Chapter 4

Impaired recognition and expression of emotional prosody in schizophrenia: review and meta-analysis*

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Abstract

Background Deficits in emotion processing may be one of most pervasive disturbances in schizophrenia that may contribute to social isolation. In this report, we focus on vocal emotion processing. This function bears upon two corner stones of social functioning, language and emotion, which have both been found to be impaired in schizophrenia. *Methods* We used meta-analysis to integrate findings of studies published between 1980 and June 2007 on perception of emotional prosody in schizophrenia. Seventeen studies provided sufficient information to be included. A mean weighted effect size was computed in the random effects model. Publication bias was tested using funnel plots and fail-safe number of studies. Seven studies were included in an analysis on the expression (i.e. production) of emotional prosody in schizophrenia. *Results* A significant and stable mean weighted effect size was found for the perception of emotional prosody, d= -1.24, 95% CI = -1.55 to - 0.93. The effect was also found in the early stages of the illness. Expression of emotional prosody was also significantly impaired, d=-1.11, 95% CI = - 1.78 to - 0.43. *Conclusions* Results indicate that individuals with schizophrenia are impaired in the perception and expression of emotional prosody, with a large effect size. As a growing body of evidence shows that impaired social cognition in schizophrenia may be an important predictor of social outcome, training programs that aim at the recognition of emotional prosody should be developed.

**Schizophrenia Research 96 (2007) 135 - 145*

Introduction

Schizophrenia patients have deficits in a large number of functional domains, including social skills and social cognition. These social impairments consist of difficulties in perceiving, understanding, anticipating and reacting to social cues that are crucial for normal social interaction. Social skills like developing and maintaining social networks are deficient (Yager and Ehmann, 2006). Disturbances in social cognition are thought to explain impairments in social functioning (Pinkham et al., 2003). Social cognition indicates aspects of cognition that potentially have an independent link to social behaviour and social function. It includes processes as theory-of-mind skills, social perception, and attributional style (Pinkham et al., 2005). Clearly, vocal emotion perception is an aspect of social cognition. Deficits in facial and vocal emotion perception may lead to decreased social skills, like misunderstandings and inappropriate social responses (Pinkham and Penn, 2006; Kee et al., 2003).

Emotional abnormalities in SCZ have been categorized under the headings of positive (hyperarousal), negative (blunted affect) and cognitive (impairments in affect recognition) symptoms (Aleman and Kahn, 2005). Vocal emotion perception refers to the evaluation of emotional prosodic information of spoken sentences. The term prosody denotes non-lexical cues in spoken language and can be divided into emotional and linguistic prosody. Linguistic prosody implies decisions about semantic meaning, for example, stressing essential parts of a sentence, or presenting information as a statement or a question. Emotional prosody concerns the emotional tone of voice and is important for the perception of the emotional state and intentions of others (van Rijn et al., 2005;Edwards et al., 2002). Perception of emotional prosody contributes to our understanding of what is known as the pragmatic meaning of speech, the intended between-the–lines meaning (Murphy and Cutting, 1990). In order to understand verbal messages, one should not only pay attention to *what* is said, but also to *how* it is said (van Rijn et al., 2005). For example, a man hearing his wife say, "you are a workaholic", can receive completely different messages depending on whether the tone of her voice is angry or playful.

Impaired emotional processing may affect functional outcome independently of symptoms (Kee et al., 2003). Based on clinical observations it has been hypothesized that individuals with schizophrenia might suffer from impairments in the perception of emotional prosody. In contrast to the volume of research on facial emotion perception in schizophrenia, the literature on vocal emotion perception remains sparse. In a review of the literature, the authors conclude that the evi-

dence of impairment in emotional prosody perception in schizophrenia remains unclear, (Edwards et al., 2002;Edwards et al., 2001). Over the last five years, however, more articles have been published on emotional prosody perception in schizophrenia. Most of these articles reported significant impairments (Murphy and Cutting, 1990;Kerr and Neale, 1993; Haskins et al., 1995;Ross et al., 2001; Hooker and Park, 2002; Kucharska-Pietura et al., 2005; Leitman, 2005; Rossell, 2005; Bozikas et al., 2006). According to some studies the deficit in vocal emotion perception is as pronounced as in brain damage patients with right hemisphere lesions (Ross et al., 2001; Borod et al., 1989). In some the results showed smaller impairments (Kee et al., 2004;Edwards et al., 2001;Leentjens et al., 1998).

Other issues regarding schizophrenia and emotional prosody perception that remain to be clarified are whether the ability to decode emotional prosodic information remains stable over years and whether chronic patients with schizophrenia show greater impairment than acutely ill patients do. Preliminary evidence suggests that emotion recognition deficits are apparent at early stages of the disorder (Edwards et al., 2001) and are significantly larger in chronic patients as compared to early stage patients (Kucharska-Pietura et al., 2005). Deficits in emotional prosody have also been identified in children and adolescents with early-onset schizophrenia (Baltaxe and Simmons, 1995). Subtle deficits in emotion perception are detectable in unaffected siblings of schizophrenia patients and may be direct indicators of vulnerability factors (Kee et al., 2004).

