His name is Misha. Don't you think he's kind of weird? He is also super tiny,’ – said Vanya. Misha got up from the bench and the guys noticed him. ‘Oh, Misha, hello! Let's go play football?’ – said Petya.

STORY 13

Seryozha was supposed to visit his cousin Stasya and she made an apple pie for him. After dinner she said, ‘I made a pie especially for you. It’s in the kitchen’. ‘Mmm! It smells great! I love pies! Except for apple, of course,’ - exclaimed Seryozha.

STORY 14

Marina bought a crystal vase as a wedding present for her friend Anya. Anya had a wedding with many guests and gifts. A year later, Marina dined at Anya's house. She accidentally dropped a bottle of wine on the crystal vase and it shattered. ’I am very sorry that the vase broke,’ Marina said. ‘Don't worry,’ Anya said, ‘I never liked it. Someone gave it to us as a wedding present’.

STORY 15

There was an essay competition held at school. Everyone was invited to participate, including several fifth graders. Christina, a fifth-grader, was very proud of the essay that she wrote for the competition. A few days later, the results were posted: Christina's essay did not win, the winner was Fedya, her classmate. The next day, Christina and Fedya sat on a bench looking at the prize Fedya got. ‘It was very easy to win the competition. All other compositions were terrible,’ – Fedya said.

STORY 16

Gena was at the restaurant. He accidentally spilled coffee on the floor. ‘I’ll bring you another cup of coffee now,’ – said the waiter and left. He was gone gone a long time, so Gena approached Egor, another restaurant customer, who was standing at the checkout counter to pay, and said: ‘I spilled coffee on the table. Could you wipe it off?’

STORY 17

Alena was at the bus stop. The bus was late and she had been waiting for a long time. She is 65 years old, and it is hard for her to stand for so long. When the bus finally arrived, it was full and there were no seats. She saw her neighbour Pasha standing in the aisle. ‘Hello, Alena!’ – Pasha said. ‘Have you been waiting for the bus for a long time?’ ‘For about 20 minutes,’ – she replied. The young man sitting beside them got up and said, ‘Sit down please!’

STORY 18

Ruslan got a new job at a company. got into a conversation with his new colleague Andrey in the dining room. ‘What does your wife do?’ – asked Andrey. ‘She is a lawyer,’ – Ruslan replied. A few minutes later, Ksenia entered the dining room. She was very irritated. ‘I just had a terrible phone call. Lawyers are so arrogant and greedy, I can't stand them!’ - she said. ‘Let's go see the latest reports?’ – Andrey asked Ksenia. ‘Not now, I need to get some coffee first,’ – she replied.

STORY 19

Vitya bought a new car, a red Peugeot. A few weeks later, he crashed into his neighbour Denis's car, an old wrecked Volvo. His new car was not damaged, and Denis's car was left with only a small scratch above the wheel. Nevertheless, Vitya went to Denis's door and knocked. ‘I am very sorry, I just scratched your car,’ said Vitya. Denis looked at the car and said: ‘Don't worry. It was just an accident.’

STORY 20

Lyudmila went to the butchers. There were a lot of people there and it was very noisy. She asked the butcher, ‘Do you have any boiled chicken?’ – he nodded and began packing the fried chicken for her. ‘Sorry,’ – said Lyudmila, ‘I probably didn't say it clearly. I asked for boiled chicken.’ ‘Oh, I'm sorry,’- said the butcher. ‘We're out of boiled chicken.’

Affidavit

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Eidesstattliche Versicherung

Alexandra Morozova
Name, Vorname

Ich erkläre hiermit an Eides statt, dass ich die vorliegende Dissertation mit dem Titel:

Theory of Mind in schizophrenia: focusing on the role of non-verbal communication and motor function

selbständig verfasst, mich außer der angegebenen keiner weiteren Hilfsmittel bedient und alle Erkenntnisse, die aus dem Schrifttum ganz oder annähernd übernommen sind, als solche kenntlich gemacht und nach ihrer Herkunft unter Bezeichnung der Fundstelle einzeln nachgewiesen habe.

Ich erkläre des Weiteren, dass die hier vorgelegte Dissertation nicht in gleicher oder in ähnlicher Form bei einer anderen Stelle zur Erlangung eines akademischen Grades eingereicht wurde.

Munich, 01.11.2022
Ort, Datum

Alexandra Morozova
Unterschrift Doktorandin bzw. Doktorand

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