Cognitive impairments in schizophrenia
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CHAPTER 4A
Impaired perception of negative emotional prosody in schizophrenia*

4.1 Abstract

This paper aims to report on the perception of emotional prosody in schizophrenia and to discuss its relationship with performance on general cognitive measures. It consists of a comparison of twenty clinically stable people with schizophrenia with twenty healthy controls. People with schizophrenia were impaired in emotional prosody perception, in particular in the perception of negative emotions. This impairment could not be explained on the basis of task difficulty or a general impairment in the decoding of speech intonation. Emotional prosody perception correlated moderately strong with general cognitive measures. We did not find a negative bias in the perception of emotional prosody.


4.2 Introduction

Impaired social functioning is part of the DSM IV criteria of schizophrenia. Social cognition, is a crucial element of successful social functioning. Social cognition is defined as “mental operations underlying social interactions, which include the human ability and capacity to perceive the intentions and dispositions of others” (Brothers, 1990). This definition encompasses numerous social-cognitive abilities and links social cognition directly to behaviour (Penn, 2000). The ability to understand non-verbal emotional cues is an important aspect of social cognition and is necessary to understand the intentions or motives of others in social interactions. The two main modalities for perception of non-verbal emotional information in humans are auditory and visual.
In schizophrenia research the visual modality, in particular the perception (encoding and identification) of facial affect, has received the most attention (see Edwards et al., 2002, for a review). Impairments have been found in the perception of facial expressions of affect, in particular with regard to negative emotions (eg. Mandal et al., 1998, Edwards et al., 2001). In addition, it has been shown that the processing of threat-related facial affect is delayed in delusion-prone individuals (Green, 2001). Functional deficits in the limbic system and particularly the amygdala, appear to be related to a deficit in the perception of negative non-verbal affect (Edwards, 2001), since recent studies have demonstrated abnormalities in amygdala functioning during fear affect perception (Baird et al., 1999) and sad mood induction in schizophrenia (Schneider et al., 1998). Perception of facial affect has been reported to be associated with measures of intelligence (Borod et al., 1993), level of education (Van der Gaag & Haenen, 1990) and attention (Addington & Addington, 1998; Bellack et al., 1992). Deficits in the perception of facial affect show minimal response to antipsychotic medication (Herbener et al., 2005). Finally, there is evidence of a negative bias in the perception of facial affect: patients tend to misidentify neutral faces as negatively valenced (Kohler et al., 2003).

Auditory perception of affect, or emotional prosody, has received less attention. Emotional prosody refers to information conveyed by pitch, amplitude, and duration contours of speech which conveys information about a speaker’s emotional state (Luks et al., 1998). Edwards et al. (2002) reviewed seven studies on prosody perception in schizophrenia. In most studies, sentences without semantic content were administered with a tape recorder. People with schizophrenia appeared to be impaired in the perception of emotion in speech (Kerr & Neale, 1993; Leentjens et al., 1998; Murphy & Cutting, 1990; Billenberg & Johnson, 1965). This finding was confirmed in three additional studies (Ross et al., 2001; Hooker & Park, 2002; Shaw et al., 1999).

No relationship has been reported between positive and negative symptoms and the ability to encode emotional prosody. This finding has been reported in a variety of patients, including first episode patients, stable outpatients and chronic patients (Fricchione et al., 1986, Edwards et al., 2001, Shaw et al., 1999, Bozikas et al., 2004). However, Leitman et al., (2005) found an association between severity of negative symptoms and prosody perception. Some evidence suggests that people with schizophrenia are especially impaired in the perception of negative emotional prosody (Edwards et al., 2001, 2002).

It has been argued that impairments in other cognitive abilities in schizophrenia may underlie impaired perception of emotional prosody, but results with regard to the covariation of general cognitive functioning and prosody perception are not
consistent. Bozikas et al. (2004) found emotional prosody perception to be associated with performance on tests of attention and executive functioning; others (Whittaker et al., 1994), however, did not find such associations. In addition, basic pitch perception deficits may be associated with deficits in the perception of emotional prosody (Leitman et al., 2005).