Further unanswered questions are whether medication may account for a portion of the impairment and whether number of years of hospitalization plays a role and wether there is a relationship between the ability to perceive emotional prosody and positive or negative symptoms. Indeed, there have been reports of a negative association between emotion discrimination and severity of negative emotions (Schneider et al., 1995).

We conducted a meta-analysis to evaluate the consistency and strength of the impairment in perception of emotional prosody in schizophrenia, using a quantitative review of published experimental studies. Our study had three aims:

1) To review the literature on perception of emotional prosody in schizophrenia,

2) To determine, by meta-analysis, the magnitude, and nature of impairments in perception of emotional prosody in schizophrenia and

3) To identify factors that significantly affect the magnitude of the impairment.

Method

Literature search

Relevant articles were found through a broad literature search in the computerized databases, Pubmed and Web of Sciences in the period between 1980 and June 2007. The starting- point of this time period was chosen because the most influential diagnostic system for schizophrenia, DSM-III, was introduced in 1980, leading to better uniformity in diagnosis than what is found in earlier years (American Psychiatric Association et al., 1980). The following combination of words were used as search terms combined with "schizophrenia": "prosody", "vocal emotion", "emotion perception", "emotional information processing", "affect perception" and "vocal affect recognition". In addition manual searches of the reference lists of the selected articles and the review of Edwards were conducted (Edwards et al., 2002). The search produced 487 studies of which we selected 17 articles that met our inclusion criteria as presented below. The studies included in the meta-analysis are summarized in table 1. Impairments in vocal emotion recognition are not specific for schizophrenia, but are also reported in other clinical groups. Our literature search identified three reports that provided comparisons with other clinical groups. We were also interested in the expression of emotional prosody in schizophrenia. Research terms for the inclusion of articles for this supplemental analysis were: "emotion expression", "emotion production", "affect expression" and "vocal affect expression" and "vocal affect production", combined with "schizophrenia".

Study selection

The identified studies had to meet the following criteria: First, patients had a diagnosis of schizophrenia according to the criteria of DSM-IV, DSM-III-R, DSM-IV, Research Diagnostic Criteria (RDC), ICD-9 or ICD-10 (International classification of Disease) or Schedule for Affective Disorders and Schizophrenia (SADS). Studies on patient groups consisting of both schizophrenia and schizoaffective disorder patients were also included (Haskins et al., 1995;Leitman, 2005; Leitman et al., 2007;Rossell, 2005;Shea et al., 2007). Second, the study had to report on a behavioural measure of emotional prosody. Behavioural measures of emotional prosody perception typically consist of a number of audiotaped sentences (or sometimes words) with a linguistically neutral content, e.g., "He tossed the bread to the pigeons", or "The boy went to the store" (items from the Voice Emotion Identification Test (VOICE-ID) (Kerr and Neale, 1993). These sentences are spoken aloud by an actor to convey an emotion in the intonation. In most studies participants are given a piece of paper with the emotions listed and are asked to decide which of the

listed emotions best describes the speaker's tone of voice. Third, studies had to compare the performance of schizophrenia patients with that of healthy comparison subjects who were not at increased risk for schizophrenia or psychosis. Fourth, studies had to be published in English-language international, peer reviewed journals. Finally, studies had to report sufficient data for the calculation of a *d*-value. This implies that means and standard deviations, exact p-values, t-values, or exact F-values and relevant means had to be reported (cf. (Aleman et al., 1999)).

Calculation of effect sizes and data analysis

Effect sizes (Cohen's *d*) for the difference in perception and in production of emotional prosody performance between schizophrenia patients and a healthy control subjects were calculated on the basis of reported statistics. When mean and standard deviations were reported for both treatment (schizophrenia) and comparison (healthy control) group, Cohen's *d* was calculated with the effect size computation program developed by D. Wilson (http://mason.gmu.edu/~dwilsonb/ma.html). If studies did not report means and standard deviations, effect size *d* was calculated with reported *t* or *F* statistics or the significance values. One of the studies in this analysis included more than one behavioural measure of emotional prosodic comprehension (Rossell, 2005). In addition, in one study more than one group of schizophrenia patients was included (Kucharska-Pietura et al., 2005;Leitman et al., 2007). In both situations we calculated one pooled effect size estimate. For the moderator variable analyses these studies were split on basis of the variable of interest. After computation of the effect sizes for the individual studies, meta-analytic analyses were performed with the Comprehensive Meta-analysis computation program (Borenstein et al., 2005). A combined effect size with corresponding confidence intervals (95%), which indicated the magnitude of the effect across all studies was calculated cf. (Aleman et al., 1999). In addition, the homogeneity Qw statistic refers to the heterogeneity of studies within categories. In the case of significant heterogeneity, further analyses were performed in search for potential moderators of effect size (Lipsey and Wilson, 2001). A few studies did not provide sufficient statistical data to be included in the meta-analysis. To obtain a representative impression of the studies done on emotional prosody in schizophrenia, a vote count analysis was also carried out including all studies (cf. (Sommer, I, 2004)). For this analysis, we counted the number of all studies and the sum of patients included in these studies that reported a worse performance for schizophrenia patients on an emotional prosody task as compared to healthy controls and all studies that reported no difference in

