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"Theory of Mind" in Schizophrenia: A Review of the Literature

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The term *theory of mind* (ToM) refers to the capacity to infer one's own and other persons' mental states. A substantial body of research has highlighted the evolution of ToM in nonhuman primates, its emergence during human ontogeny, and impaired ToM in a variety of neuropsychiatric disorders, including schizophrenia. There is good empirical evidence that ToM is specifically impaired in schizophrenia and that many psychotic symptoms—for instance, delusions of alien control and persecution, the presence of thought and language disorganization, and other behavioral symptoms—may best be understood in light of a disturbed capacity in patients to relate their own intentions to executing behavior, and to monitor others' intentions. However, it is still under debate how an impaired ToM in schizophrenia is associated with other aspects of cognition, how the impairment fluctuates with acuity or chronicity of the schizophrenic disorder, and how this affects the patients' use of language and social behavior. In addition to these potential research areas, future studies may also address whether patients could benefit from cognitive training in this domain.

Keywords: Theory of mind/brain evolution/ schizophrenia/linguistics/behavior/social competence

The term *theory of mind* (ToM) refers to the cognitive capacity to represent one's own and other persons' mental states, for instance, in terms of thinking, believing, or pretending. Interestingly, the term was first used by primatologists and psychologists Premack and Woodruff, who asked whether the chimpanzee had a theory of mind (Premack and Woodruff 1978). In the years following this publication, it has been argued from an evolutionary point of view that a "theory of self and others' minds" has emerged in hominid evolution as an adaptive response to an increasingly complex social environment (Brothers 1990). In accordance with what has become known as the "social brain hypothesis" (Brothers 1990; Dunbar 1998), individuals with good mind-reading abilities may outperform poor mentalizers with respect to social success, which ultimately may increase the reproductive success of the former.

There may, however, be costs to having a highly developed ToM (Brüne 2001). In humans, for instance, ToM is apparently permanently "online," such that other persons and sometimes even nonliving objects are continuously "screened" for their putative intentions. Thus, human ToM is inherently linked to the risk of making false conjectures about other people's intentions, for instance, by inferring "too much" or simply by overrating one's personal affectedness in a given social interaction. It is therefore crucial that every person who imputes mental states to others be able to crosscheck his or her inference against reality—that is, to interpret signals from the social environment supporting or refuting his or her assumption. Extract the *relevant* meaning from speech depends upon an intact ToM. To effectively use and interpret language, one usually has to go beyond the literal meaning of words and utterances on the basis of contextual information (Sperber and Wilson 1986, 2002). However, functional or structural disruption of the neural mechanisms underlying ToM may give rise to various types of psychopathology, including schizophrenia (Frith 1992; Brüne 2001).

In fact, impaired ToM has been described in a variety of neuropsychiatric disorders. The most extensive ToM studies have been carried out in autistic spectrum disorders (e.g., Baron-Cohen et al. 1985; Baron-Cohen 1995), in adult patients with frontal lobe damage (e.g., Rowe et al. 2001; Stuss et al. 2001), and in schizophrenia (overviews in Corcoran 2000; Brüne 2003*a*). Only recently has ToM research been extended to patients with frontotemporal dementia, Alzheimer's dementia or other dementing disorders (e.g., Cuerva et al. 2001; Gregory et al. 2002; Snowden et al. 2003; Starkstein and Garau 2003), antisocial personality disorder (Richell et al. 2003), bipolar affective disorder (Kerr et al. 2003), and normal aging (Happé et al. 1998; Maylor et al. 2002).

Clinical findings strongly suggest that patients with schizophrenia are impaired in social interaction relating to their reduced capacity to effectively engage in communication (e.g., Trognon 1992; Sperber and Wilson 2002). Frith (1992) has foremost suggested that ToM in schizophrenia patients is compromised because of their failure to monitor their own and other persons' mental states and behavior, which may account for many positive and negative symptoms in schizophrenic disorders. There is dispute, however, over such questions as whether ToM is impaired or exaggerated in some types of schizophrenia, whether ToM represents a state or trait marker of these

disorders, and the extent to which ToM abnormalities in schizophrenia are linked to the execution of other cognitive functions and language.

In this article—based on a MEDLINE and EMBASE survey of the relevant literature published between 1995 and 2003, including important cross-references—I shall therefore summarize the current ToM research in schizophrenia and discuss some future directions. The first part deals with some critical theoretical issues relating to ToM; the second part outlines the main findings of empirical research of ToM in schizophrenia.

Theoretical Background

Evolutionary Trajectories of ToM. The evolutionary perspective of ToM in the context of schizophrenia is helpful insofar as the emergence of ToM in humans is paralleled by adaptive changes in the brain. Second, it is precisely the brain areas involved in ToM that are frequently, although not exclusively, found to be abnormal in schizophrenia, such as parts of the prefrontal cortex (of particular interest could be the paracingulate cortex) and the temporal cortex, including cortical connectivity (e.g., Crow 1993; Narr et al. 2001; Burns, in press). Furthermore, ToM research in nonhuman primates has helped clarify how ToM may best be conceptualized and tested (Brownell et al. 2000).

ToM probably emerged quite recently during the late Pleistocene in hominids because individuals needed to cope with an increasingly complex social environment (Whiten 2000). Group living's costs and benefits in terms of survival and reproduction have been outlined elsewhere (Alexander 1987); one advantage of sociality may have been better protection from predators, while one problem may have been how to be socially smart (and hence reproductively successful in competition with conspecifics). While primates and great apes are experts in "behavior reading"—for instance, reading gestures, intention movements, and facial expressions of emotions—the ability to "read" minds and to cognitively represent one's own and others' mentalities (full-blown ToM) does not necessarily depend on sensory input from the outer environment (although in real-life situations it usually does); an individual may just think what others have in mind without seeing them (Premack and Woodruff 1978).

Regardless of whether ToM (and language) evolved to improve a person's capacity for "social grooming" (Dunbar 1996), for detection of intentional deception by conspecifics (Byrne 2003), or for both, there is some empirical evidence that other great apes, especially chimpanzees, evolved the cognitive capacity to represent other minds to a certain degree—and perhaps to go beyond, as may tentatively be concluded from observations of seemingly intentional deception and teaching (Suddendorf and Whiten 2001; Byrne 2003). Recently, however, initial enthusiasm about the chimpanzee's ToM has given way to the debate about whether chimpanzees have ToM-like abilities such as visual perspective taking and whether such capacities reflect chimps' ability to understand other chimpanzees' *minds* or whether chimps simply are "different," using other means to predict the behavior of their conspecifics (Povinelli and Vonk 2003; Tomasello et al. 2003). However, exploration of this topic surpasses the scope of this article.

Interestingly from an evolutionary perspective, there is evidence that the neural system underlying ToM most likely evolved from the capacity to monitor biological motion as represented in the superior temporal sulcus, the medial prefrontal cortex, and particularly the anterior cingulate (Frith and Frith 1999, 2001; Siegal and Varley 2002); or from neural structures subserving imitative behavior such as the so-called mirror neurons (Gallese and Goldman 1998; Umiltà et al. 2001). In other words, monitoring the *behavior* of conspecifics may have formed the basis for the evolution of monitoring others' *minds.*

Ontogeny of ToM. Understanding the ontogeny of ToM abilities in the context of ToM research in schizophrenia is critical for two reasons: first, standard tests devised by developmental psychologists to assess *children's* ToM acquisition have been adopted by schizophrenia researchers; second, we do not know whether the implicit assumption that ToM development in schizophrenia patients prior to the clinical manifestation of the disorder has been normal—as opposed to autistic—is correct.

