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The feasibility and clinical benefits of improving facial affect recognition impairments in schizophrenia: Systematic review and meta-analysis

Running Head: Facial affect recognition and schizophrenia

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Abstract

Background
People diagnosed with schizophrenia have significant difficulty accurately recognising emotions expressed by others. This may generate anomalous experiences which, if misinterpreted, could contribute to experiences of social defeat, psychotic symptoms and reduced social functioning. It remains unclear whether this impairment is responsive to non-pharmacological intervention, or what the effect of modifying it is.

Methods
We did a systematic review and meta-analysis to examine whether and to what extent facial affect recognition impairments can be improved by psychological intervention and, if so, whether this leads to improvements in psychotic symptoms and social functioning.

Results
A total of 8 randomised controlled trials (RCTs) consisting of 300 participants were included. Focused yet brief psychological interventions led to very large improvements in facial affect recognition ability in psychosis [k=8, N=300, g=1.26, 95% Confidence Interval (CI) 0.92, 1.60, I^2 41%]. Early evidence suggests this may cause large improvements in social functioning (k=3, N=109, g=0.98, 95% CI 0.37, 1.36, I^2 38%), but not psychotic symptoms.

Conclusions
Facial affect recognition difficulties in schizophrenia are highly responsive to psychological interventions designed to improve them, and there is early evidence that this may lead to large gains in social functioning for this group - but not symptoms. A large-scale high-quality RCT with longer-term follow-up period is now required to overcome the limitations of the existing evidence.

1. Introduction

People diagnosed with schizophrenia report significantly reduced social functioning (APA, 1994; Bellack et al., 1990). This may be related to difficulties in 'social cognition' (Addington et al., 2006; Penn et al., 1997), which refers to the way in which we understand, perceive and interpret our social world (Penn et al., 1997) and consists of various components including facial affect recognition, 'theory of mind', social perception and our ability to make appropriate attributions for events. These have a direct impact on one's ability to interact socially (Couture et al., 2006) and problems in any one of these areas may have a large impact on a person's day to day functioning (Irani et al., 2012).

Indeed, there is robust and consistent evidence that patients with a diagnosis of schizophrenia have significant difficulties in recognising facial expressions of emotion (Kohler et al., 2009) and that these difficulties may be associated with reduced social functioning (Hooker & Park, 2002; Irani et al., 2012). These difficulties appear to be unrelated to the phase of the disorder (Penn & Combs, 2000), are not remediated by antipsychotic medication (Addington & Addington, 1998), are not simply a reflection of general cognitive impairment (Barkhof et al., 2015) and appear to exist prior to onset of the illness (Gibson et al., 2010). The real-world impact of these difficulties has been illustrated by their association with poor performance in social role plays (Mueser et al., 1996), although a recent study using experience sampling has challenged this claim (Janssens et al., 2012). Some studies suggest that people with schizophrenia have particular difficulties in recognising negative facial expressions (Demirbuga et al., 2013; Hofer et al., 2009), although the cause and consequences of this remain unclear.

Impaired facial affect recognition may also contribute to both negative and positive symptoms. They may be implicated in asociality (Poole et al., 2000), impaired emotional expression (Gaebel & Wölwer, 1992) and anhedonia (Green & Walker, 1986; Gur et al., 2006; Neale et al., 1985). Difficulty in interpreting emotions correctly could generate confusion regarding the intentions of others, which may lead to a confusing social world for people with psychosis (Couture et al., 2005). Attempting to make sense of this may therefore trigger an increase in positive symptoms such as paranoia (Garety et al., 2001; Green & Phillips, 2004; Couture et al., 2005) and delusional ideation (Arguedas et al., 2006).

Various interventions have been devised to try to improve facial affect recognition difficulties in psychosis. Kurtz and Richardson carried out a meta-analysis of social cognitive remediation programmes, and reported a moderate to large effect size (d=0.78) for improved identification of facial expressions and a large effect size (d=1.01) for improved discrimination of facial expressions (Kurtz & Richardson, 2012). Furthermore when looking at functioning within the community or institution, a large effect size was also found (d=0.78) after completion of the programme. Although this meta-analysis provides support for the efficacy of interventions to improve these difficulties, the included programmes varied between ones which solely focused on targeting facial affect recognition, others with a broader focus on social cognition in general, which includes addressing theory of mind deficits and social skills training in addition to facial affect recognition and some treatment programmes which targeted cognition and social cognition.

