

# Figurative Language Comprehension in Schizophrenia and Its Neural Basis

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## Abstract

Schizophrenia is a kind of serious mental disease, which may cause major impairment in patients' social-cognitive ability. It has been found that pragmatic ability in schizophrenic patients is often impaired, especially for figurative language comprehension. Figurative language refers to irony, metaphor, idiom and the like. People with schizophrenia tend to interpret figurative language as its literal meaning, which is called schizophrenic concretism. By reviewing extant literature, we found that the literature concerning this topic mainly consists of two parts: behavioral studies and brain-imaging studies. The behavioral studies mainly explore how clinical factors and cognitive ability have an impact on figurative language comprehension. Brain-imaging studies mainly discuss hemisphere lateralization in schizophrenia and whether theory of mind network in schizophrenic patients is different from that of normal groups. We conclude that future research should further explore the relationship among figurative language comprehension, cognitive ability and clinical factors, and also reveal related neural mechanism.

**Keywords:** behavioral studies, brain-imaging studies, figurative language comprehension, schizophrenia

## 1. Introduction

Schizophrenia is a serious mental disease which is among one of the ten most damaging diseases (Vos et al., 2015). It is known that there are more than 20 million schizophrenic patients (SPs) in the world, and therefore 1% of the population in the world suffer from schizophrenia (Sela, Lavidor, & Mitchell, 2015). Patients with schizophrenia have impaired social-cognitive ability, as well as their pragmatic language ability (Colle et al., 2013).

Figurative language comprehension (FLC) is an important part of pragmatic ability, and schizophrenic patients are less able to understand figurative language. Researchers have found that those patients' problem in FLC had a negative effect on their social interaction and led to social segregation.

Figurative language comprehension as a test has been used in mental disease diagnosis and intervention. For example, Sacco et al. (2008) designed Assessment Battery of Communication (ABACO), and it has been used to test schizophrenic patients' pragmatic ability. Bohrn, Altmann, and Jacobs (2012) also assessed how pragmatic ability had an impact on patients' cognition and life quality.

The study of FLC in schizophrenic patients helps to explore the neural basis of pragmatic ability. In daily communication, there is a gap between utterance meaning and sentence meaning, and pragmatics helps to construct utterance meaning (Giora, 1995, 1997; Grice, 1975, 1991). Many pragmatists and psycholinguists believe that theory of mind (ToM) can help listener to fill in the gap between the two meanings, and it is believed that pragmatic ability is in close relationship to ToM (Champagne-Lavau & Charest, 2015; Champagne-Lavau, Charest, Anselmo, Rodriguez, & Blouin, 2012; Spotorno, Koun, Prado, Van Der Henst, & Noveck, 2012).

Recently, neural studies on figurative language tend to explore the activation of ToM neural network and its function. For schizophrenic patients, their abnormal activation pattern in FLC has been heatedly discussed (Akimoto, Miyazawa, & Muramoto, 2012; Uchiyama et al., 2012).

This article will discuss schizophrenic patients' comprehension of irony, metaphor and idioms, and also explore neural basis of figurative language in terms of lateralization and neural mechanism of ToM.

## 2. Behavioral Approach

Schizophrenic patients (SP) show a tendency of concretism in their comprehension of figurative language (Schneider et al., 2015). It means they tend to choose literal meaning when they interpret figurative language. Some researchers believed that they lacked the ability to integrate the context, while other researcher believed that the reason might be impaired inhibitory control. So far, researchers do not reach agreement on the topic. As a result, researchers begin to explore FLC in schizophrenic patients and considering factors like executive functions, verbal intelligence, gender and semantic memory. Besides, schizotypal personality questionnaire has been discussed since it is shown in both normal people and patients.

### 2.1 Irony

Irony is one kind of figurative language, in which utterance meaning is always contrary to literal meaning. Compared with metaphor and idiom, irony in daily use is more complicated, since it should integrate contextual information and social clues. Therefore, researchers have studied how SPs integrated those information and clues. Champagne-Lavau and Charest (2015) compared 30 schizophrenic patients and 30 normal participants, and they found patients had difficulty in using social and contextual knowledge. By pretest, they defined two kinds of occupations: ironic occupation and non-ironic occupation. People who had ironic occupation tend to speak ironic utterance more than normal people, and people with non-ironic occupation were the opposite. They found that schizophrenic patients could understand irony with the help of social-contextual knowledge. However, it was not easy for them to evaluate mocking effect of irony and literal sentences, which means they had problem to understand negative context. Further study should explore how schizophrenic patients understand negative context, and explore function of intonation, body language, facial expression and the like.