Baron-Cohen (1995) has proposed an ontogenetic model of ToM maturation based on an evolutionary concept. According to his model, very early in development, infants selectively pay attention to eyelike stimuli. At about 18 months, the human child is able to associate "seeing" with "knowing," to use protodeclarative pointing gestures, and to engage in pretend play (Leslie 1987). At the same time, the child starts to recognize him- or herself in a mirror. Not until age 3 to 4, however, is a child able to distinguish between his or her own and another person's beliefs—for example, that someone may hold false beliefs that do not match the child's own knowledge, a situation commonly referred to as first order false belief. At 6 to 7 years old, children learn to understand higher order representations—for instance, to know that someone else thinks that a third person believes something. A faux pas is somewhat more difficult to comprehend, because it involves the capacity to understand a situation in which one character should have kept information from another but did not. Children's comprehension of faux pas is unstable before the age of about 10, with girls apparently able to understand faux pas somewhat earlier than boys.

However, this rather fixed model of ToM acquisition in ontogeny partly neglects the impact of the social environment on the development of ToM skills in infants

and children. As Carpendale and Lewis (in press) have pointed out, for instance, young children whose parents frequently use expressions referring to mental states when talking to them pass ToM tests at an earlier age than children whose parents use such terms less often. Moreover, the presence of older siblings likewise speeds up young children's understanding of other minds (overview in Carpendale and Lewis, in press). Thus, there is clearly input from the social environment that facilitates cognitive maturation, including ToM.

Theoretical Conceptualizations of ToM. There are several terms that more or less accurately circumscribe the cognitive capacity to represent the mental states of oneself and others, including "theory of mind," "mental state attribution," taking the "intentional stance," "mentalizing," and "reflexive awareness." Although some may object to the expression "theory of mind," I shall use it, because it is the original one coined by Premack and Woodruff (1978).

More relevant is the fact that there are different theoretical conceptualizations regarding the cognitive architecture of ToM.

ToM module. With respect to Fodor's (1983) concept of a modular organization of the human mind, Leslie and coworkers have proposed the existence of a separate ToM module (ToMM; recently updated by Scholl and Leslie 1999). Like other domain-specific cognitive capacities represented in the brain that operate on only a certain class of information, the ToMM is supposed to process information restricted to social inference. Cognitive modules are supposed to be reliable, efficient, and economic. Scholl and Leslie (1999) have furthermore argued that the accurate functioning of ToMM depends on what they have called a selection processor (SP) to separate relevant from irrelevant contextual information, which may enhance the likelihood that a person's inference of others' mental states is correct.

Theory-theory perspective. The "metarepresentational" theory-theory first put forward by Perner (1991) represents primarily a nonmodular model. This model suggests that infants and children acquire different levels of representational skills in steps during ontogeny, starting out with primary representations of the self as an acting agent. Secondary representation, accomplished after the second year of age, allows for distinction between reality and hypothetical situations. Having genuine "metarepresentations" enables a person (similar to scientific theories) to "theorize" about other persons' representations, including possible misrepresentations (Perner 1991). In contrast to the strict modular model, the metarepresentational theory holds that the differentiation between reality and mental models may underlie not only ToM but also the more general capacity to "collate" multiple mental models simultaneously (Suddendorf and Whiten 2001). In other words, the theory-theory model maintains that metarepresentational skills are not necessarily restricted to the execution of ToM.

Simulation theory of ToM. The "simulation" theory proposes that ToM relates to the ability to imaginatively "put oneself into others' shoes" (e.g., Davies and Stone 1995). In contrast to the theory-theory model, the simulation theory posits that attributing mental states to oneself is at the core of inferring the mental states of others by replicating or mimicking the mental life of other individuals. This model has recently received additional support from the observation that monkeys and humans possess mirror neurons that are active when certain hand or mouth movements are being observed in others. Gallese and Goldman (1998), for instance, have therefore argued that the ability to "read minds" may have evolved from the mirror neuron system in primates.

This overview article certainly cannot explore these divergent theoretical models in depth. All of them have gained empirical support, but it remains unclear which one best underpins the cognitive architecture of ToM. It seems likely that the divergent positions in this debate are not irreconcilable, but such a discussion is beyond the scope of this article.

Are Schizophrenia Symptoms Related to ToM?

Frith's concept of a ToM deficit in schizophrenia. Chris Frith (1992) has raised the intriguing question of whether psychotic symptoms in schizophrenia might be explained in terms of an underlying cognitive misrepresentation of one's own and others' intentions—that is, impaired ToM.[1] Some patients with schizophrenia, for instance, instead of taking beliefs as *subjective representations* of reality, equate their representations with reality and may therefore have difficulty distinguishing between subjectivity and objectivity and maintain false beliefs in the form of delusional convictions. Moreover, a neglect of other persons' social signals and putative intentions may lead to a breakdown of communication and eventually formal thought disorder. Furthermore, schizophrenia patients who have difficulties in experiencing their behavior as the result of their own intentions may interpret their actions as being under alien control. Frith (1992) has therefore argued that a compromised theory of one's own and others' minds in schizophrenia may account for (1) disorders of "willed action" (e.g., negative and disorganized symptoms), (2) disorders of self-monitoring (e.g., delusions of alien control and voice-commenting hallucinations or other "passivity" symptoms), and (3) disorders of monitoring other persons' thoughts and intentions,

[1]Much earlier, Klaus Conrad (1958) argued from a Gestalt theoretical viewpoint that impaired perspective taking and compromised self-reflection represented core symptoms of early schizophrenia.

including delusions of reference and persecution. According to his model, Frith (1992) has predicted that patients differ in their ToM abilities depending on whether objective (''behavioral'') or subjective (experiential) symptoms prevail. Patients with prominent negative or disorganized (behavioral) symptoms would accordingly be most impaired in ToM performance, similar to autistic persons, because of their incapacity to represent mental states at all. Patients with paranoid symptoms would perform poorly, relative to healthy control subjects, because of their difficulties in accurately monitoring other people's intentions. Clearly, paranoid patients have an intact ToM in the sense that they know that other people have mental states. They are, however, impaired in using contextual information, which leads them to make incorrect ''online'' inferences about what these mental states are. Patients with passivity symptoms and patients in remission have been predicted to perform normally on ToM tasks, because their ability to represent other persons' mental states, as opposed to their own mental states, would be relatively preserved (Pickup and Frith 2001). Frith's concept would best match the modular perspective of ToM.

Hardy-Baylé's concept of impaired ToM in relation to disorganized thought, language, and communication in schizophrenia. In contrast to Frith, Hardy-Baylé (1994) has argued that impaired ToM in schizophrenia is primarily related to an executive or planning deficit. In particular, patients with highly disorganized thought, language, and communication skills (Andreasen 1986) are predicted to perform most poorly on ToM tasks, because they are unable not only to monitor their own actions but also to adequately represent other persons' mental states and to integrate contextual information (Hardy-Baylé et al. 2003). In other words, the absence of a mental representation of a patient's own intended action would also compromise a patient's capacity to assign mental states to other persons' actions. According to this model, ToM deficits are expected to occur exclusively in patients with prominent thought and language disorganization, whereas patients without disorganization symptoms are predicted to have preserved ToM abilities. This model would best fit into the simulation theory of ToM.

Alternative proposals. A divergent view on schizophrenia patients' ToM has been put forward by Abu-Akel (1999). He suggested, partly contrary to the models mentioned above, that some schizophrenia patients with positive symptoms may even have ''hyper ToM.'' The patients' way of ''overattributing'' intentions to themselves or others, as reflected in delusions, may relate to a violation of pragmatic rules in their use of language. Patients with schizophrenia may actually incorrectly infer that their communication partners would share the patients' knowledge. Abu-Akel and Bailey (2000) have further proposed a continuity model of ToM deficits: (1) genuinely impaired ToM, (2) normal ToM without the ability to apply this knowledge, and (3) hyper ToM, associated with quantitative overgeneration of hypotheses or overattribution of mental states (Abu-Akel and Bailey 2000). Similarly, Walston et al. (2000) have argued in favor of an intact ToM in some patients with schizophrenia, because an unimpaired ability to attribute mental states to others may be a prerequisite for developing persecutory delusions, at least in ''pure'' delusional disorders.