A previous meta-analysis by Fett et al., (2011) demonstrated that different domains of social cognitive training programmes have different effects on components of social cognition and functioning. They therefore recommend that treatments targeting specific domains be

examined to obtain a truer picture of the key active domains of social cognition that improve social functioning. No meta-analysis has specifically investigated the benefit of programmes solely focused on treating and improving facial affect recognition. Whether facial affect recognition training (FRT) improves facial affect recognition ability in people with schizophrenia and, if so, whether this has any important benefits on other outcomes of value, therefore remains unclear.

The aim of the this study was to address this gap in the evidence, and conduct a systematic review and meta-analysis to determine whether FRT programmes do improve facial affect recognition ability in schizophrenia and, if so, to what extent. The effect of FRT on social functioning and psychotic symptoms will also be assessed, since impaired facial recognition ability is hypothesised to be involved in causing or maintaining these problems. If FRT causes improvements in these domains, then it would be a valuable treatment for promoting recovery in psychosis.

2. Method

2.1.Search Strategy

A systematic review of the literature was conducted in accordance with PRISMA (Moher et al., 2009) and AMSTAR (Shea et al., 2007) guidelines. A search of the following electronic databases was carried out in March 2015:- Medline, Embase, PsychInfo and Web Science. All years available were searched, using the following terms: 'facial affect recognition, facial emotion recognition, facial affect recognition training, social cognition, emotion perception, schizophrenia' and 'schizoaffective'. Additionally in order to identify any unpublished studies the US government clinical trials register (clinicaltrials.gov), European Union clinical trials register (clinicaltrials-register.eu), World Health Organisation (apps.who.int/trialsearch) and Current Controlled Trials Ltd (controlled-trials.com) were all searched in May 2015. Reference sections within the articles which met the inclusion criteria were also searched by hand to identify any further papers.

2.2.Inclusion Criteria

Intervention studies involving adult (18 years+) participants with a diagnosis of non-affective psychotic illness (schizophrenia, brief psychotic disorder) or schizoaffective disorder were eligible for inclusion. Eligible studies required at least 50% of participants to have a diagnosis of non-affective psychosis. Studies where 50% or more participants had learning disability, predominantly substance induced psychosis, or organic brain damage were excluded. Studies which took place in a variety of settings such as inpatient and outpatient were included providing the other criteria were met. Eligible studies had to assess the effect of interventions that were specifically designed to improve facial affect recognition. Studies were only included if more than 50% of the intervention was judged to specifically address facial affect recognition. This was determined by accessing the intervention manual or description, and calculating a percentage of the total time dedicated within the programme to facial affect recognition training. In order to minimise risk of bias, only randomised controlled studies were included in the main meta-analyses. We planned to use narrative synthesiss to summarise findings from uncontrolled or non-randomised studies, however for ease of interpretation we decided to instead perform meta-analysis where possible, limiting the use of narrative synthesis to outcomes where we had only one or two studies.

2.3.Data Extraction and Outcomes

In line with previous meta-analyses (Kohler et al., 2009; Kurtz & Richardson, 2012) different measures of facial affect identification and discrimination were included and combined given the assumed similarity of the task of labelling emotional expressions and distinguishing emotional expressions between two different faces. These included the Facial Emotion Identification Test (FEIT), Vienna Emotion Recognition Task (VERT-K), Pictures of Facial Affect (PFA) and an Emotion Matching Task. Many of these measures are based on the Ekman pictures of facial affect (Ekman & Friesen, 1976) making their results comparable. Only studies using these or other valid and reliable measures of facial affect recognition were eligible for inclusion. For the outcomes of psychotic symptoms and social functioning, a scoping review suggested there may be limited data. In order to be as inclusive as possible, no a priori decisions were made regarding preferred measures aside from the requirement that they have established reliability and validity. For symptoms, included data could be mean change or endpoint data from the PANSS or the BPRS or any other reliable and valid measure of symptoms as used by study authors. Authors were contacted in the event of missing data. If means or standard deviations were not reported and not obtainable, then where possible we derived estimates of the between and within-group effect size from other statistical parameters, including confidence intervals, standard errors, p-values, t-values and/or f-values, following procedures outlined in the Cochrane Handbook (Higgins et al., 2011).