The aim of the present study is to examine the presence and severity of a deficit in the perception of emotional prosody in schizophrenia in more detail. Three main issues are addressed. First, we wanted to know whether a possible deficit in the perception of emotional prosody is indeed emotion-specific. We hypothesized that people with schizophrenia are relatively more impaired in the perception of negative prosody, as compared to positive and neutral prosody. Therefore, a standardized measure was used to test the ability to perceive emotional prosody. This measure was complemented with a syntactic prosody control task with the same response format and performance of people with schizophrenia was compared with a healthy control group. In our test, difficulty of the items varied independent of the emotional category, which is needed to test our hypothesis of a specific deficit in the perception of negative expressions.

Second, we expected perception of emotional prosody to be associated with other general cognitive abilities. Therefore, we assessed all people with schizophrenia with a battery of general cognitive tests, tapping on intelligence, vigilance, psychomotor speed and verbal memory.

Finally, we wanted to know whether a bias existed in the perception of emotional prosody. We hypothesized that patients would mislabel neutral emotional prosody more often as negative than healthy subjects do, like they do in the perception of facial affect (Kohler et al., 2003). Therefore, the patterns of errors of patients and controls were compared. To detect a possible negative bias in the labeling of emotional prosody, the direction of errors in emotional prosody perception was analyzed.

4.3 Materials and Methods

4.3.1 Participants
Twenty patients diagnosed with schizophrenia according to DSM-IV criteria were included in the study. Fourteen patients were male and six were female. They were all right handed. Diagnoses were based both on chart review and judgement of an independent clinician. Patients were assessed during treatment at the Department of Psychotic Disorders and were clinically stable at the time of assessment. After the experimental procedures had been explained, all patients gave their written informed consent. Exclusion criteria were the existence of co-morbid neurological
pathology, hearing disorders, mental retardation or drug abuse at the time of the study. Their mean age was 30 years (SD =8). A scale ranging from 1= primary school to 7=university (Verhage, 1983) was used to classify the level of education; the mean level of education was 5 (SD 1.3).

Two patients did not use anti-psychotic medication; 10 patients used classic anti-psychotic medication (Haloperidol; n=6, Zuclopentixol; n=1 and Pimozide; n=3) and 8 patients used atypical anti-psychotic medication (Clozapine; n = 2, Olanzapine; n = 6). Thirteen patients were living independently and received outpatient care. The remaining seven patients were inpatients, following a rehabilitation programme. The mean number of psychotic episodes experienced by the patient sample in the past was 5 (SD= 4.5), ranging from 1 to 15. The mean duration of illness was 8 (SD=7.5).

Furthermore, a control group of 20 healthy individuals was tested for the purpose of this study. Eleven controls were male and nine were female. Controls were recruited by advertising in a local newspaper and matched according to age, and level of education. All controls were right-handed. Exclusion criteria for controls were a self-reported history of psychiatric disorders, the existence of co-morbid neurological pathology, hearing disorders, mental retardation or drug abuse at the time of the study. Controls received a small financial compensation for their participation.

Their mean age was 34 years (SD =6), and the mean level of education was 5 (SD 1.8). Patients and controls did not significantly differ with regard to age and education level, but the control group contained slightly more females.

4.3.2 Materials and Procedure
Emotional Prosody Perception Task
The Prosody Test used in this study is a modified version of a test described elsewhere (Bos et al., 2005). This Prosody test was originally designed to test the ability to perceive emotional prosody and to detect a possible perceptual bias. Therefore, the test contains ambiguous items besides items that are easily identifiable by healthy subjects, which also avoids a ceiling effect. The original version of the test consisted of 36 items. For test construction purposes, items of the original test were divided into two categories: negative items; anger, sadness, and fear, and positive or neutral items: happiness, surprise, and neutral. Previously, data from a sample of 27 healthy college students, recruited through advertising at the Faculty Behavioural and Social Sciences of the University of Groningen, were assessed to analyze errors in identification, reaction time and subjective judgment of difficulty.
Subjective difficulty was judged using a five point scale, ranging from very easy to very difficult. Results of these analyses showed that positive and neutral emotions in the original test were more difficult to identify than negative emotions. To ensure a more balanced comparison between negative and positive and neutral items, the two easiest items of each negative category and the two most difficult items of each of the non-negative categories were removed from the test, leading to the 24 item version used in this study. Data from a sample of 49 college students, also recruited through advertising at the Faculty of Behavioural and Social Sciences of the University of Groningen, were used to calculate split-half reliability. For this sample, Spearman-Brown split-half coefficient was .70.