Researchers also discussed emotions in both schizophrenic patients and normal people. Rapp, Langohr, and Mutschler (2014) compared 20 female SPs and 27 normal people, who were required to rate meanness, humorousness and certainty of utterances. Besides, they also test participants' schizotypal personality score and proverb comprehension. They found that SPs' accuracy in irony comprehension was lower than that of control group, and SPs showed no difference in meanness, humorousness and certainty evaluation, compared with normal group. However, schizophrenic patients had higher certainty and lower meanness rating when they made incorrect responses. Meanwhile, they also found schizotypal personality might be a mediator variable in SPs' figurative language comprehension, since SPQ seemed to be in relation to both irony and proverb comprehension. The result does not consist with previous studies, because some researchers found high SPQ participants showed no semantic N400 effect and pragmatic P600 effect, while other researchers have no similar finding (Goletto, Kostova, & Blanchet, 2016; Humphrey, Bryson, & Grimshaw, 2010; Jahshan & Sergi, 2007).

### 2.2 Metaphor

Metaphor is a kind of figurative language, and modern metaphor theorists believe that metaphor is a kind of conceptual tool. For example, in the metaphor "time is money", the target concept "time" should be understood by source concept "money". Based on the relationship between source concept and target concept, researchers divide metaphor into two kinds: novel metaphor and conventional metaphor. They believed that conventional metaphor was understood as literal language, which was processed automatically by semantic memory, while novel metaphor was processed in a controlled way and had higher demand for cognitive ability (Bowdle & Gentner, 2005; Jahshan & Sergi, 2007; Mashal & Kasirer, 2011).

Mossaheb et al. (2014) studied how patients with schizophrenia-spectrum disorders produced novel metaphor and how they identified or paraphrased conventional metaphor. Besides, they also explored effects of executive functions, verbal intelligence and non-verbal intelligence. By further analysis, they found novel metaphor was significantly related to verbal intelligence and cognitive flexibility; conventional metaphor identification was significantly related to verbal intelligence, non-verbal intelligence, and cognitive flexibility; paraphrase of conventional metaphor was significantly related to cognitive flexibility and inhibitory control. The study found that cognitive functions restricted metaphor processing in patients with schizophrenia-spectrum disorders. At present, many researchers have begun to explore how executive functions influenced SPs' pragmatic ability. Future study should study the topic in a more systematic way.

### 2.3 Idioms

Idioms refer to expressions or sentences that have been fixed during language using, and their meanings are difficult to decode from literal meaning. Language impairment in schizophrenic patients was also found in idiom comprehension. Many researchers found SPs could not inhibit idioms' literal meaning (Titone, Holzman, & Levy, 2002). Schettino et al. (2010) and Iakimova et al. (2010) used sentence-picture matching task and

semantic-judgment task to study the problem respectively.

Schettino et al. (2010) used three kinds of sentences in the experiment, and the materials were ambiguous idioms, unambiguous idioms and literal sentence. In the experiment, participants were required to decide whether a picture matched the sentence shown before. At the same time, they also evaluated participants' executive functions, negative symptoms, and positive symptoms. The result showed that SPs had lower accuracy and longer response time in idiom comprehension, especially for ambiguous idioms. Since it had been found that ambiguous idioms were not more difficult than unambiguous idioms, combined with the fact that Wisconsin Card Sorting Task (WCST) was related to former, researchers believed that patients may had difficulty in inhibiting the literal meaning. Besides, they also found negative symptoms might be related to ambiguous idioms. However, some researchers thought complexity of the pictures in the experiment should be controlled (Papagno & Caporali, 2007).

Titone et al. (2002) believed that SPs' idiom comprehension was related to the plausibility of literal meaning, while Iakimova et al. (2010) thought plausibility would be mediated by salience. Iakimova et al. (2010) asked participants to carry out semantic judgment on idioms, and the idioms they used all had plausible literal meaning, though they had different salient meaning under different conditions. Namely, there are literal-meaning salient idioms, figurative-meaning salient idioms and equally salient idioms. Participants were required to decide the relation between target word and salience meaning, when their accuracy and response time would be recorded. Results showed that both SPs and control group had salience effect, which meant they would react faster to target word of figurative meaning when figurative meaning was salient, and they would react faster to target word of literal meaning when literal meaning was salient. Besides, for equally salient idioms, control group would have figurative-bias effect, which meant they respond faster to target word of figurative meaning, but SPs did not have the effect. Therefore, they thought salience had an impact on SPs' idiom comprehension, and patients did not show figurative effect because they could integrate global context in the interpretation. They also found that verbal intelligence and logical ability would influence idiom comprehension.