These theoretical models of how ToM may be involved in schizophrenic symptoms, divergent as they may be, are open to empirical testing. As discussed in the next section, the crucial task, then, is to develop ToM tests that are suitable for adults with schizophrenia and do not interfere too much with other cognitive functions.

Testing ToM Abilities in Schizophrenia. Many tests of ToM applied in schizophrenia research so far have been adopted from psychological tasks developed to test young children's ability to infer the mental states of other individuals (e.g., Doody et al. 1998). Whereas infants as young as 18 months start to engage in ''pretend play'' (Leslie 1987) as an early indicator of a developing ToM, because pretending requires at least the capacity to distinguish between hypothetical and real situations, the ''gold standard'' test of comprehending other persons' minds is grasping that others can hold false beliefs that are different from one's own (correct) knowledge (Dennett 1978). The classic Sally and Anne Test (Wimmer and Perner 1983) involves experimental creation of a situation in which a test person has to distinguish his or her own knowledge that an object has been hidden by one character (Anne) in the absence of another person (Sally) from the knowledge of the other characters involved. The crucial question is where Sally would look for the object when she returned: the place it was before she left the scene, or the place where it had been moved by Anne. Children under the age of 4 usually perform quite poorly on this test. The cognitive capacity to pass the test requires the ability to ''metarepresent'' Sally's mental state—that is, ''I know that she does not know where the object really is.'' The Sally and Anne Test therefore encompasses what is called understanding a first order false belief.

More sophisticated cognitive capacities relating to ToM include the understanding of higher order false belief tasks (e.g., Perner and Wimmer 1985), metaphor, irony, and faux pas. It has been argued that understanding metaphor requires at least first order ToM comprehension, whereas irony involves second order ToM, because these processes relate to the ability to go beyond the literal meaning of utterances by inferring what the speaker actually might have intended (Happé 1993; Langdon et al. 2002*b*).

In terms of presentation of ToM tasks, simple tests of first and second order false beliefs may be depicted using picture stories or may be enacted with props. These devices are probably easier to understand than a more abstract form of presentation such as short written stories that have to be kept in memory.

In ToM research in schizophrenia, short stories with or without use of props and picture sequencing tasks have been primarily used to assess different levels of "intentionality"; tests of comprehension of hints behind indirect speech, metaphor, and irony have also been used. Over the years, ToM tasks used in schizophrenia research have been modified to better control for interference with attention, memory, "general" intelligence, and verbalization. One problem in earlier studies was that patients with schizophrenia not only performed poorly on ToM tasks but also often failed to correctly respond to the control or "reality" questions (e.g., Frith and Corcoran 1996; Drury et al. 1998). Therefore, "physical" control tasks of similar complexity but without the requirement to refer to mental states have been introduced, in particular to investigate whether ToM deficits are specific (Frith and Corcoran 1996; Langdon et al. 1997; Sarfati et al. 1997*a*; Drury et al. 1998; Brunet et al. 2003*a*). It should be kept in mind, however, that the problem of "real life" presentation of the tasks cannot fully satisfactorily be resolved in experimental laboratory "offline" test conditions. Therefore, persons with psychiatric disorders who on one hand are highly personally involved in their delusional systems, for instance, may in the test situation be relatively unaffected in abstract reasoning tasks (Simpson et al. 1998). Also, comparability of ToM studies in schizophrenia may to some extent be limited because of subtle differences of task presentation, for instance, using picture stories that depict the outcome of the scene versus using open-ended picture sequences (Sarfati et al. 1997*b*; Brüne 2003*a*).

Empirical Findings of ToM in Schizophrenia

Specificity of ToM Deficits. A crucial question of ToM research in schizophrenia concerns whether deficits in this domain are specific, similar to the deficits found in autistic spectrum disorders, or are the consequence of more general cognitive impairments of attention, executive functioning, memory, general intelligence, and so on (e.g., Mitchley et al. 1998; Langdon et al. 2001; Pickup and Frith 2001). Answering this crucial question would also shed some light on the validity of the different theoretical conceptualizations of ToM, that is, modularity, theory-theory, or simulation.

Only one study has directly addressed which of the above conceptualizations of ToM fits best into schizophrenia research. Langdon et al. (2001) have theoretically argued that the theory-theory is least suitable to account for ToM deficits in schizophrenia, because, in contrast to persons with autism, schizophrenia patients do not necessarily lack the conceptual knowledge about the representation of mental states. For example, deluded patients may be able to comprehend that beliefs can be false.

In terms of the simulation theory of ToM, Langdon et al. (2001) have in addition reasoned that if ToM impairments in schizophrenia would relate to patients' incapacity to imaginatively mimic other persons' mental states, then impaired ToM could emerge from one of two causes: (1) the inability to inhibit cognitively salient information ("impaired disengagement"), or (2) "an impaired ability to reason consequentially on the basis of hypothetical states" (p. 86). In a series of experiments involving so-called capture stories in addition to ToM picture stories, where a salient clue has to be suppressed in favor of less salient information, Langdon et al. (2001) found a subgroup of schizophrenia patients to be specifically impaired on ToM tasks independent of an executive planning deficit. They interpreted this finding as speaking against the simulation theory. Because of the specificity of the ToM deficits in schizophrenia, in essence this study foremost supports the assumption of a modular organization of ToM (Langdon et al. 2001). This assumption would also further be supported by the theoretical consideration of a possible functional disruption of ToMM and SP. Damage to the *interface* between ToMM and SP, leaving both mechanisms intact, could result in a preserved capacity to infer mental states but an inability to use contextual information, which could, for instance, explain paranoid ideation (Frith 1992; Langdon et al. 2001).

Taking the evidence together, there is a substantial body of evidence that ToM deficits in schizophrenia are likely to be specific rather than to be the result of general cognitive impairments (e.g., Langdon et al. 2001; Pickup and Frith 2001; overview in Brüne 2003*a*), although the deficits are probably not the same as those seen in autism (Corcoran 2000; Pilowsky et al. 2000). Table 1 summarizes the study designs and main results of ToM research in adult patients with schizophrenia.

While attention deficits, executive dysfunction, and lower intelligence scores negatively influence performance on ToM tasks, differences between schizophrenia subjects and healthy control persons in task performance remain significant, even when general cognitive deficits and measures of executive functioning are controlled for, although my own study has suggested that ToM performance may be closely associated with verbal intelligence in disorganized patients (Brüne 2003*b*). These findings seem to be robust, irrespective of whether picture-sequencing tasks (e.g., Langdon et al. 1997, 2001; Sarfati et al. 1997*a*, 1997*b*, 1999; Brunet et al. 2003*a*); tasks involving the detection of irony (Mitchley et al. 1998), metaphor, or "real intentions" behind indirect speech (Corcoran et al. 1995); short text passages illustrated by cartoons (Frith and Corcoran 1996; Pickup