The Prosody Test in the present study consists of two practice items, 16 sentences with a neutral content and eight patterned syllable structures. The sentences with a neutral content were presented in the Dutch language and can be translated as follows: “The old car drives through the streets of the capital” and “The big plane flies over the trees of the rain forest”. The patterned syllable structure was “ba ba ba ba ba”. Two experienced amateur actors, one male and one female, pronounced these sentences with five different emotions (fear, sadness, anger, surprise and happiness) and in a neutral way. Four sentences of each of these five emotional categories and four neutral sentences were included in the test.

Administration of the test occurred via a Compact Disk Player. The task was subject-paced, the next item was presented six seconds after the participant had responded to the preceding item, but the Compact Disk was paused when allocated time was not enough to finish an item. The response categories were presented in a multiple choice format. Response categories were printed on a form, which was placed in front of the subjects. As the Prosody Test was constructed in such a way that it could also be used to assess patients with brain injuries exhibiting various impairments in understanding words or pictures of emotional faces, the response categories were indicated both by verbal labels and pictures of emotional faces indicating fear, sadness, anger, surprise, happiness and neutral (Ekman and Friesen, 1975).

Participants were required to indicate their responses verbally. All responses were scored and noted on a score form by the experimenter.

**Syntactical Prosody Control Task**

To ascertain that all participants were able to decode the intonation of speech, the perception of syntactic prosody was assessed in a second part of the test. This part consisted of two practice items and six sentences with neutral content expressed in a neutral, enquiring, or a affirming tone of voice. The sentences from the first part of
the test were pronounced by the same actors. The procedure of the control task was equal to the emotional prosody perception task, with one exception: photographs of faces were replaced by pictures of punctuation marks: a dot, a question mark and an exclamation mark. The verbal category each punctuation mark indicated was printed underneath each picture; the categories were neutral, enquiring and affirming.

General Cognitive Functioning
All people with schizophrenia were tested with a battery of neuropsychological tests concerning intelligence, attention, and verbal memory. Limitations in these cognitive domains in schizophrenia have been well-documented (see Heinrichs & Zakzanis for a review, 1998).

Intelligence. A shortened version of the Groninger Intelligence Test , a widely used Dutch intelligence test, (GIT; Luteijn & Van der Ploeg, 1983) was used. The short GIT consists of five subtests: Spatial Abilities, Arithmetic, Verbal Knowledge, Verbal Logical Reasoning and Word Fluency I and II.

Attention. Attention was assessed with a vigilance test for assessing focused attention and a test of visual search and cognitive flexibility for assessing divided attention and mental speed. The vigilance test used is a double stimulus version of the Continuous Performance Test (Van den Bosch et al., 1996). Participants are presented with rapidly alternating numbers on a computer screen, ranging from 1 to 10, for a period of ten minutes. They are required to push a button each time a target stimulus occurs; this is each time a seven follows a three, over period of ten minutes. The sensitivity index (d') is used, indicating focused attention in the sense of discriminating relevant stimuli from distractors.

As a test of divided attention and mental speed, the Trail Making B (Reitan, 1979) was used. In this paper and pencil test subjects are required to draw a line alternating between subsequent letters and numbers as fast as possible (1-A-2-B-3-C etc). This test score comprises elements of perceptual-motor and mental speed, as well as elements of divided attention and flexibility.