2.4.Meta-Analysis Calculations

If studies had two or more FRT arms (or two or more usable control group arms), then these were combined into one using procedures outlined in the Cochrane Handbook (Higgins et al., 2011). For each meta-analysis of between group differences, means and associated standard deviations were entered into MetaXL (Barendregt & Doi, 2016), which computed a pooled standardised mean difference (Hedges's g) and 95% confidence interval. A random effects model was used, since this assumes the true effect size can vary across studies (Borenstein et al., 2009), and that the individual effect sizes are a random sample from the distribution of possible effects. The heterogeneity of the effect sizes was measured using the I^2 statistic, and a Chi-Square test was performed to evaluate if the intervention effects vary more than could be expected due to random error only. Similar procedures were followed for meta-analyses of within-group change.

2.5. Risk of Bias and Study Quality

The Cochrane Collaboration Risk of Bias Tool (Higgins et al., 2011) was used to assess the methodological quality of the randomised controlled trials included in the meta-analysis. It involves examining a range of biases that can occur in trials such as how participants are randomised, blinding of both participants and study personnel and selective reporting of results. Each feature of interest is given a rating of either 'low', 'high' or 'unclear' risk of bias and these ratings are then taken into account when interpreting the effect sizes of the outcomes and subsequently the conclusions that can be made from the data. The quality of the overall meta-analytical estimates was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) (Guyatt et al., 2011). GRADE rates the quality of the evidence across studies and is an effective method of linking evaluations of the quality of the evidence to clinical recommendations.

For the non-randomised studies, a tool developed by the Agency for Healthcare Research and Quality (AHRQ, 2012) was used to assess the quality of the studies. This tool is recommended by the Centre for Reviews and Dissemination (CRD, 2009) as suitable for assessing the quality of observational studies and it is advised that the tool should be adapted

for the individual requirements of the systematic review. An adapted version of the AHRQ tool was therefore used which included the domains of selection bias, detection bias, statistical power, validity of measures and method of analysis. Each item was rated using the tool and assigned a rating of either 'yes', 'no', 'partially', 'or unclear'.

3. **Results**

3.1.Study Selection

Figure 1 outlines the process of study selection. The initial search, after removal of duplicates, identified 2439 papers, conference abstracts and dissertations. The majority of these papers were discarded on the basis of their title or abstract where it was clear that they did not involve treatment programmes for facial affect recognition, or did not include people with psychosis. The full text of 44 papers were reviewed in detail, and from these 12 papers were identified as suitable for inclusion. One further paper was identified from the reference section of these included studies bringing the total to 13. Eight were randomised controlled trials, 4 were correlational studies and 1 used a healthy matched control group design.

3.2.Study Characteristics

A total of 8 studies involving 300 participants were included in the meta-analysis of the effect of FRT on facial affect recognition ability. As shown in Table 1, a range of FRT programmes were assessed. These included Training of Affect Recognition, Attentional Shaping, Micro-Expression Training Tool and Facial Feedback. All programmes were solely focused on improving facial affect recognition, but varied in duration from 1 treatment session to 12 sessions. Control group participants received various interventions, including cognitive remediation therapy, repeated exposure to pictures of facial affect, or simply treatment as usual.

3.3.Outcomes from randomised controlled trials

3.3.1. Facial affect recognition

An analysis of post-intervention data from all 8 RCTs (300 participants) found a very large effect of FRT on facial affect recognition ability [g=1.26, 95% CI 0.92, 1.60; see Figure 2 (a)]. This estimate was judged to be low in quality primarily because the studies were small and generally at high or unclear risk of various forms of bias, including lack of information about generation of allocation sequences or use of rater blinding. Although the overall sample size (N=300) had adequate power to detect effects of moderate magnitude, and although the reported effects were very large, sample sizes of less than 400 are generally considered to produce fragile estimates (Guyatt et al., 2011).