performance between the two groups with the total number of patients in these studies. In the study that applied two tasks measuring the perception of emotional prosody, these two were taken together as one value. The studies selected for the vote count analysis are described in table 1 and 2, for perception and expression respectively.

Publication bias/File drawer Analysis

Publication biases influence the reliability of mean effect sizes. Studies with non–significant findings remain unpublished, which has been termed the "file-drawer problem" (Rosenthal, 1979). In order to identify and deal with publication bias, we calculated the fail-safe number and visualized a funnel plot. A fail-safe number of studies estimates the number of non-significant, unpublished studies that would need to be added to a meta-analysis to reduce an overall statistically significant observed effect to non-significance (Rosenthal, 1979;Rosenberg, 2005). In a funnel plot effect size estimates are plotted against sample size (Egger et al., 1997). The funnel plot is based on the fact that precision in estimating the effect of underlying variable of interest becomes larger with the increase of the sample size. Thus, at the bottom of the plot, where the sample sizes are smaller, the scatter should be wider and becomes smaller going the top of the plot. If there is bias this inverted funnel will often be skewed and asymmetrical, because studies with smaller sample sizes and non significant results remain unpublished (Egger et al., 1997).

Moderator Variables

The literature suggests a number of factors that may affect the performance of schizophrenia patients in the perception of emotional prosody. To investigate this, categorical values were entered in the meta-analysis program and analyses were performed (Borenstein et al., 2005). The potential moderator variables we evaluated were either clinical or methodological; The clinical variables were: age of the patients, patient status, duration of illness and medication status, methodological variables were: group size, whether schizophrenic and comparison group were matched for age, sex and level of education, task difficulty (number of stimuli and of emotions), task quality and validation, sex of the speaker of the stimuli used in the task and whether expressed emotional intonations were negative or not (i.e. positive or neutral). Unfortunately, sex differences, negative and positive symptoms and severity of psychopathology could not be studied, because of the very small number or complete lack of included studies reporting exact results for these variables. In the moderator analyses, the Qb statistic reflects a test difference between categories. This between- group homogeneity statistic is analogous to the F statistic.

Table 1 Characteristics and main findings of the studies included in the meta- and vote count analysis on the perception of emotional prosody

Author, year	Participants (Male)	Mean age (yrs)	Characteristics of the task.	Score for the quality of the task	Authors report worse performance for SCZ as compared to C.	Effect size (95% CI) or reason for exclusion
Borod et al, 1989	P: 6 (M:?) C: 4 (M:?)	P: 39 C: 35	16 sentences, 1 male actor, 4 emotions, validated, response format: 4 choices, no practice items.	**3**	Yes	Excluded, insufficient data.
Borod et al, 1990	P: 20 (M: 19) C: 21 (M: 11)	P: 57 C: 39	Same task as Borod et al, 1989	**3**	Yes	Included, d=-1.20 (- 1.86 to -0.53)
Murphy & Cutting, 1990	P: 15 (M: 10) C: 15 (M:8)	P: 28 C: 38	10 sentences, 1 male author, 4 emotions, no validation, response format:4 choices, no practice items.	**1**	Yes	Included, d=-1.73 (-2.57 to -0.89)
Kerr & Neale, 1993	P: 29 (M:25) C: 23 (M: 19)	P: 38 C: 39	21 stimuli, 4 different sentences, 3 male and 3 female students, 6 emotions, self made task, validated, response format: circle on a response sheet, no practice items (VOICE-ID).	**1**	Yes	Included, d=-1.64 (-2.27 to -1.01)
Whittaker et al, 1994	P: 16 (M:?) C:11 (M:?)	? ?	Same task as Murphy & Cutting, 1990.	**1**	No	Excluded, insufficient data.
Haskins et al, 1995	P: 47 (M: 26) C: 51 (M: 22)	P: 34 C: 36	12 stimuli, 3 different sentences, 4 emotions, no validation, response format: circle on a response sheet, no practice items, comprehension checked.	**1**	Yes	Included, d=-0.96 (-1.38 to -0.54)
Leentjens et al, 1998	P:26 (M:7) C:24 (M:12)	P: 41 C: 40	25 sentences, one actor, 5 emotions, self made, no validation.	**2**	Yes	Included, d=-0.70 (-1.27 to -0.13)
Shaw et al, 1999	P: 30 (M:30) C:normal control data	P: 42 C: ?	20 sentences, spoken by ?, 5 emotions, validated, (Florida Affect Battery).	**2**	Yes	Excluded, insufficient data.
Edwards et al, 2001	P: 29 (M:22) C: 24 (M:15)	P: 22 C: 22	60 stimuli, 16 different sentences, three actors, 5 emotions, validated, single emotion response format, three practice items.	**4**	Yes	Included, d=-0.59 (-1.14 to -0.04)
Ross et al, 2001	P: 37 (M:?) C: 19 (M:7)	P: ? C: 46	72 stimuli, sentences +words+ monosyllables, 6 emotions, no validation, response format, 1 of 6 choices.	**1**	Yes	Included, d=-1.80 (-2.45 to -1.15)