Verbal memory. The 15-Words Test (Saan & Deelman, 1986), a Dutch modification of the Rey Auditory Verbal Learning Test, was used to assess verbal memory. The test consists of five tape-recorded presentations of a list of 15 semantically unrelated words, with immediate free recall after each presentation. The total number of words remembered over five trials results in a learning score. After twenty minutes, free recall is measured again, resulting in a delayed recall score. The number of words
produced in the delayed recall condition was used as a measure of retrieval from episodic verbal memory.

4.3.3 Data-analysis

Between-Groups Analyses: To compare mean accuracy scores of patients and controls on the emotional prosody task and the syntactical prosody task, differences between groups on each task were computed. Group differences and their confidence intervals were computed using an two-tailed Independent Sample T-test.

Regression Analysis: Pearson’s correlation coefficients were used to determine the relationship between emotional prosody perception and general cognitive functioning in the patient group, and confidence intervals were provided for these correlations, using Fisher Z-transformation based standard procedure. Univariate Linear Regression (method: enter) was used to determine the predictive value of general cognitive variables on the perception of emotional prosody in the patient sample.

Analysis of mislabeling errors: For the purpose of error-analysis, items of the Prosody test were classified as negative (fear, sadness and anger) and positive or neutral (happiness, surprise and neutral). Mislabeling errors were divided into four categories, according to Walker’s (1981) procedure: 1. Positive or neutral emotion labeled as another positive or neutral emotion; 2. Positive or neutral emotion labeled as a negative emotion; 3. Negative emotion labeled as a positive or neutral emotion; 4. Negative emotion labeled as another negative emotion. To correct for the number of errors, errors indices were calculated for both patients and controls. Error indices were the sum of errors of each type divided by the total number of positive or neutral errors in case of category 1 and 2, and by the total number of negative errors in case of category 3 and 4. Because the results after the calculation of these error indices were very clear, no further statistical analyses were performed.

4.4 Results

Patients versus controls

The mean scores on the emotional prosody task of the patients was 13.1 compared to 16.1 for the controls. An Independent Sample T-test was computed to test the significance of the observed difference in means (see Table 4.1). Patients show significantly poorer perception of emotional prosody than controls. To further investigate the effect of specific emotions, an Independent Sample T-test was
computed for each emotional category and for neutral items. Mean scores of patients and controls per emotion, t-values, significance levels and the confidence interval for the differences, are also presented in Table 4.1. The percentage of correct responses for each emotion is presented in Figure 4.1.

**Table 4.1** Mean scores of patients and controls on the perception of emotional prosody and syntactical prosody, t-values, significance levels and 95% confidence intervals

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Mean score patients</th>
<th>Mean score controls</th>
<th>T-values</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fear</td>
<td>1.3</td>
<td>2</td>
<td>.14*</td>
<td>.0 -- 1.4</td>
</tr>
<tr>
<td>Sadness</td>
<td>2.3</td>
<td>3.2</td>
<td>.36*</td>
<td>.1 -- 1.7</td>
</tr>
<tr>
<td>Anger</td>
<td>2.9</td>
<td>3.6</td>
<td>.01**</td>
<td>.4 -- 1.1</td>
</tr>
<tr>
<td>Surprise</td>
<td>2.1</td>
<td>2.4</td>
<td>.81</td>
<td>-.5 -- .8</td>
</tr>
<tr>
<td>Happiness</td>
<td>1.4</td>
<td>1.6</td>
<td>.72</td>
<td>-.4 -- .8</td>
</tr>
<tr>
<td>Neutral</td>
<td>3.2</td>
<td>3.4</td>
<td>.08</td>
<td>-.4 -- .8</td>
</tr>
<tr>
<td>Prosody Total</td>
<td>13.1</td>
<td>16.1</td>
<td>.11**</td>
<td>3.1 -- 4.9</td>
</tr>
<tr>
<td>Syntactical Prosody</td>
<td>5.2</td>
<td>5.4</td>
<td>.44</td>
<td>-.6 -- .9</td>
</tr>
</tbody>
</table>

Range 0-4 (4 items per emotion)