Table 1. Overview of ToM studies in schizophrenia in chronological order

Study	Sample (*n*) inclusion criteria	Symptom cluster	Mean age	Sex (m:f)	Medication	ToM method/tasks	Additional variables/measures	Main findings/conclusion
Corcoran et al. (1995)	55 schizophrenia (*DSM–III–R*)	23 paranoid 10 negative 3 incoh. 7 passivity 8 remitted 4 other	31.8	38:17	?	10 short stories about a social interaction between 2 characters, read aloud to subjects (“hinting task”)	IQ (Quick Test, Ammons and Ammons 1962) psychopathology (PSE)	Schizophrenia patients with negative symptoms performed worst on ToM tasks, even when IQ was covaried out. Patients with passivity symptoms and remitted patients performed equally compared to controls; patients with incoherence and paranoid symptoms were in between. This study suggests that performance on ToM tasks is a state rather than a trait variable.
	14 depressed/ anxious		46.7	8:6				
	30 controls		31.2	20:10				
Frith and Corcoran (1996)	55 schizophrenia (*DSM–III–R*)	24 paranoid 12 behav. 10 passivity 9 remitted	33.7	14:10 33.1 31.3 31.1	+ 8:4 7:3 7:2	6 ToM stories including a first or second order false belief; additional cartoon drawings	IQ (Quick Test, Ammons and Ammons 1962) psychopathology (PSE)	Patients with behavioral and paranoid symptoms performed more poorly on ToM tasks compared to the other groups and controls. However, according to memory problems in the former groups, easier ToM tasks are warranted.
	13 depressed/ anxious			48.1	7:6			
	22 controls			32.9	7:15			
Corcoran et al. (1997)	44 schizophrenia (*DSM–IV*)	16 paranoid 7 behav. 8 passivity 13 remitted	30.1 30.9 29.5 32.1	11:5 5:2 5:3 10:3	+	To test appreciation of jokes; 10 jokes could be understood in physical or behavioral terms, and 10 jokes required mental state attribution, with 7 of the latter set involving understanding false belief	IQ (Quick Test, Ammons and Ammons 1962) psychopathology (PSE)	Appreciation of jokes was impaired in schizophrenia patients. Patients with behavioral symptoms performed worst, particularly if mental state attribution was involved. Patients with passivity and paranoid symptoms also performed worse than controls.
	7 depressed/ anxious		43.3	2:5				
	40 controls		32.2	17:23				

Langdon et al. (1997)	20 schizophrenia (*DSM–III–R*)	11 chronic residual 8 chronic paranoid 1 acute paranoid	33.4	9:11	+	4 four-card picture sequences of false beliefs	Social-script picture sequences mechanical picture sequences capture picture sequences mental state language in story narratives self-awareness block design, digit backward (WAIS–R) SANS, SAPS	Patients were impaired in monitoring their own and others' mental states. Subgroups of patients could be differentiated according to their representational abilities. Picture sequencing difficulties were associated with psychomotor poverty symptoms and reality distortion, suggesting impaired symbolic representation in the former, and a failure to critically evaluate cause-effect consequences. Impaired ToM was associated with an "autistic-like" syndrome.
	20 controls		Matched	Matched				
Sarfati et al. (1997*a*)	24 schizophrenia (*DSM–III–R*)	7 paranoid 6 residual 5 disorg. 6 undiff.	31.9	19:5	+	30 picture stories consisting of 3 pictures and 3 answer cards (15 false belief and 15 intention attribution stories)	IQ (BPVS) TLC SANS; SAPS	Performance on ToM tasks correlated with thought and language abilities and level of disorganization. No differences among the schizophrenia group emerged when it was traditionally classified into subtypes.
	12 depressed		41.9	3:9				
	24 controls		32.4	14:10				
Sarfati et al. (1997*b*)	12 schizophrenia (*DSM–III–R*)	4 paranoid 5 undiff. 3 residual	27.2	5:7	+	30 picture stories consisting of 3 pictures and 2 answer cards (15 false belief and 15 intention attribution stories) presented in 2 different conditions	TLC SANS; SAPS	Schizophrenia patients could be divided into 2 groups according to their ToM abilities (normal vs. poor performers), corresponding to their level of thought and language disorder. False belief tasks were significantly more difficult than attribution of intentions.
	12 depressed		36.3	3:9				
	12 controls		26.2	6:6				

Table I. Continued

Study	Sample (*n*) inclusion criteria	Symptom cluster	Mean age	Sex (m:f)	Medication	ToM method/tasks	Additional variables/measures	Main findings/conclusion
Doody et al. (1998)	28 schizophrenia (*DSM–III–R*)		46.3	17:11	?	Sally Anne Task (Wimmer and Perner 1983; first order false belief), Icecream-Van Test (Perner and Wimmer 1985; second order false belief), tasks illustrated by dolls and maps	ART Quick Test (Ammons and Ammons 1962) PANSS	Schizophrenia patients with a comorbid learning disorder performed worst on ToM tasks; schizophrenia patients in general performed more poorly on second order false belief tests compared to normal controls, associated with level of psychopathology. Patients with learning disabilities also performed more poorly compared to healthy controls, suggesting interference of ToM abilities with IQ.
	12 depressed		42.3	1:11				
	19 learning disabil.		50.7	7:12				
	18 comorbid.		50.4	10:8				
	20 controls		20.4	9:11				
Drury et al. (1998)	14 schizophrenia (*DSM–IV*)	9 paranoid 3 undiff. 2 disorg.	30.1	11:3	+	3 second order false belief tasks, read aloud and enacted with props; assessment after admission and following recovery	Substitution of coreferential terms, metaphor sentence completion task, interpretation of irony and metaphor symptomatology (PAS) WAIS–R (partially)	Acute schizophrenia patients performed more poorly on ToM tasks and metaphor tasks compared to nonschizophrenia patients. No such difference emerged after recovery. Patients with persecutory delusions performed more poorly on memory tasks during the acute phase, and after recovery on the second order false belief task, indicating interference of ToM abilities with attention and memory load.
	10 psychotic controls		40.7	6:4	+			
	12 depressed		42.41	6:6	+			
Mitchley et al. (1998)	18 schizophrenia		45.28	15:3	+	9 brief written scenarios involving irony	9 brief written scenarios to be literally interpreted IQ (NART) PANSS	Schizophrenia subjects were impaired in understanding irony relative to psychiatric controls. They were also more likely to interpret the ironical stories literally. The failure to understand irony was
	13 various psychiatric controls		41.31	2:11				

								associated with lower IQ and with negative (but not positive) symptoms in the schizophrenia group. The difference between the schizophrenia subjects and controls remained significant when IQ was covaried out.
Sarfati and Hardy-Baylé (1999)	25 schizophrenia (*DSM–IV*) 10 manic 15 controls	15 disorg. 10 nondisorg.	35.7 29.2 33.9 28.6	5:10 2:8 6:4 5:10	+	14 comic strips consisting of 3 pictures; a fourth picture to be chosen from 4 pictorial alternatives	IQ (BPVS) PANSS TLC	Schizophrenia patients with disorganization performed more poorly compared to nondisorganized schizophrenia patients, manic patients, and controls on ToM tasks. Global psychopathology score was also elevated in this group, suggesting that the ToM deficit is a state variable rather than a trait.
Sarfati et al. (1999)	26 schizophrenia (*DSM–III–R*) 13 depressed 13 controls	13 disorg. 13 nondisorg.	35.1 30.3 40.6 33.0	11:2 10.3 4:9 11:2	+	28 comic strips consisting of 3 pictures; a fourth picture to be chosen from 4 alternative pictures, in a second assessment from 4 alternative sentences	IQ (BPVS) PANSS TLC	Disorganized schizophrenia patients performed more poorly on both the verbal and nonverbal mode of ToM tasks compared to nondisorganized patients and controls. Positive and negative symptomatology did not account for the differences.
Sarfati et al. (2000)	25 schizophrenia (*DSM–IV*) 25 controls		?	7:18		28 comic strips consisting of 3 pictures; a fourth picture to be chosen from 4 alternative pictures, in a second assessment from 4 alternative sentences	IQ (BPVS) PANSS TLC	A subgroup of schizophrenia patients improved in ToM measures after introduction of verbal material, whereas a subgroup of poor performers did not, possibly related to chronicity of the disorder.