Table 1 *Continued*

Author, year	Participants (Male)	Mean age (yrs)	Characteristics of the task.	Score for the quality of the task	Authors report worse performance for SCZ as compared to C.	Effect size (95% CI) or reason for exclusion
Hooker & Park, 2002	P: 20 (M:15) C: 27 (M:14)	P: 40 C: 34	24 stimuli, 1 sentence, spoken by 11 year old girl, 4 emotions, validated, response format; circle 1 of 4 emotions.	**3**	Yes	Included, d=-1.27 (-1.90 to -0.64)
Kee et al, 2004	P: 58 (M: 55) C: 49 (M: 24)	P: 43 C: 36	Task developed by Kerr and Neale (Kerr and Neale, 1993) (VOICE-ID).	**1**	No	Included, d=-0.42 (-0.80 to -0.04)
Mitchell et al, 2004	P:12 (M:12) C:13 (M:13)	P: 46 C: 32	60 stimuli, sentences with emotional content, experienced phonetician, 2 emotions, validated, respond when emotional tone is happy.	**3**	No	Included, d= -2.39 (-3.42 to -1.36)
Chernigovskaya et al, 2004	P: 100(M:52) C: 60 (M:28)	P: 31 C: 29	Number of sentences ?, number of complex emotions ? (surprise, condemnation, bewilderment etc.),1 female professional announcer, 1 of 2 choices.	**1**	No	Excluded, task too different from other tasks.
Kucharska-Pietura et al, 2005	P: 100(M:51) C: 50 (M: 24)	P: 32 C: 37	35 stimuli, 5 different sentences, 1 male actor, 7 emotions, self made, validated, response format; circle on an answer sheet.	**2**	Yes	Included, d=-2.46 (-2.90 to -2.02)
Leitman, 2005	P: 43 (M: 33) C: 34 (M: 14)	P: 39 C: 36	Task developed by Kerr and Neale (Kerr and Neale, 1993).	**1**	Yes	Inlcuded, d=-1.66 (-2.17 to -1.14)
Rossell, 2005	P: 40 (M: 24) C:26 (M: 13)	P: 39 C: 37	Same task as Hooker And a new task: 196 stimuli, 22 different sentences, 1 female voice, 7 emotions, pilot tested, keyboard response	**3** **3**	Yes	Included, d= -0.77 (-1.28 to -0.26)
Bozikas et al, 2006	P:36 (M: 22) C:32 (M: 23)	P: 37 C: 34	30 stimuli, 5 different sentences, 1 male actor, 6 emotions, validated, response format; list of options, training trials**.**	**2**	Yes	Included, d=-0.82 (-1.31 to -0.32)
Shea et al, 2007	P: 67 (M:46) C: 31(M:20)	P: 42 C: 37	45 stimuli, 15 sentences, 2 male+2 female actors, 3 emotions, validated, response format; 7 point Likert scale, practice items.	**4**	Yes	Included, d=-0.74 (-1.18 to -0.30)

Table 1 *Continued*

Author, year	Participants (Male)	Mean age (yrs)	Characteristics of the task	Score for the quality of the task	Authors report worse performance for SCZ as compared to C.	Effect size (95% CI) or reason for exclusion
Leitman et al, 2007	P: 24 (M: 21) C: 17 (M: 14)	P: 38 C: 38	Task developed by Kerr and Neale (Kerr and Neale, 1993) (VOICE-ID).	**1**	Yes	Included, d=-1.60 (-2.32 to -0.89
Pijnenborg et al, 2007	P:20 (M: 14) C:20 (M: 11)	P: 30 C: 34	24 stimuli, 16 sentences + 8 syllable structures, 1 male +1 female actor, 6 emotions, validated, response format; multi-ple choice, practice items.	**2**	Yes	Included, d=-0.98 (-1.64 to -0.33)

Effect size cohen's d, negative, indicates worse performance in patients with schizophrenia. Participants, P means patients, C: controls, M: number of male participants. Age is given in years. A score for the quality of the task is given in a separate column, ranging from 0 to 4, with 4 as the best score.