 Patients: n=20
Controls: n=20

* significant at a .05 level
** significant at a .001 level

**Figure 4.1** Percentage of correct responses per emotion
As shown in Table 4.1 and Figure 4.1, patients score significantly lower on the identification of the emotions fear, anger and sadness\(^1\). A specific impairment on the perception of negative emotions could not be explained by the difficulty of the stimulus material, as the impaired categories did not equal the categories in which most errors are made (Figure 4.1). Both patients and controls most frequently misidentified happy and fearful expressions, and identified angry and neutral expressions best. The mean scores on the control task were 5.2 for patients and 5.4 for controls. The percentage of correct responses for the control task is presented in Figure 1. Patients and controls did not differ with regard to the perception of syntactical prosody (see Table 4.1 for t-value, significance level and the confidence interval for the differences).

**Relationship between emotional prosody and general cognitive functions**

In the schizophrenia group performance on the tests of intelligence, attention and memory was correlated moderately strong with performance on the Prosody Test (see Table 4.2 for performance of people with schizophrenia on all tests and Table 4.3 for Pearson’s correlation coefficients and 95% CI’s).

As intelligence test performance and prosody test performance showed the highest association, a first regression analysis (method: enter) was performed, with only intelligence as a predictor. The regression gave a moderately strong adjusted fit value \(R^2_{\text{adj}} = 53\%\) and the overall relationship was highly significant \(F_{4,19} = 22,03, p < 0.001\). Regression weight was .15, with a confidence interval ranging from .086

Note\(^1\): Ambiguous items were included in the test to detect a possible bias. A test score for negative and non-negative expressions based on 16 unambiguous items (more than 70% correct in a sample of 49 college students) was also calculated. When this version of the test was used in the analysis of group differences, we found the same results: negative prosody perception is impaired in schizophrenia, while performance on non-negative items is comparable to controls.

**Table 4.2 Performance of schizophrenic patients on neuropsychological tests**

<table>
<thead>
<tr>
<th>Test</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groninger Intelligence Test</td>
<td>95</td>
<td>13.3</td>
</tr>
<tr>
<td>Continuous Performance Test (d’)*</td>
<td>3.2</td>
<td>0.8</td>
</tr>
<tr>
<td>15 Words Test (number of words DR)**</td>
<td>6</td>
<td>2.7</td>
</tr>
<tr>
<td>Trailmaking B (time needed in seconds)</td>
<td>100</td>
<td>45</td>
</tr>
</tbody>
</table>

Patients: n=20

*\(d’\) = a sensitivity index, indicating focused attention in the sense of discriminating relevant stimuli from distractors.

**\(DR\) = free recall after twenty minutes
Chapter 4

Table 4.3 Pearson’s correlations between emotional prosody perception and performance on neuropsychological tests and 95% confidence intervals (n=20)

<table>
<thead>
<tr>
<th>Prosody</th>
<th>95% CI</th>
<th>GIT-IQ</th>
<th>95% CI</th>
<th>Trail B</th>
<th>95% CI</th>
<th>CPT d’</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIT-IQ1 r²</td>
<td>.74**</td>
<td>.44 -.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trail B² r²</td>
<td>.59**</td>
<td>.20 -.82</td>
<td>.65**</td>
<td>.29 -.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT d³ r²</td>
<td>.48*</td>
<td>.05 -.76</td>
<td>.57**</td>
<td>.17 -.81</td>
<td>.26</td>
<td>-.21 -.64</td>
<td></td>
</tr>
<tr>
<td>15 WT⁴ r²</td>
<td>.56*</td>
<td>.16 -.80</td>
<td>.68*</td>
<td>.34 -.86</td>
<td>.62**</td>
<td>.25 -.83</td>
<td>.62**</td>
</tr>
</tbody>
</table>

1 Groninger Intelligence Test
2 Trailmaking B
3 Continuous Performance Test
4 15 Words Test

Patients: n=20

* significant at a .05 level
** significant at a .01 level

to .24. Fifty-three percent of the variance in prosody perception was explained by intelligence; the predictive value of intelligence was highly significant (t=4.69, p<.001).