Three studies (108 participants) reported data at 1-week following the intervention. As shown in Figure 2 (b), a large significant effect was found (g=1.46, 95% CI 0.61, 2.32). Although there was considerable heterogeneity (I^2= 72%), it should be noted that all studies reported large effects. Nonetheless, the risk of bias in the included studies and the small overall sample size meant the estimate was judged to be low in quality.

A third analysis was carried out of studies comparing FRT to interventions which controlled for potential non-specific effects of additional therapeutic attention and time [see Figure 2 (c)]. These interventions included repeated exposure to pictures of facial affect or Cognitive Remediation Training (CRT). Comparisons involving waiting list or usual treatment groups were excluded from this analysis. This calculation was based on 5 studies and included data

for 198 participants. A large significant effect was found (g=1.45, 95% CI 0.98, 1.92, I^2 72%), but risk of bias and small overall sample size meant the overall estimate was rated as low in quality.

3.3.2. Psychotic symptoms

As shown in Figure 3, no significant benefits of FRT were found for negative symptoms (k=4; g= -0.11, 95% CI -0.41, 0.20), positive symptoms (k=3; g=0.10, 95% CI -0.25, 0.45) or general psychopathology (k=3; g=0.12, 95% CI -0.44, 0.69). The confidence intervals for each estimate include the possibility of both small to moderate benefits and small to moderate harms. This, together with the risk of bias in the trials included in the analyses meant each of these estimates were rated as very low quality.

3.3.3. Social Functioning

A large effect of the facial affect recognition interventions on social functioning emerged from a meta-analysis of data from 3 trials (k=3, N=114, g=0.87, 95% CI 0.37, 1.36, I^2 38%), however a high risk of bias in these trials and their small sample size meant this estimate was rated as low in quality.

3.4. *Outcomes from non-randomised or uncontrolled trials*

3.4.1. Facial affect recognition ability

Seven groups of participants from 5 non-randomised controlled trials provided data on the association over time between facial affect recognition ability and exposure to facial affect recognition training. Reported associations ranged from moderate in magnitude to very large. However all studies were small, meaning their individual estimates were generally very imprecise. To facilitate accurate interpretation, a post-hoc meta-analysis was carried out; this suggested facial affect recognition training was associated with a large improvement in facial affect recognition ability (k=7, N=106, Cohen's d=0.95, 95% CI 0.52, 1.38), although there was considerable variance in estimates of exactly how large this association was (I^2 68%). There was very limited follow-up data from these studies.

3.4.2. Psychotic symptoms

Data on the association over time between facial affect training and psychotic symptoms was limited and conflicting. One small study (Frommann et al., 2003; N=16) reported significant improvements in positive, negative and general psychotic symptoms after participants received 12 sessions of training, whereas a comparable study (Drusch et al., 2014; N=16; 12 sessions) reported no change in any symptom domain. None of the studies included in this section reported additional data on social functioning.

4. Discussion

There is compelling evidence that patients with a diagnosis of schizophrenia have a large and specific difficulty in recognising facial affect (Kohler et al., 2009). This difficulty is associated with both psychotic symptoms (Ventura et al., 2013) and impaired social functioning (Hooker & Park, 2002; Irani et al., 2012). It precedes the development of psychotic symptoms (Gibson et al., 2010), and persists despite successful antipsychotic treatment (Addington & Addington, 1998). The potential significance of this particular impairment has encouraged several research groups to develop targeted interventions to improve it. Our meta-analytical synthesis of randomised controlled trials of these interventions suggests that they are highly efficacious. Although existing studies are small,

very large improvements in facial affect recognition were also demonstrated in those trials which controlled for non-specific effects of additional therapist time and attention. We also found early evidence that facial affect recognition training may have large effects on real-world social functioning. Although there do not appear to be immediate effects on psychotic symptoms of these improvements, the apparent malleability of facial affect recognition is welcome news for people with psychosis, and offers considerable encouragement to those trying to develop ways of altering their adverse social trajectory.