Table I. Continued

Study	Sample (*n*) inclusion criteria	Symptom cluster	Mean age	Sex (m:f)	Medication	ToM method/tasks	Additional variables/measures	Main findings/conclusion
Mazza et al. (2001)	35 schizophrenia (*DSM–IV*) 17 controls	11 disorg. 16 psychomotor 8 reality distortion	35.3 33.06 34.5 37.3	10:1 15:1 5:3 1:16	+	2 first and 2 second order ToM tasks read aloud plus cartoon drawings	WAIS Verbal Memory Test (Novelli et al. 1986) Verbal Fluency Test (Novelli et al. 1986) TOL WCST SANS; SAPS	Schizophrenia patients with psychomotor poverty performed worst on first order ToM tasks and on one of the second order ToM tasks. Disorganized patients performed more poorly than the other groups and controls on the other second order false belief test, suggesting that negative symptoms may affect metarepresentational capacities in schizophrenia independent of IQ.
Pickup and Frith (2001)	41 schizophrenia (*DSM–IV*) 18 depressed/anxious 35 controls	16 paranoid 16 behav. 1 passivity 8 remitted	40.9 37.3 22.0 36.4 43.6 43.3	10:6 12:4 0:1 7:1 7:11 19:16	+	2 first order and 1 second order ToM task enacted with props; answers rated according to their explanatory power and use of mental state language	Two first order and one second order nonmental control tasks IQ (Quick Test, Ammons and Ammons 1962) psychopathology (PSE)	Patients with behavioral symptoms performed more poorly on second order false belief tasks and made less use of mental state language compared to controls, independent of memory and IQ. Paranoid patients performed more poorly as well, but this effect disappeared when IQ was controlled for, indicating a specific and state-dependent ToM deficit in schizophrenia.
Langdon et al. (2001*a*)	30 schizophrenia (*DSM–IV*) 2 schizoaffective 24 controls		37.31 34.54	18:14 12:12	+	4-card picture sequences of false beliefs	Social-script picture sequences mechanical picture sequences capture picture sequences visual memory (WMS–R) TOL SANS, SAPS	Schizophrenia patients have executive planning deficits, disengagement failures, and poor mentalizing abilities compared to controls. Multiple regression analysis revealed that poor mentalizing predicted the odds of being a patient. Executive planning deficits did not fully account for poor

								ToM, thus supporting the modular hypothesis of mental state representation. However, no association between ToM abilities and positive symptoms (e.g., paranoia) was found.
Langdon et al. (2002)	23 schizophrenia (*DSM–IV*) 2 schizoaffective 20 controls			?	+	4-card picture sequences of false beliefscomputerized story comprehension of metaphor and irony	Social-script picture sequences mechanical picture sequences capture picture sequences Spot-the-Word Test (Baddeley et al. 1993) verbal memory (WAIS–R) TOL SANS, SAPS	Selective impairments of schizophrenia patients on ToM tasks confirmed. Metaphor and irony understanding made independent contributions to distinguish patients from controls, suggesting divergent underlying mechanisms. Irony but not metaphor comprehension was associated with ToM abilities. Positive formal thought disorder was associated with poor performance on ToM tasks, whereas negative formal thought disorder was associated with poor metaphor understanding. Impaired ToM may relate to poor pragmatic use of language in schizophrenia.
Roncone et al. (2002)	40 schizophrenia (*DSM–IV*) 4 schizoaffective	25 paranoid 2 disorg. 1 catatonic 6 undiff. 6 residual	33.4	34:10	+	2 first and 2 second order ToM tasks read aloud plus cartoon drawings	IQ (SPMR) Verbal Memory Test (Novelli et al. 1986) Verbal Fluency Test (Novelli et al. 1986) TOL WCST BPRS DAS	Patients' poor ToM abilities contributed significantly to predicting their poor social functioning in the community. Duration of illness, verbal fluency, and the presence of negative and positive symptoms also contributed to poor social functioning, with duration of illness being the strongest predictor of impaired social functioning.

Table I. Continued

Study	Sample (*n*) inclusion criteria	Symptom cluster	Mean age	Sex (m:f)	Medication	ToM method/tasks	Additional variables/measures	Main findings/conclusion
Herold et al. (2002)	26 schizophrenia (*DSM–IV*) 26 controls	20 paranoid in remission	? ?	?	+	1 first order ToM task 1 second order ToM task 2 metaphor and 2 irony tasks	PANSS	The major difference between patients and controls was their ability to correctly interpret irony, indicating impaired ToM to be a traitlike state in schizophrenia.
Brunet et al. (2003*a*)	25 schizophrenia (*DSM–IV*) 25 controls	4 paranoid 9 disorg. 6 undiff. 6 residual	31.2 34.2	19:6 17:8	+	14 comic strips consisting of 3 pictures; a fourth picture to be chosen from 4 pictorial alternatives	28 picture stories involving physical causality depicted IQ (BPVS) PANSS TLC	Patients performed significantly more poorly than controls on tasks requiring attribution of intentions. This deficit was found to be specific and independent of IQ.
Brüne (2003*b*)	23 schizophrenia (*DSM–IV*) 12 controls	23 disorg.	29.2 30	17:6 7:5	+	ToM picture story involving first and second order false belief and deception	"Nonsocial" picture sequencing task IQ (MWT) BPRS	Patients were impaired on ToM tasks; after IQ was covaried out, no difference emerged compared to controls, independent of duration, age at onset of illness, or psychopathology.
Mazza et al. (2003)	42 schizophrenia (*DSM–IV*) 42 controls	18 paranoid 17 residual 7 undiff.	31.27	?	+	2 first and 2 second order ToM tasks read aloud plus cartoon drawings	IQ (SPMR) SAPS SANS BPRS Mach-IV	Patients who performed well on ToM tasks showed a more cynical and pragmatic view of life as indicated by higher scores on the Mach-IV scale. Patients with negative symptoms were less strategic in their thinking than patients with positive symptoms.
Janssen et al. (2003)	43 schizophrenia (RDC) 41 first degree relatives 43 controls	34 remitted	32.9 40.2 34.8	24:19 16:25 22:21	+	2 short stories involving a social interaction between 2 characters, read aloud to subjects, and 4 "hinting" tasks adopted from Frith and Corcoran 1996	Digit span AVLT verbal fluency SCWT CST GIT BPRS PANSS	Patients with schizophrenia performed more poorly on ToM tasks compared to controls, with first degree relatives performing in between. This was largely independent of age, education, or IQ. These findings indicate that

								impaired ToM in schizophrenia may reflect a traitlike deficit.
Corcoran and Frith (2003)	59 schizophrenia (*DSM–IV*)	16 paranoid 10 negative 10 thought disorder 8 passivity 15 remitted	40.5	50:9	+	10 short stories involving a social interaction between 2 characters, read aloud to subjects (“hinting task”);4 ToM stories involving a first order or a second order false belief; additional cartoon drawings	IQ (Quick Test, Ammons and Ammons 1962) psychopathology (PSE) AMI (autobiographical section) AMIPB (story recall subtest)	As with previous studies, patients with schizophrenia were impaired on ToM task performance; schizophrenia patients (particularly those with negative symptoms) also had poorer recall of autobiographical events compared to controls. Performance on ToM tasks and autobiographical memory were related. This could indicate that schizophrenia patients have problems with inductive reasoning when inferring the mental states of others.
	44 controls		40.0	35:9				

Note.—AMI = Autobiographical Memory Interview (Kopelman et al. 1990); AMIPB = Adult Memory and Information Processing Battery (Coughlan and Hollows 1985); ART = Adult Reading Test (Nelson and O’Connell 1978); AVLT = Auditory Verbal Learning Task (Lezak 1995); behav. = behavioral symptoms; BPRS = Brief Psychiatric Rating Scale (Overall and Gorham 1962); BPVS = Binois and Pichot Vocabulary Scale (Binois and Pichot 1947); CST = Concept Shifting Test (Houx et al. 1991); DAS = Disability Assessment Schedule, Italian (Morosini et al. 1988); disorg. = disorganized; GIT = Groningen Intelligence Test (Luteijn and van der Ploeg 1983); MWT = Multiple Verbal Comprehension Test (Lehrl 1976); NART = National Adult Reading Test (Nelson 1991); nondisorg. = nondisorganized; PANSS = Positive and Negative Syndrome Scale (Kay et al. 1987); PAS = Psychiatric Assessment Scale (Krawiezcka et al. 1977); PSE = Present State Examination (Wing et al. 1974); psychomotor = psychomotor poverty; RDC = Research Diagnostic Criteria; SANS = Scale for the Assessment of Negative Symptoms (Andreasen 1984*a*); SAPS = Scale for the Assessment of Positive Symptoms (Andreasen 1984*b*); SCWT = Stroop Color-Word Test (Stroop 1935); SPMR = Standard Progressive Matrices of Raven (Raven 1960); TLC = Thought, Language and Communication Disorders (Andreasen 1979); TOL = Tower of London Test (Morice and Delahunty 1996); undiff. = undifferentiated; WAIS–R = Wechsler Adult Intelligence Scale–Revised (Wechsler 1982); WCST = Wisconsin Card Sorting Test (Heaton 1981); WMS–R = Wechsler Memory Scale–Revised (Wechsler 1987).