To determine the unique contribution of each of the general cognitive tests to the prediction of performance on the prosody task, all four variables associated with prosody perception were entered simultaneously in a regression equation, using as predictors intelligence, attention and verbal memory. Though this regression gave a slightly poorer adjusted fit (R² adj = 52%), the overall relationship was once more significant (F 4,19 = 5.29, p < 0.01). Due to high intercorrelations, none of the regressors contributed exclusively to the prediction of prosody perception. Thus, adding attention and memory to the model did not contribute to the prediction of prosody perception; the adjusted R² did not increase by adding these predictors. A model in which only intelligence is used as a regressor best predicts prosody perception.

Analysis of errors

Finally, we examined how participants did interpret the expressions, when they did not correctly identify the emotion. In Table 4.4, errors indices of patients and controls are displayed (see analysis of mislabelling errors for details on calculation of error indices). As shown in Table 4.2, there was no difference in error indices between patients and controls. Stated differently, people with schizophrenia showed no different bias in the labeling of incorrectly recognized emotions. When expressions were labeled incorrectly, both patients and controls were most likely to
Impaired perception of negative emotional prosody in schizophrenia

**Table 4.4** Error Indices (number of errors in each category corrected for the total number of errors in prosody perception)

<table>
<thead>
<tr>
<th></th>
<th>Labelled as Positive-neutral</th>
<th>Labelled as Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive-neutral</td>
<td>Negative</td>
</tr>
<tr>
<td><strong>Patients</strong></td>
<td>.71</td>
<td>.28</td>
</tr>
<tr>
<td><strong>Controls</strong></td>
<td>.71</td>
<td>.28</td>
</tr>
</tbody>
</table>

Patients: n=20  
Controls: n=20

...perceive a positive or neutral emotion, regardless of the actual emotional valence of the expression.

### 4.5 Discussion

This study provides further evidence for impairment in the perception of emotional prosody in people with schizophrenia. As predicted, patients performed worse than controls on emotional prosody perception. Both patients and controls most frequently misidentified happy and fearful expressions, and identified angry and neutral expressions best. This pattern is in line with a study on the perception of prosody in healthy controls (Johnson et al., 1986). On the syntactical prosody control task, performance of both patients and control subjects was very good; hence the difference between patients and controls in prosodic comprehension was not caused by the patients’ misunderstanding of test instructions or caused by a grossly impaired decoding of speech intonation in general.

On average, patients performed worse than controls on the identification of each emotion, and did so in particular on the perception of negative emotional prosody. This confirms previous findings with regard to decoding of non-verbal affect. Edwards et al. (2001) found that schizophrenic patients performed particularly poor at the identification of sad and fearful emotional prosody. In addition, several authors have suggested impaired perception of negative emotions in schizophrenia in studies on the decoding of facial affect (Archer et al., 1994, Gaebel & Wölver, 1992, Bellack et al., 1992, Schneider et al., 1995). Since the difference between negative and positive emotions is shown for emotions with both high and low average performance scores in healthy subjects, we argue that it is a specific difference that cannot be explained on the basis of task difficulty or on a general impairment in the decoding of speech intonation.
The second hypothesis was confirmed as well: in our sample of people with schizophrenia more than half of the variance in performance on the emotional prosody test was shared with intelligence, memory, psychomotor speed and attention. Up to then our results had indicated that the prosodic impairment is quite specific, because it is restricted to the perception of negative affect. Therefore, the strong association with general cognitive abilities is rather surprising, since it appears to be in line with the general deficit model of schizophrenia. According to this model, patients are expected to be impaired on most tests of cognition, regardless of assessment method (e.g. Blanchard & Neale, 1994). However, with regard to the results of the present study, this model does not explain negative emotions being degraded specifically. Therefore, instead of being part of a general deficit, a disparity in general cognitive or intellectual abilities may underlie impaired prosody perception. Alternatively, impaired perception of emotions may have limited the use or perhaps even the development of general cognitive abilities. If people with schizophrenia have difficulties in identifying negative emotions expressed by others, they may be less sensitive to punishment and negative social reinforcement delivered by non-verbal cues. A diminished sensitivity to corrective social signals may impair the quality of their pedagogic relationships, which may eventually have negative consequences for performance on tests of cognitive functioning.