One particularly influential theory proposes that psychosis develops in response to repeated experiences of social defeat (Selten et al., 2013). This theory helps to account for the well-established findings that childhood adversity (Varese et al., 2012), migration, urbanicity and discrimination (Selten et al., 2013) are each associated with an increased risk of psychosis, and as well as the more recent finding that adult trauma survivors have an increased risk of developing psychosis (Okkel et al., 2016). A recent iteration of the neurodevelopmental hypothesis endorses this theory (Howes & Murray, 2014), which suggests that social defeat may lead to sensitisation of the dopaminergic neurotransmitter system, which in turn may cause changes in the perceived importance or salience of normally innocuous environmental stimuli. Howes and Murray (2014) attempt to integrate this with the perspective offered by cognitive models of psychosis (Garety et al., 2001; Morrison, 2001), that delusions develop as the affected individual tries to make sense of these and other odd, intrusive, experiences, and that this meaning-making process is strongly influenced by pre-existing schemata as well as specific cognitive processing biases.

Surprisingly, the significant associations between facial affect recognition difficulties and psychotic symptoms (Kohler et al., 2009; Ventura et al., 2013) are not discussed in any of these models, despite clear associations between emotion perception skills and social defeat-like risk factors for psychosis, including trauma and migration. There is good evidence that emotion recognition is impaired in children who experience early adversity (see Pollack, 2006, for overview) or relational bullying from peers (Woods et al., 2009) or are adopted and raised in a country they were not born in (Hwa-Froelich et al., 2014). Migrants are known to have an increased risk of psychosis, and there is evidence that adult migrants also have relatively lower accuracy (Derntl et al., 2009) and confidence in emotion recognition (Beaupré & Hess, 2006), although both grow as duration of stay in the host culture increases (Derntl et al., 2009; Beaupré & Hess, 2006). It is highly plausible that not being able to accurately identify emotions may leave individuals struggling to navigate the complexities of social interaction and therefore vulnerable to social defeat-like experiences. Indeed, a relative inability to understand the motives of others may not only reduce one's chances of achieving valued goals such as employment, relationships, and friendships, it may also make a person more vulnerable to exploitation by those with hostile intent. Difficulty interpreting social cues such as facial affect may also generate puzzling experiences, in that not knowing how others are feeling may make it difficult to predict or explain their subsequent actions, which may fuel paranoia and distrust.

Our finding that FRT consistently rectifies this impairment is therefore a welcome one, and the observed improvements in social functioning also raises the hope that this relatively simple intervention may also increase the capacity of individuals with psychosis to experience social *success*, rather than defeat. Although no parallel improvement in symptoms was observed in those who received FRT, the few studies that measured psychotic symptoms did so soon after the intervention, and a longer follow-up period of time may be required

before symptomatic improvement occurs. Equally, researchers may consider using measures that are more sensitive to early, perhaps subtle, evidence of change in symptoms.

4.1.Limitations

The trials we reviewed suffered from a number of difficulties. Little information on randomisation procedures (eg sequence generation, allocation concealment) were provided, and the majority of the studies did not report whether assessors were blind to group allocation. The quality of the non-RCT studies was also reduced by small sample sizes and partial reporting of selection processes. Future trials should therefore ensure that not only are adequate randomisation procedures and blinding of participants and personnel carried out, but that this is reported in any publications in line with the recommendations of the CONSORT criteria (Schulz et al., 2010). While all of the studies and indeed the final analysis demonstrated positive results of the various programmes on facial affect recognition, given the small sample sizes considerable caution must be taken when interpreting these results. In accordance with the GRADE approach, the meta-analytical estimates were assessed as low quality for the primary outcome of improvement in facial affect recognition, low quality for social functioning, and very low quality for psychotic symptoms - largely because of the risk of bias in the included studies. There were also too few studies to assess for the presence of publication bias (Higgins et al., 2011; Ioannidis & Trikalinos, 2007). Although future meta-analyses may be able to address this question, pre-registration of RCTs and other studies in clinical trial registries will aid assessment of this.