and Frith 2001); or visual jokes as depicted in cartoon drawings (Corcoran et al. 1997) are employed. Not surprisingly, in general, patients' task performance is related to the complexity of the social inference task, such that performance on higher order or subtler ToM tests is more impaired than performance on first order tasks (e.g., Doody et al. 1998). However, many studies have now demonstrated that the difficulties schizophrenia patients have in correctly sequencing ToM stories is not due to a general sequencing deficit, because patients' sequencing abilities of "physical" stories may well be preserved. It is rather their lack of understanding of the mental states of the story characters that makes them fail in such tests (Langdon et al. 1997, 2001; Pickup and Frith 2001; Brunet et al. 2003*a*).

Although not specifically addressed so far, an association of ToM impairment with medication seems at least unlikely (Sarfati et al. 1999).

Frith's and Hardy-Baylé's Models Put to the Test

Schizophrenia core symptoms and impaired ToM. Besides the above-mentioned questions relating to the specificity of ToM impairments in schizophrenia, a substantial number of studies have been carried out to test the theoretical models put forward by Frith (1992) and Hardy-Baylé (1994) with respect to core symptoms of schizophrenia. Both models have received empirical support, but some studies have revealed inconsistent results (more details regarding sample sizes, subtyping, medication, and study materials are presented in table 1). As predicted by Frith (1992), patients with negative behavioral symptoms such as avolition or social withdrawal, or positive behavioral symptoms such as incoherent or inappropriate speech, performed worst on ToM tasks across several studies. Patients who experienced subjective symptoms of passivity such as thought insertion or delusions of alien control and patients in remission performed relatively normally on ToM tasks (Corcoran et al. 1995, 1997; Frith and Corcoran 1996). Some controversy exists, however, about the nature of the ToM deficit in paranoid patients. A couple of studies have shown, in line with Frith's model, that patients who experience paranoid ideation but do not exhibit behavioral symptoms are impaired in their ToM capacity (Corcoran et al. 1995, 1997), but other studies could not confirm a link between paranoia or "reality distortion" (Liddle 1987) and ToM deficits (Langdon et al. 2001; Mazza et al. 2001). Pickup and Frith (2001) have suggested that some paranoid patients might be able to compensate for their impaired ToM by using general intelligence. This notion would also be consistent with Walston et al.'s (2000) finding that patients with "pure" persecutory delusions performed normally on ToM tasks. These authors suggested distinguishing between persecutory delusions and delusions of self-reference, as the patients' cognitive deficits might be distinct. It is therefore conceivable that patients with persecutory delusions are particularly compromised when they have to "mentalize on the spot" but may perform quite normally on standard ToM tests when not under time pressure (Pickup and Frith 2001). Interestingly, Corcoran and Frith (2003) have recently elaborated on their model to include schizophrenia patients' ability to recall autobiographical events. They have argued that inferring the mental states of others often involves utilizing previous experiences in social interactions. In a study examining ToM performance and autobiographic memory, schizophrenia patients performed more poorly on ToM tasks relative to control subjects. Moreover, in an autobiographical memory interview, patients with schizophrenia tended to recollect odd or negative events. Impaired ToM performance and poor autobiographical memory correlated in the patient group. This finding indicates that schizophrenia patients' poor recall of information from past social interactions could compromise their ability to infer other people's mental states (Corcoran and Frith 2003).

Likewise, Hardy-Baylé's model has been confirmed in a series of studies, indicating that patients with pronounced thought and language disorganization are impaired in ToM task performance (Sarfati et al. 1997*a*, 1997*b*, 1999; Sarfati and Hardy-Baylé 1999). However, according to her model, patients *without* thought and language disorganization ought to be relatively unimpaired on all ToM measures, which is apparently not unequivocally the case. For example, Mazza et al. (2001) found only partial support for Hardy-Baylé's model because patients with psychomotor poverty symptoms performed more poorly on the ToM tasks than did disorganized patients, and in my own study patients with disorganized schizophrenia did not perform more poorly than controls when their verbal intelligence was taken into account (Brüne 2003*b*). On the contrary, and as predicted by Hardy-Baylé's model, several studies have revealed that at least in a subset of patients with thought and language disorganization, the introduction of verbal material may improve ToM task performance, but probably not in the most chronic patients (Sarfati et al. 1999, 2000).

A number of studies have alternatively based group comparisons on Liddle's (1987) three-dimensional model of schizophrenia, which distinguishes between psychomotor poverty, reality distortion, and disorganization syndromes. All subgroups have been found to be impaired in ToM task performance (e.g., Langdon et al. 1997; Mazza et al. 2001), but probably for different reasons. Given all the evidence, it is likely that patients with prevailing negative symptoms are the most severely impaired in ToM, in particular when the symptomatology resembles that of autism (Langdon et al. 1997).

ToM deficit in schizophrenia—state or trait variable? According to Frith's model (1992), patients

with remitted psychoses and patients who experience only "passivity" symptoms may perform quite normally on ToM tasks. Likewise, Hardy-Baylé's model posits that patients without disorganized symptoms would perform normally on ToM tasks. This suggests that an impaired ToM represents a state rather than a trait variable (e.g., Corcoran et al. 1995; Drury et al. 1998; Pickup and Frith 2001). However, the fact that it is not only patients with acute exacerbations who perform poorly on ToM tasks but also patients with a long duration of the disorder makes a decline of ToM abilities likely to occur in chronically deteriorating cases (Drury et al. 1998; Sarfati et al. 2000).

The assumption that ToM deficits are state dependent has been questioned by a study of ToM in persons with high versus low schizotypy scores (Langdon and Coltheart 1999). Langdon and Coltheart predicted that, if a continuum existed between schizotypy and schizophrenia, persons with high scores on a rating of schizotypy would perform more poorly on ToM tests than would "low schizotypals." In fact, the finding that "high schizotypals" did less well than persons with low schizotypy scores may be interpreted in favor of a traitlike ToM deficit. Interestingly, not only was the deficit in high schizotypals specific to ToM abilities, the poor performers also demonstrated a (nonsignificant) trend toward higher amounts of magical thinking and unusual perceptual experiences, supporting the assertion that ToM deficits may causally be related to some psychotic symptoms (Langdon and Coltheart 1999). Similarly, in favor of a persistent deficit, Herold et al. (2002) found that remitted patients with paranoid schizophrenia performed more poorly on an irony task than control subjects, whereas no significant differences emerged in first and second order tasks or understanding metaphor. The assumption that impaired ToM is a traitlike deficit in schizophrenia has further been fueled by a study in which remitted patients with schizophrenia were compared to first degree relatives and controls without a family history of psychotic disorders. Janssen et al. (2003) found that schizophrenia patients were most impaired on ToM tasks relative to unaffected controls and that first degree relatives performed somewhere in between on these tasks. This finding corroborated a preliminary report where unaffected siblings of patients with schizophrenia were likewise impaired in ToM task performance (Wykes et al. 2001). Thus, there is now sufficient evidence to assume that ToM deficits in schizophrenia represent a trait marker of the disorder that is not explained by the acuity or chronicity of the disorder alone.