Table 2 Characteristics and main findings of the studies included in the meta- and vote count analysis on the expression of emotional prosody

Author, year	Participants (Male)	Mean age (yrs)	Characteristics of the task	Authors report worse performance for SCZ as compared to C.	Effect size (95% CI) or reason for exclu-sion
Levin et al, 1985	P:23 (M:23) C: 8 (M: 8)	P: 36 C: 37	Were asked to speak about three experi-ences in their lives that made them happy,/ sad / angry. Validated (method of Hall/Levin) rated by 100 undergraduates.	No	Included, d=0.87 (0.03 to 1.70)
Borod et al, 1989	P: 6 (M:?) C: 4 (M:?)	P: 39 C: 35	16 sentences, 1 male actor, 4 emotions, validated, response format: 4 choices, no practice items.	Yes	Excluded, insufficient data.
Borod et al, 1990	P:20 (M:19) C: 21(M:11)	P: 57 C: 39	2 sentences, each read out in 8 different emotions, rated on Likert scale by 4 normal adults, validated.	Yes	Included, d=-1.80 (-2.52 to -1.07)
Murphy & Cutting, 1990	P: 15 (M:10) C: 15 (M: 8)	P: 28 C: 38	10 sentences, read out in 4 emotions, analyzed by 4 normal raters, no valida-tion.	Yes	Included, d=-0,90 (-1.65 to -0.15)
Whittaker et al, 1994	P: 16 (M:?) C:11 (M:?)	P: ? C: ?	Same task as Murphy & Cutting, 1990.	Yes	Excluded, insufficient data.
Haskins et al, 1995	P: 47 (M:26) C: 51(M:22)	P: 34 C: 36	10 min. interview to elicit emotional responses, 2 raters, validated.	Yes	Included, d=-1.95 (-2.43 to -1.47)

Table 2 ***Continued***

Author, year	Participants (Male)	Mean age (yrs)	Characteristics of the task	Authors report worse performance for SCZ as compared to C.	Effect size (95% CI) or reason for exclusion
Leentjens et al, 1998	P: 26 (M:19) C:24(M: 12)	P: 41 C: 39	Repetition of 10 affect laden sentences, scored blindly by speech therapist.	Yes	Included, d=-1.19 (-1.79 to -0.59)
Shaw et al, 1999	P:30 (M:30) C:Normal control data	P: 42 C: ?	20 min. interview, in which they describe happy, sad and neutral experiences, computerized acoustic voice analysis (VOXCOM, Alpert et al. 1986).	Yes	Excluded, insufficient data.
Alpert et al., 2000	P:46 (M: 46) C:20 (M: 20	P: 41 C: 41	Asked to describe a happy and a sad experience, each 3 to 5 min. computerized acoustic voice analysis (VOXCOM, Alpert et al. 1986).	Yes	Excluded, no data on correctness, other measures of prosody are used: emphasis and inflection.
Ross et al, 2001	P: 29 (M: ?) C: 19 (M: 7)	P: ? C: 46	12 word, 12 monosyllabic, 12 sentence repetition, 6 different emotions, no validation, F_0 variation analyzed by PC.	Yes	Included, d=-1.20 (-2.70 to -1.30)
Putnam et al, 2007	P: 26 (M:26) C: 20(M:20)	P: 40 C: 37	Asked to read out 16 stimuli, 4 different sentences, 4 different emotions, scored by trained raters, validated.	Yes for some but not all emotions	Included, d=-0.61 (-1.20 to -0.01)

Effect size Cohen's d, negative, indicates worse performance in patients with schizophrenia. Participants, P means patients, C: controls, M: number of male participants. Age is given in years.

Results

Twenty-one studies had been selected that had measured the perception of emotional prosody in both a group of schizophrenia patients and a group of healthy controls. Characteristics and data are provided in Table 1. Eleven studies were selected that had measured the expression of emotional prosody, in schizophrenia patients compared with healthy controls.