4.2.Conclusion

Many individuals with psychosis struggle to identify the emotions of other people, which may have a negative impact on their ability to experience social success and wellbeing. There is also good reason to think this well-established difficulty may exacerbate psychotic symptoms, either indirectly via social defeat or directly via the generation of confusing interpersonal experiences. The evidence we have synthesised here suggests that this difficulty can be easily and effectively ameliorated with a simple psychological intervention. Although there are problems with the quality of this evidence, this no doubt reflects the early stage of work in this area. Although social functioning seemed to improve following FRT, the null findings with respect to psychotic symptoms underlines the fact that we cannot take it for granted that these interventions actually do have transferable or meaningful benefits. If established psychosis lies at the end of an adverse social trajectory, then perhaps we need to offer these interventions at a much earlier stage in order to see meaningful change? We urge trialists to begin to measure and report data which will allow us to answer this and other related questions regarding the benefits and costs of facial affect recognition training in psychosis.

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Figure 1. Search Process

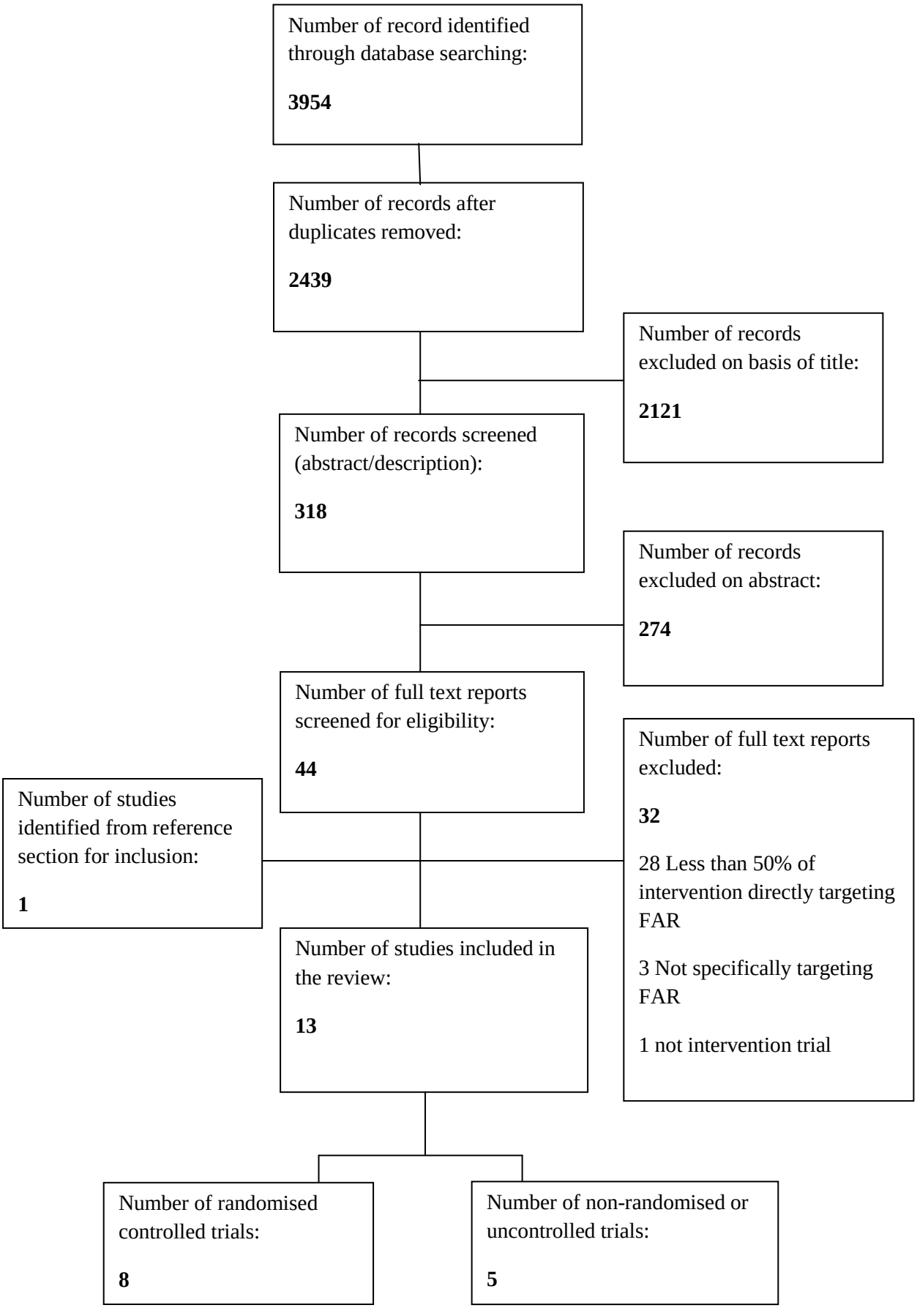

Table 1. Study Characteristics

Trial	Treatments	N	Maximum duration of treatment (N sessions)	FAR measures	Additional measures	Inpatients	Age (years) mean (sd)	Female N (%)	Follow up
Randomised controlled trials (k=8)									
Penn & Combs. (2000)	Monetary reinforcement and facial feedback	9	1	Face Emotion Identification Test (FEIT); Facial Emotional Discrimination Task (FEDT)		100%	38.3 (6.04)	44%	1 week
	Monetary feedback only	12					40.42 (6.08)	42%	
	Facial feedback only	9					39.1 (8.3)	33%	
	Repeated exposure/ active control	10					41.5 (12)	50%	
Russell et al., (2008)	Micro-expression training tool (METT)	26	1	EMT (emotion matching task) pre and post		0%	40 (10)	35%	1 week
	Repeated exposure/ active control	14					44 (9)	29%	