In summary, irrespective of some contradictory findings, it may be concluded that Frith's model and Hardy-Baylé's model have proven to be fruitful attempts to address the question of impaired ToM in schizophrenia patients using a symptom-based approach. It may be critically remarked at this stage that, given the considerable overlap of Frith's behavioral subgroup, Hardy-Baylé's disorganized subtype, and Liddle's psychomotor poverty and disorganization syndromes, it is understandable why both Frith's and Hardy-Baylé's models have been empirically buttressed to a certain extent.

ToM and Linguistic Skills in Schizophrenia. Since the 1970s, many studies have shown that schizophrenia patients are impaired in their ability to decode and use language in a pragmatic manner. A stimulating question leading to novel lines of research has concerned whether language deficits in schizophrenia could be related to schizophrenia patients' impaired ToM. Linguists have proposed, following Grice (1975), that the use of language involves a set of conversational rules, referred to as "pragmatics," to transfer meaning in a useful way and that the pragmatic use of language in terms of both encoding and decoding requires the ability to infer the mental states of others (e.g., Trognon 1992; Trognon and Kostulski 1999). Extending Grice's original formulation, Sperber and Wilson (2002) have proposed that humans have evolved a submodule of ToM to extract relevance from speech or utterances in a cognitively efficient way, because the demands of language comprehension would surpass normal ToM by involving multiple levels of metarepresentation.

It has long been known that patients with schizophrenia tend to interpret metaphorical speech literally (e.g., Gorham 1956). More recently, several studies have shown that patients with schizophrenia also *use* language abnormally and are more impaired in pragmatics than in syntax or semantics (e.g., Frith and Allen 1988). In addition, it has been shown that patients with schizophrenia are impaired in using context-dependent information when ambiguous verbal material is being presented (Bazin et al. 2000). More specifically, schizophrenia patients' compromised linguistic skills seem to be linked to their failure to adjust their speech to conventional norms of conversation—that is, that they disregard a shared knowledge between themselves and their interlocutors (Harrow and Miller 1985). Corcoran and Frith (1996), for instance, have shown that patients with schizophrenia violate universal conversational rules such as quantity, quality, relevance, politeness, and tact. They found that in particular paranoid patients were unable to be polite and tactful, suggesting that patients with paranoid schizophrenia were impaired in "mentalizing on the spot" (Corcoran and Frith 1996). Similarly, schizophrenia patients' ability to appreciate visual jokes (Corcoran et al. 1997), cartoons (Sarfati et al. 1997*a*), and ironical statements (Mitchley et al. 1998) is consistently impaired.

In an interesting case study of two nonmedicated patients with disorganized schizophrenia, Abu-Akel (1999) revealed that they violated the linguistic maxims of relation and quantity and that they used unclear references more often than healthy control subjects, indicating

that disorganized schizophrenia patients may be unaware of which and how much information is required by their interlocutors for effective conversation. Abu-Akel noticed, however, that his patients nevertheless tried to cooperate with their interview partners, because they used certain cohesive links (so-called bridging endophoric references) during conversation. This could indicate that the patients referred to some shared reality and even assumed that their interlocutors shared their knowledge. This in turn could support the assumption that some patients may overattribute intentions and dispositions to others, that is, had a hyper ToM, rather than being generally impaired in this domain (Abu-Akel 1999).

In a more extensive study, Langdon et al. (2002*a*, 2002*b*) examined the understanding of metaphor and irony in relation to schizophrenia patients' performance on ToM tasks used in previous studies. Interestingly, ToM deficits were related to an impaired understanding of irony but not to metaphor comprehension. Metaphor and irony comprehension impairments made independent contributions in distinguishing patients from controls, which implied that the underlying cognitive processes were qualitatively distinct. Moreover, whereas ToM and irony comprehension were associated with the severity of formal thought disorder, compromised metaphor understanding was related to negative symptoms and poor executive functioning. The authors concluded that impaired understanding of irony could be explained by patients' poor pragmatic abilities, whereas poor metaphor understanding might relate instead to poor semantics, that is, the ability to transpose certain attributes to a contextually different utterance (Langdon et al. 2002*a*, 2002*b*). In a similar vein, Tényi et al. (2002) found that paranoid schizophrenia patients made significantly more errors compared to controls in detecting an implicitly coded negative opinion in a speaker's utterance about a person where the maxim of relevance was deliberately violated.

ToM Deficit and Social Competence. An intriguing question remains whether an impaired ToM in schizophrenia patients may actually account for their poor social functioning. Only a few studies have directly linked impaired ToM skills of schizophrenia patients to their level of social competence. Indirect hints come from a study of schizophrenia patients' ability to appreciate social knowledge about their culture, in which they showed a specific social naïveté compared to depressed or manic patients (Cutting and Murphy 1990).

Another indirect clue arises from a study that measured the attitude of schizophrenia patients toward the use of interpersonal deception and moral issues (Sullivan and Allen 1999). In essence, men with schizophrenia scored lower on the Mach-IV scale (Christie and Geis 1970) compared to healthy male controls and to women with schizophrenia, whereas in nonclinical samples men usually scored higher than women. The authors concluded that both men and women with schizophrenia unconditionally valued honesty and morality but that women with schizophrenia were at the same time more suspicious, such that their total score did not differ from a female control group's. These findings, tentatively interpreted, may indicate that patients with schizophrenia have difficulty applying strategic social rules and tactics because of an impaired ToM (Sullivan and Allen 1999). More recently, Mazza et al. (2003) directly confirmed that ToM deficits in schizophrenia may be associated with impaired strategic social thinking. Patients with predominantly positive symptoms who performed better on the ToM tasks than patients with negative symptoms also had a more "cynical" and pragmatic view of the world as measured using the Mach-IV scale, whereas patients with negative symptoms obtained lower scores in Machiavellianism. Thus, impaired strategic social reasoning might reflect a deficit in appreciation of second order mental states (Mazza et al. 2003).

More specifically with respect to social functioning, Roncone et al. (2002) found that compromised ToM abilities in schizophrenia significantly contribute to correctly predicting patients' poor social functioning in the community, although in this study the duration of illness was the most significant predictor of poor social functioning.

All these studies point to the fact that patients' impaired understanding of other people's thoughts and intentions in schizophrenia is likely related to level of social skills. How this relates to the patients' actual symptomatology and other cognitive deficits, however, needs to be carved out in more detail.

Functional Brain Imaging of ToM in Schizophrenia. Neuroimaging studies of ToM in healthy subjects have consistently revealed that the medial prefrontal cortex represents a core area, corresponding to Brodmann's areas 8/9 (overview in Russell and Sharma 2003). Gallagher and Frith (2003) have recently drawn attention to the paracingulate gyrus (Brodmann's area 32), which contains a specific cell type, the so-called spindle cells, that have emerged quite recently in hominid evolution (Nimchinsky et al. 1999). Activation of the medial prefrontal cortex during ToM tasks was confirmed in a ToM study of event-related potentials (Sabbagh and Taylor 2000). In a positron emission tomography (PET) study in healthy individuals, Brunet et al. (2000) found a specific activation of the *right* middle, the right medial prefrontal cortex, and the temporal cortex using a paradigm that involved the attribution of a character's intentions as depicted in picture stories.