Finally, analysis of the error pattern showed that no bias was found in prosody perception, when corrected for the number of errors, which was in contrast with the negative perceptual bias in the perception of facial affect (Kohler, 2003). Patients in our study did not interpret neutral expressions as negative more frequently than healthy controls did. Instead, when they made an error, patients were most likely to perceive a positive or neutral emotion, regardless of the actual emotional valence of the expression. A negative perceptual bias may be limited to the visual modality, and therefore be absent in the perception of prosody. It is also possible that a negative bias in schizophrenia is state-dependent (e.g. related to paranoid delusions) and was therefore not present in the clinically stable sample in this study. The present study has a number of limitations. In the first place, cognitive functioning was only assessed in people with schizophrenia. Since cognitive data are gathered on patients only, a confounding effect of underlying differences in cognitive abilities and intelligence cannot be totally excluded. Although patients and controls did not differ significantly with regard to education level, cognitive functioning and intelligence are known to deteriorate after onset of the disease (Heinrichs & Zakzanis, 1998, Aylward et al., 1984). Since schizophrenia typically starts in late adolescence, educational level for these patients may be an overestimation of their actual cognitive abilities. Therefore, it could be argued that
differences in cognitive abilities underlie group differences in prosody perception, as a relationship between cognitive functioning and prosody perception was found in schizophrenia. However, the fact that only perception of negative emotional prosody is impaired in schizophrenia is a strong argument against the existence of this artefact. In future research, it should be explored whether an equally strong relationship between prosody perception and general cognitive functioning exists in healthy subjects. To our knowledge, such a study has never been performed, although some studies on the matter do exist in ageing research (Orbelo et al., 2005) and in neurological patient groups (Breitenstein et al., 2001). Results of these studies are inconsistent: impaired emotional prosody perception was not predicted by age related cognitive decline, while working memory dysfunctions were associated with prosody perception in Parkinson’s disease.

A second limitation of the present study is the control task, which was useful to exclude the possibility of impaired decoding of speech intonation in general as the cause of impaired emotional prosody perception. However, if we had not found the difference between positive and negative emotions, we would not have been able to conclude that the impaired perception of emotional prosody is a differential deficit (Chapman & Chapman, 1978) due to a near ceiling effect in both patients and controls on the control measure.

Although social cognition in schizophrenia has been studied extensively, up to now, it is not common practice to include measures of social cognition in test batteries used to assess individual patients. Generally, only classical cognitive measures are assessed, such as intelligence, attention, and memory (e.g. Knegtering et al., 2003). Although these general general cognitive measures have been associated with social and occupational functioning (Green, 1996), and are considered to be rate limiting factors for rehabilitation (for example Mueser, 2000), they leave a substantial part of the variance in social functioning unexplained (Van Beilen, 2004, Holthausen, 2003). We hope that the incorporation of measures of social cognition may further enhance the ecological validity of neuropsychological assessment with regard to patients’ social and occupational functioning, since the ability to understand other people’s emotional expressions is a prerequisite for to respond to them in an adequate and adaptive manner. Indeed, it has been demonstrated that face and voice affect perception are significant predictors of these important outcome measures (Hooker & Park, 2002, Poole et al, 2000). Therefore, the authors recommend further exploration of the clinical use of tests of social cognition in future studies.
**Chapter 4B Supplement**

After the previous Chapter was accepted for publication the effect of gender on prosody perception was demonstrated (Scholten et al., 2008). Furthermore, we found an effect of gender on prosody perception in one of our own studies (see Chapter 5). Therefore, we re-analysed the between group difference and included gender as a covariate in a two-way ANOVA. Results showed a significant main effect for diagnosis (F 1,37 =8.7, p<.01). Overall women performed somewhat better than men (m=15.2 vs. m= 14.1), but the main effect for gender was not significant in our sample (F1,37 =.45, n.s.). Thus, the group differences we found in our study could not be attributed to the fact that there were more men in the patient sample than in the control group.