Results of the meta-analysis

From these studies, 17 studies could be included in the meta-analysis. Figure 1 shows the forest plot with results of the meta-analysis of schizophrenia and comparison group differences in performance on perception of emotional prosody tasks. The magnitude of the overall effect size was large: -1.240 (range -0.42 to -2.46), implying worse performance in patients. All effect sizes, including confidence intervals were below zero. The total group size of patients of these 17 studies was 623 (range 12 to 100) (Table 1). The homogeneity statistic showed significant heterogeneity among studies: Q = 82.0, df =16, $p<0.0005$. The funnel plot (figure

2) shown in a scatterplot of effect size by sample size, reveals a weak indication of a publication bias: no studies were identified with a small effect size and a small sample size, although there was a study with a relatively low effectsize and a large sample size. We can however assume that an unpublished study with a low effect size and small sample size, would not significantly affect the overall mean effect size. Orwin's fail-safe number was 88 for the studies on perception of emotional prosody, which means that 88 studies reporting a null result are needed to reduce the effect size to a negligible effect (d=0.20) (Orwin, 1983). This is sufficiently large to lend credence to the robustness of our mean effect size. Three studies were found that compared other clinical groups with schizophrenia patients, on measures of emotional prosody perception (Murphy and Cutting, 1990; Borod et al., 1990;Mitchell et al., 2004). Statistical data were insufficient to be included in a meta- analysis. Borod concluded that individuals with schizophrenia showed a much stronger impairment in emotional prosody perception as compared to patients with unipolar depression (Borod et al., 1990). Another study found similar impairments for depressive and manic patients and schizophrenia patients in the perception of emotional prosody (Murphy and Cutting, 1990). Mitchell and colleagues found no significant difference between individuals with schizophrenia, individuals with bipolar disorder and healthy controls, this is however probably due to a simple task, made for fMRI studies (Mitchell et al., 2004) . With regard to the expression of emotional prosody in schizophrenia, 11 studies were found that compared performances of schizophrenia patients and healthy controls on an emotional prosody expression task. Of these 7 studies could be included in a meta-analysis, with a total group size of 186 patients (range 15 to 47) (Table 2). The overall mean effect size was large: -1.11 (range 0.87 to -2.0), $Q = 44.8$, $df = 6$, $p<0.0005$. Fail safe N was 32.

Potential moderators

None of the potential clinical moderator variables (patient status, age, duration of illness and medication status) showed a significant effect on the magnitude of the effect size. Likewise for all methodological variables; the group size and whether schizophrenic and comparison group were matched for age, sex and level of education did not make a difference. To investigate whether task complexity would be an important variable, we compared studies with more than four emotions included in the task, with studies looking at four or less emotions. Furthermore, we compared subgroups of studies based on the number of stimuli that were included. Both analyses did not show significant results. Contrasting studies using established and validated tasks with studies with new "self made" tasks was also not

significant. We also hypothesized that the quality of the task could make a difference in the assessment of the perception of emotional prosody. Therefore we rated all tasks on 4 points; the first was the number of emotions, three to five emotions was scored with one point, more emotions increases task difficulty and cognitive demands, which may mask impairments in affect perception. Second issue was by whom the sentences were spoken, spoken by actors or other professional announcers, was one point, otherwise, no points were given. The third evaluation factor was psychometric value; one point was given if a task had information about validation or reliability, if nothing was mentioned about this, no points were given. Fourth issue is the number of items per emotion, 1 point was given when at least 6 stimuli per emotion were included in the task. The maximum score for the quality was 4, minimum score was 0. All scores are presented in table 1. The studies were divided in two groups, one with low quality scores (0 to 2) and the other with high quality score (3 and 4), no significant difference emerged. We must however conclude that the quality of the tasks differs, with only two studies rated with 4 points (Shea et al., 2007;Edwards et al., 2001) and nine studies with a score of 1. An example of a task that received just 1 point, is the one developed by Kerr and Neale (Kerr and Neale, 1993). Also used in three other studies included in this quantitative review (Kee et al., 2004; Leitman et al., 2007;Leitman, 2005). The task is validated, but includes 6 emotions, which makes it more a working memory task, i.e. by imposing strong working memory load, patients may be deficient on the task for other reasons than deficient emotion processing. Furthermore only 3 or 4 stimuli for each emotion were presented and the sentences were spoken by students. Four points were given for a task that was validated, presented 12 stimuli for each of the 5 emotions and sentences were spoken by actors (Edwards et al., 2001).

Results of the vote count analysis

All 21 studies were included in the vote count analysis, providing data on 775 schizophrenia patients. From these 17 studies reported a significantly worse performance of the schizophrenia patients as compared to the healthy controls. Four studies reported finding no significant difference. One of these studies (Kee et al., 2004) did not report a significant difference between the two groups, but the difference between the performance of schizophrenics and healthy controls approached significance. The vote-count revealed a score of 589 for studies that reported worse results for schizophrenia patients as compared to healthy controls, on a task measuring the perception of emotional prosody. The score for no difference between the two groups was 186. We must mention that Chernigovkaya

(Chernigovskaya et al., 2004) measured complex emotions, very different from the other studies. They found no difference in error percentages between healthy controls and patients, but the response time was significantly higher in the schizophrenics than in the healthy subjects. Results from the vote count analysis imply that the total number of schizophrenia patients with a reduced performance on emotional prosody perception tasks was three times higher than the total number of patients that showed no difference in performance as compared with healthy controls. From the eleven studies on the expression of emotional prosody, nine studies reported a worse performance in schizophrenics, and one found a worse performance, but not for all emotions. One study found even a better performance for schizophrenics than healthy controls (Levin et al., 1985). This can be explained by positive schizophrenics being highly responsive to demands of a story context, resulting in a exaggerated intensity of expressed emotions, that was rated as a better score (by undergraduate volunteers).