Pesciarelli et al. (2014) used sentence completion task to study idiom comprehension in SPs and control group, and the emphasis was on how executive functions (working memory, cognitive flexibility and inhibitory control) and clinical conditions influenced idiom comprehension. They put an idiom in a sentence, changed part of the idiom and asked participants to judge whether those sentences made sense. They found that schizophrenic patients had longer response time, and both groups processed faster under idiom condition. Based on hierarchical regression analysis, they found cognitive ability like working memory and intelligence influenced participants' idiom comprehension; clinical factors like conceptual disorganization (P2) and difficulty in abstract thought (N5) had an impact on idiom comprehension. Both negative scores and positive scores were in relation to the judgment of idioms and literal sentences. All those results show that idiom comprehension in schizophrenic patients would be useful in diagnosis and intervention of schizophrenia.

### **3. Neural Mechanism**

The cognitive neuroscience approaches begin to play an important part in figurative language research, and some researchers have come up with the concept of "neuropragmatics" (Schnell et al., 2016). So far, neural study of figurative language mainly used fMRI (functional Magnetic Resonance Imaging), and ERPs (Event-Related Potentials) or NIRs (Near-infrared Spectroscopy). Cognitive neuroscience approaches to figurative language comprehension mainly focuses on two topics. The first is the lateralization of figurative language comprehension, and the second is how ToM neural network influenced the comprehension in SPs.

#### *3.1 Lateralization*

Cerebral lateralization of language in normal people is a natural process, and most people's dominant hemisphere for language is the left part, which means that the left hemisphere has much more activation in using language. However, in clinical groups like schizophrenic patients or autistic patients, many studies showed that they had different language lateralization compared with normal people. Some researchers believe that abnormal lateralization may lead to their symptoms.

The research of figurative language in schizophrenia and its relation to lateralization are very important, since it has been found that emotional factors and intonation had right hemisphere advantage. Giora, Zaidel, Soroker, Batori, and Kasher (2000) pointed out that figurative language was processed by right hemisphere, and literal language was processed by left hemisphere. However, it is difficult to decide whether right hemisphere plays an exclusive role in figurative language processing.

Schmidt, DeBuse, and Seger (2007) used divided visual field technique to study metaphor comprehension and

found sentence familiarity influenced related hemisphere. In other word, participants had right hemisphere advantage towards unfamiliar sentences, while they had left hemisphere advantage towards familiar sentences. In 2009, they explored how familiarity and difficulty influenced metaphor comprehension (Schmidt & Seger, 2009). They found under all conditions participants would activate more in right inferior frontal gyrus (rIFG), right insular cortex, and left temporal pole. Therefore, right hemisphere might be influenced by familiarity in the processing of figurative language. Mashal, Vishne, and Laor (2014) found that novel metaphor might trigger more activation in right inferior frontal gyrus (rIFG), right superior temporal gyrus (rSTG), left middle frontal gyrus (lMFG). The condition seems to be more complicated in schizophrenic patients for they have abnormal lateralization (Kircher, Leube, Erb, Grodd, & Rapp, 2007; Mashal, Vishne, Laor, & Titone, 2013).

Rapp et al. (2013) carried out an experiment in which 15 SPs and 15 healthy participants were involved and they were all female. The participants were asked to read irony and their brain activation had been recorded. Compared with literal sentence, the blood oxygen level dependent (BOLD) of irony in SPs was lower than that of control group. Comparing irony sentences with visual baseline, schizophrenic patients were found to have lower activation in the posterior medial prefrontal cortex and left anterior insula regions. Schnell et al. (2016) used similar design and found SPs had much activation in middle frontal gyrus (MFG), temporal pole and inferior parietal lobule (IPL), when comparing literal sentences with irony sentences. When they comprehended ironic context, they had more activation in the left inferior frontal gyrus (IFG) and inferior parietal lobule (IPL). Therefore, the two studies are contradictory to each other. However, it should be pointed out that in the previous study, the context could decide whether the following sentence was irony or literal sentence, while in the next study, both irony and literal sentences had their own contexts, and there was slight difference between the two studies. Besides, Schnell et al. (2016) not only observed irony comprehension, but also context comprehension, as a result of which, the two hemispheres were all possible to be involved. In daily communication, context and irony are not separated, so their study may support the idea that both hemispheres were involved in the comprehension.