Data on the cerebral representation of ToM functions in patients with schizophrenia are scarce. In the only ToM study of schizophrenia using functional magnetic resonance imaging (fMRI), in which five patients were compared to seven matched control subjects, Russell

et al. (2000) determined that the middle, inferior frontal, and middle temporal brain regions were activated during the ToM test performance. In its simpler version, this test required a person to choose one of two words that best described the mental state of another person whose eye region only was depicted; the control task involved a judgment regarding the gender of the person with those eyes (Baron-Cohen et al. 1997). The schizophrenia patients, relative to controls, showed a significant underactivation in the *left* inferior frontal gyrus (Brodmann's area 44/45) but not in the amygdala. However, the number of patients assessed was fairly small, they were not grouped according to symptomatology, and ToM effects were confounded with word reading. A further PET study in five patients with schizophrenia compared to eight normal subjects during performance of a task requiring the attribution of intentions using picture stories revealed that schizophrenia patients failed to activate their *right* prefrontal cortex (Brunet et al. 2001). Like normal subjects, however, schizophrenia patients showed enhanced activation of the occipitotemporal regions and the posterior part of the superior temporal sulcus during perception of human figures (Brunet et al. 2003*b*), a region that is known to be involved in monitoring biological motion (Frith and Frith 1999, 2001; Gallagher and Frith 2003). Abnormal patterns of activation have also been found in brain imaging studies in patients with Asperger's syndrome who, in a PET study, showed additional activation in the Brodmann's areas 9/10 adjacent to area 8 (Happé et al. 1996), whereas an fMRI study of Baron-Cohen et al. (1999) revealed further activation in left inferior prefrontal areas and in the amygdala. Given the potential role of the paracingulate gyrus in ToM performance, it is noteworthy that this brain region has been shown to be less asymmetric in patients with schizophrenia (Le Provost et al. 2003), but a link to ToM performance has not been established.

Autism and schizophrenia studies and brain lesion studies have produced different results regarding the laterality of the brain areas accounting for ToM deficits. Whereas findings in autism mainly point to lesions in the *left* prefrontal and temporal areas, studies on patients with brain lesions have shown ambiguous results (Rowe et al. 2001; Stuss et al. 2001). According to Brownell et al. (2000), the input of the right hemisphere in ToM is particularly crucial in ambiguous or novel situations and when "affective marking" of an alternative interpretation is required. Right hemisphere pathology, on the other hand, may constitute one aspect of schizophrenia pathology, particularly in delusion formation. When functional brain imaging studies in nonclinical and other clinical groups are considered, the most likely explanation is that an extended neural network in both hemispheres is necessary for correctly inferring mental states and that disturbances of this network correspond to neuroanatomical abnormalities found in the prefrontal cortex of schizophrenia patients and in autism (Russell and Sharma 2003).

Discussion

ToM research in neuropsychiatric disorders represents a relatively novel and essentially interdisciplinary approach to the understanding of human mentality, involving primatology, developmental psychology, cognitive neuropsychology and neuropsychiatry, functional brain imaging, and linguistics. This area of research has provided outstandingly fruitful results, partly, as I understand it, because the divergent branches have adopted an evolutionary stance as the common creed regarding why and how the human mind is designed as it is (Brüne 2002). This is, however, not self-evident, as evolutionary theory has largely been neglected by psychiatry in the past, although a compelling framework with respect to human social behavior was put forward more than a decade ago (Brothers 1990).

Dissecting the cognitive architecture in terms of how human beings interact with their social environment and the pathologies that may arise from failures to do so properly has boosted our understanding of many of the cognitive and behavioral symptoms found in a group of disorders we call schizophrenia (e.g., Gallagher and Frith 2003). However, a variety of intriguing questions remain open to scientific exploration.

Abundant research has shown that patients with schizophrenia have specific difficulties in inferring what others intend, think, or pretend, and this ToM impairment probably influences the way schizophrenia patients use language and interpret speech. Moreover, because schizophrenia patients are impaired in monitoring their own actions (e.g., as being self-generated and linked to their own intentions) (e.g., Spence et al. 1997; Frith et al. 2000) and are impaired in applying pragmatic rules of conversation, it can be predicted that they also have difficulty planning and executing strategic social behavior—that is, schizophrenia patients may have difficulty utilizing so-called procedural rules (Schmitt and Grammer 1997; Sarfati et al. 1997*b*; Brüne 2003*b*; Brunet et al. 2003*a*). Clinical observation suggests that persons with schizophrenia—in contrast, for instance, to patients with personality disorders—rarely successfully cheat or manipulate others (e.g., their therapists), which may be a direct consequence of their impaired ToM. In fact, schizophrenia patients seem at the least to be compromised in appreciating Machiavellian attitudes (Christie and Geis 1970; Sullivan and Allen 1999; Mazza et al. 2003), and impaired ToM in schizophrenia has also been found to contribute to patients' compromised social functioning in the community (Roncone et al. 2002).

Most studies addressing ToM in schizophrenia implicitly assume that ToM deteriorates in the affected persons because of some unknown neuropathological process

that commences after puberty. However, as already mentioned, we do not know for sure that ToM acquisition in schizophrenia patients is normal during infancy (Corcoran 2000; Brüne 2003*a*). In fact, a variety of studies suggest that childhood precursor symptoms in schizophrenia are common and that many of these precursors can be found in the social domain, including speech (e.g., Crow et al. 1995). Individuals who later develop schizophrenia may therefore have a (genetic) predisposition to impaired ToM, and this may influence their early interactions with parents and peers. Thus, there is a need for longitudinal studies of ToM in children at risk of developing schizophrenia. Moreover, we know virtually nothing about sex differences of ToM in schizophrenia, although one may speculate—given that males usually suffer from an earlier onset and poorer outcome of the disorder—that men with schizophrenia would perform more poorly than women with schizophrenia.

The link of ToM to other *social* cognitive capacities such as emotion recognition also represents an underexplored field of research. Studies in children with autism and other developmental disorders suggest that there may be a unidirectional impairment of ToM and emotion recognition (Buitelaar et al. 1999), but this need not necessarily be the case. Frith and Frith (1999, 2001) have proposed two functionally separate neural networks, one connecting the medial prefrontal cortex, the anterior cingulate, and the superior temporal sulcus (the ''dorsal'' system), and the other linking the orbitofrontal cortex and regions next to the amygdala (the ''ventral'' system). The former of these brain circuits is supposed to be crucial for ToM, self-monitoring, and perception of biological motion (but not for movements of inanimate objects), whereas the latter is involved in emotion and face recognition (Frith and Frith 1999). Thus, ToM could have evolved from a neural system in primates responsible for the ability to predict the actions of other individuals, particularly of conspecifics (Castelli et al. 2000).

Another problem that can be addressed only briefly here concerns the open debate as to whether schizophrenia is a valid concept for neuroscientific inquiries at all, for instance, whether this group of disorders represents a disease entity (as Kraepelin had hoped), whether a dimensional approach is more accurate, or whether the entire concept of schizophrenia ought to be abandoned (Langdon et al. 1997; Penn et al. 1997).

This controversy notwithstanding, behavioral phenotyping—as suggested by Liddle (1987), Frith (1992), or Hardy-Baylé (1994)—may facilitate linking neuropsychiatry to clinical psychiatry in terms of our capacity to better predict course and outcome of the disorder in individual cases (Langdon et al. 1997). At present, we do not know whether ToM *inevitably* deteriorates with chronicity or whether medication may improve social cognition. I have speculated elsewhere that a ToM decline may follow the reverse order of ontogenetic acquisition of complexity, that is, that patients' ability to understand faux pas and irony may be affected first, whereas comprehension of first order ToM problems and metaphor may initially be relatively preserved (Brüne 2003*a*). Certain types of metaphorical understanding may, however, well relate to higher levels of ToM, as for example, in proverbs, which often involve social relationships (as, e.g., in ''when the cat's away, the mice will play'').

In any case, therapists ought to acknowledge that many schizophrenia patients may have difficulty understanding others' minds. Remembering this, therapists should carefully monitor their own pragmatic use of language and their nonverbal expression to minimize misunderstandings and anxiety in patients.

Finally, a further therapeutic consequence from ToM research in schizophrenia could be to include mental state attribution in cognitive-behavioral therapeutic programs (Sarfati 2000), similar to the promising results of emotion recognition and emotion labeling training in schizophrenia (van der Gaag et al. 2002). It may also be fruitful to study whether early detection and treatment of schizophrenic disorders (Klosterkötter et al. 2002) could remedy the outcome regarding communicative skills and ToM.

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