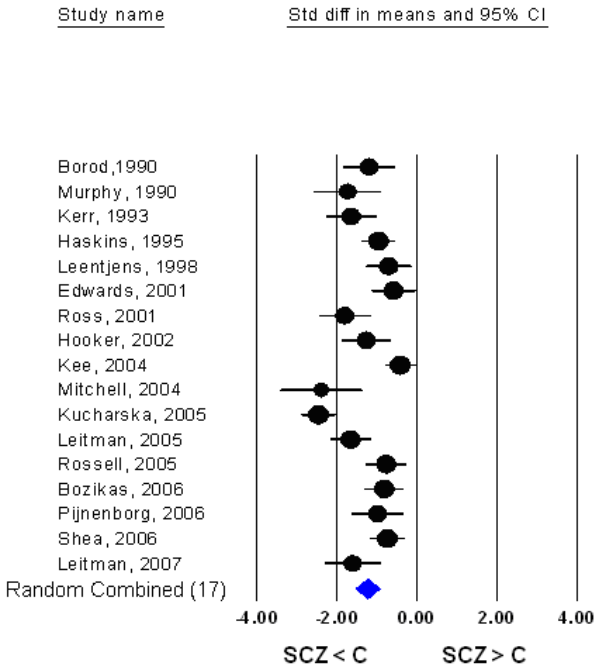

Figure 1 Forest plot with mean effect size (d) and confidence intervals for the studies. Magnitude of the symbols depicting the individual effect sizes is proportional to the number of subjects included in the study. SCZ = patients with schizophrenia, C = healthy control subjects.

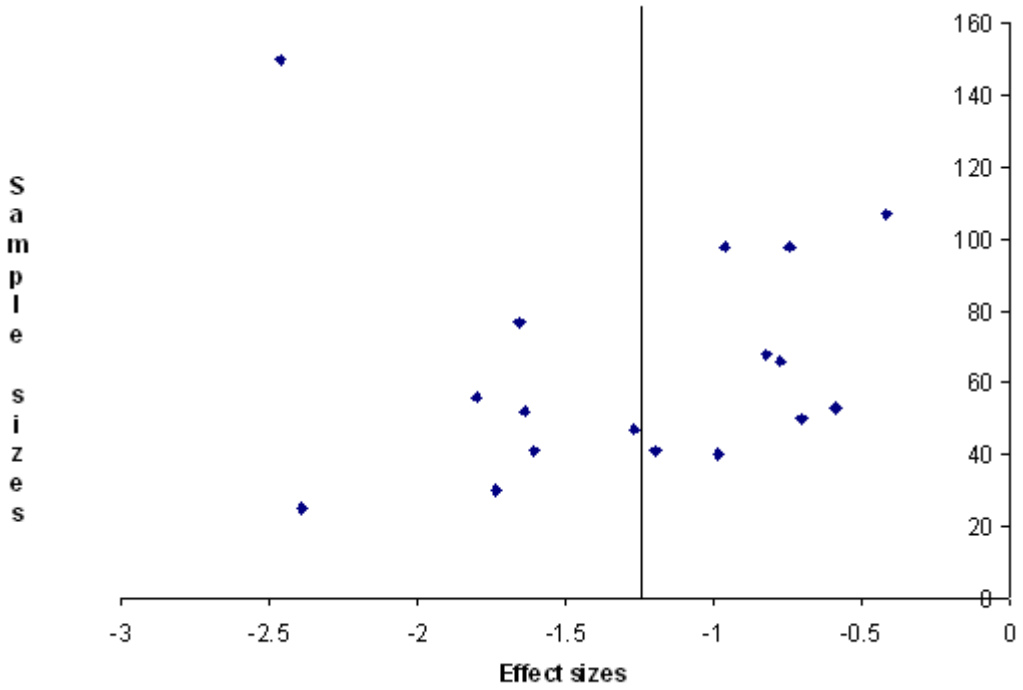

Figure 2 Funnel plot of the studies included in the analysis on studies on the perception of emotional prosody in schizophrenia: The effect size d (x-axis) is plotted against the sample size (y-axis) of each study. The vertical line points to the mean weighted effect size.