Evidences from metaphor seem to be different. Mashal et al. (2013) used fMRI to observe 14 schizophrenic patients and they compared how participants' brain activation differed from each other under three conditions, namely, novel metaphor, conventional metaphor and literal metaphor. Behaviorally, SPs' metaphor comprehension was not as good as control group. In the activation pattern, they found control group activated right inferior frontal gyrus (rIFG), while SPs over-activated left frontal gyrus and left inferior parietal lobe (lIPL), based on the comparison of novel metaphor and literal sentences. Meanwhile, they found SPs' left precuneus cortex had higher activation in both novel condition and literal condition. Schneider et al. (2015) used ERPs-NIRs technique to look into SPs' metaphor comprehension. They found that SPs' left frontal gyrus, left temporo-parietal junction (lTPJ), right inferior gyrus had lower activation under all conditions. The results are different from Marshal's experiment, and it may be explained by their experiment materials: the former used sentences, while the later used word pairs.

Generally, current study shows that both hemispheres have been involved in the figurative language processing. However, since different experiments use different designs and techniques, there is no agreement on how the two hemispheres work together.

### 3.2 Neural Network

ToM neural network plays an important role in figurative language comprehension. Though it is now difficult to define what ToM exactly is, it is agreed that ToM neural network include left and right temporo-parietal junction (rTPJ,lTPJ), medial prefrontal cortex, and precuneus (Schnell et al., 2016; Spotorno et al., 2012). Besides, superior temporal sulcus and inferior parietal lobe were activated sometimes.

Table 1. Neural Studies of FLC in SPs

	TPJ	MPFC	PCC	STS	IPL
Schnell, 2016	*	*	*	*	*
Marshal, 2013			*		
Marshal, 2014			*		
Rapp,2013		*			
Schneider,2015	*				

Note. \* stands for difference

From current studies, we find the key brain areas related to ToM network in schizophrenic patients are different from that of normal people. Schnell et al. (2016) used fMRI technique studied SPs' irony comprehension, and observed the function of language help. They found that, compared with control group, SPs not only activated temporo-parietal junction, but also activated other frontal, temporal, and parietal areas. Besides, SPs had a lower degree of activation in right medial prefrontal cortex (rMPFC) and inferior parietal area when they read ironic sentence, and when they read ironic context, the left inferior parietal area had larger activation. Meanwhile, control group activated posterior cingulate cortex (PCC) when they read irony, but SPs did not activated; yet, with language help, their activation pattern seemed to have no significant difference to control group. To sum up, the study found SPs had different activation pattern compared with normal people when they read irony. Rapp et al. (2013) found schizophrenic patients had lower activation in posterior MPFC than control group, and the BOLD effect in MPFC was negatively related to schizotypal personality traits (SPQ). In other words, for all participants, the higher SPQ score they got, the lower activation they would have in the pMPFC. Those evidences all proved that ToM network was important in irony comprehension.

For metaphor comprehension, the difference between SPs and control group is in precuneus. Mashal et al. (2013) used fMRI and found that their left precuneus would have higher activation when they read novel metaphor. Mashal et al. (2014) conducted an ROI analysis in those participants and some new ones. They found SPs had higher activation in right precuneus when they read novel metaphor, conventional metaphor and literal sentences. Besides, they also found that right precuneus's activation was related to novel metaphor comprehension. Schneider et al. (2015) used ERPs-NIRs to study SPs metaphor comprehension, and they found control group had higher O<sub>2</sub>Hb than SPs. All those evidences proved that SPs activated ToM network more or less when they read metaphor. However, compared with irony, the difference between the two groups was smaller in metaphor comprehension.

Current studies all showed that ToM network was involved in irony and metaphor comprehension, but the ToM network itself may be a problem. Happé (1993) found that autistic children depended on first class ToM to understand metaphor while depended on second class ToM for irony. It has been proved in children using Chinese (Zhang & Zhang, 2009). Therefore, in SPs, they may use different ToM network in different figurative language tasks.

#### 4. Conclusion

Generally, researchers have done profound and comprehensive research to schizophrenic patients' figurative language comprehension, and they have formed some basic hypotheses. At present, it is necessary to explore SPs' pragmatic ability, cognitive ability, clinical condition and neural network, which not only promote the development of pragmatics, but also help to offer tools and basis for diagnosis and intervention of schizophrenia. However, since figurative language comprehension always depends on contextual factors and Chinese native speakers are in a high contextual culture, it is difficult to decide whether those findings work for Chinese native speaker. Future study should also explore time course of SPs' figurative comprehension.

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