Discussion

Our meta-analysis revealed impaired processing of emotional prosody in schizophrenia. The effect size can be considered as a very large effect (-1.2), according to the nomenclature of Cohen (Cohen, 1988). Thus, the performance of schizophrenia patients was more than one standard deviation lower than that of healthy control subjects on tasks of emotional prosody perception. This was not only the case for perception, the separate analysis for studies reporting on the production of emotional prosody, revealed an almost identical effect size. When we compare this *d* value to the effect sizes reported in previous meta-analyses of cognitive function in schizophrenia, it would rank among "The most powerful and reliable neuroscience findings in schizophrenia research" (Heinrichs, 2001). Summing all cognitive effect sizes, listed as such by Heinrichs, gives an average d-value of 0.99, which is lower than the effect size we found for emotional prosody perception in schizophrenia in this meta-analysis. The results thus support the view that emotional abnormalities may be a key dysfunction in schizophrenia (Aleman and Kahn, 2005).

It can be argued from these results that the impairment in emotional prosody per-

ception is a trait deficit as opposed to a state deficit. Two studies have shown that the deficit already exist in the early years of the illness (Kucharska-Pietura et al., 2005;Edwards et al., 2001). Additionally, Kee and colleagues showed that subtle deficits in emotion perception are detectable in healthy siblings of schizophrenia patients, when multiple measures and both vocal and affect perception were taken together (Kee et al., 2004). This means that the idea that emotional prosodic comprehension deficits may be an artefact of duration of illness or institutionalisation was not supported, the deficit seems to be stable over time. Furthermore, a general prosodic comprehension deficit can be ruled out, patients with schizophrenia have no difficulty comprehending non-emotional prosody (Murphy and Cutting, 1990;Pijnenborg et al., 2007). Recent work suggests that schizophrenia patients have a deficit in the early processing of acoustic features underlying the impairments in decoding emotion based on speech intonation (Matsumoto et al., 2006;Leitman, 2005). Future studies are needed to further clarify the relation between a deficit in analyzing fundamental acoustic features and its contribution to the impairment in the recognition of emotional prosody in schizophrenia.

Limitations inherent to any meta-analysis are also present with in this study. The analysis was limited by the number and quality of studies available. In this respect the heterogeneity of tasks used in the studies stands out. As was noted above, the tasks were different on several aspects. Number of emotions, stimuli, and (sex of) speakers are factors that influence task complexity. With the increase of task difficulty, cognitive (semantic or attentional) demands increase as well, which may overestimate impairments in affect perception. This was shown in the study of Rossell, who used a task with 7 different emotions and found that not only schizophrenia patients made a large number of errors on this task, but also normal controls, showing a mean percentage correct of 64.5% (Rossell, 2005). Future research should consider using less affective categories when studying schizophrenia groups (Rossell, 2005). It is also advisable to include at least 6 trials per emotion to ensure enough measurements for statistical analysis. Practice items should also be included. Other methodological shortcomings with the included studies are that reliabilities of the tests are less than optimal. A number of them did not report on psychometric characteristics. Furthermore, looking at individual emotions and valence of emotions could reveal further insight in the deficit.

It has been shown that the right hemisphere is involved in the processing of emotional prosody (van Rijn et al., 2005;Adolphs et al., 2002). Similar dis-

turbances in the perception of emotional prosody that have been described in schizophrenia patients, have also been reported in right hemisphere damage patients (Ross et al., 2001). Our findings support the hypothesis that symptoms in schizophrenia can be consequences of not only left but also right-hemisphere abnormalities (Cutting, 2006;Mitchell and Crow, 2005). Unfortunately, the included studies did not provide all information to be able to analyze all the moderator variables of our interest. It would be interesting to further analyze the influence of severity of psychopathology and negative and positive symptoms. Future studies should examine relationships between affect recognition and symptom clusters and subtypes. Furthermore, the relationship between affect recognition and functional outcome such as vocational functioning, social skills and community functioning should also be investigated.

Despite these limitations, our results reveal that deficits in emotional prosody perception can be regarded among the most prominent cognitive deficits in schizophrenia and should thus be taken seriously in both its diagnosis and treatment. This is probably also the case for the expression of emotional prosody in schizophrenia, although we have to be cautious here, due to the limited number of studies. Because of the severity of the impairments that emerged from our meta-analysis, we stress the importance of assessing emotional prosody perception impairments in clinical settings. Furthermore, as a growing body of evidence shows that impaired social cognition in schizophrenia may be an important predictor of social outcome (Couture et al., 2006), training programs that aim at the perception of emotional prosody should be developed. While perception of facial emotions was trained successfully in schizophrenia (Wolwer et al., 2005;van der Gaag et al., 2002), to our knowledge, the perception and expression of emotional prosody was not incorporated in the cognitive rehabilitation of schizophrenia until now.

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