Sachs et al., (2012)	Training of Affect Recognition (TAR)	20	12	Vienna Emotion Recogntion Task (VERT-K)	PANSS neg. pre and post	Both (no figures given)	27.2 (7.17)	40%	none
	TAU	18					37.72 (9.35)	55%	

Trial	Treatments	N	Maximum duration of treatment (N sessions)	FAR measures	Additional measures	Inpatients	Age (years) mean (sd)	Female N (%)	Follow up
Wolwer & Frommann (2011)	Training of Affect Recognition (TAR)	20	12	Pictures of Facial Affect	Social and Occupational Functioning Assessment (SOFAS); PANSS pre and post	100%	36.7 (13.1)	32%	none
	Cognitive Remediation Therapy (CRT)	18							
Wolwer et al., (2005)	Training of Affect Recognition (TAR)	28	12	Pictures of Facial Affect	PANSS pre and post	75%	31.5 (6.9)	11%	none
	Cognitive Remediation Therapy (CRT)	24					36.7 (11.4)	42%	
	TAU	25					35.2 (11.1)	16%	
Combs et al., (2008)	Attentional Shaping	20	1	Face Emotion Identification Test (FEIT); Bell-Lysaker Emotion Recogntion Test (BLERT)		100%	38.7 (13.7)	35%	1 week
	Monetary Reinforcement	20							

Trial	Treatments	N	Maximum duration of treatment (N sessions)	FAR measures	Additional measures	Inpatients	Age (years) mean (sd)	Female N (%)	Follow up
	Repeated exposure/ active control	20							
Habel et al (2010)	Training of Affect Recognition (TAR)	10	12	Emotion identification task	PANSS pre and post	Both (no figures given)	31.4 (7.8)	0%	none
	TAU	10					33.7 (10.65)		
Luckhaus et al (2013)	Training of Affect Recognition (TAR)	10	12	Pictures of Facial Affect (PFA); Event-related potentials (ERP);	HCR-20; PANSS pre measures only given	100%	35.3 (8.2)	0%	2 months
	Waiting list control	9							
Non-randomised or non-controlled trials (k=5)									
Combs et al (2011)	Attentional Shaping	15	5	Face Emotion Identification Test (FEIT); Bell-Lysaker Emotion Recogntion Test (BLERT)	none	0%	39.0 (10.9)	40%	none

Trial	Treatments	N	Maximum duration of treatment (N sessions)	FAR measures	Additional measures	Inpatients	Age (years) mean (sd)	Female N (%)	Follow up
Drusch et al (2014)	Training of Affect Recognition (TAR)	16	12	Karolinska Directed Emotional Faces (KDEF); eye-tracking	PANSS pre and post	100%	36.9 (11.67)	25%	none
Frommann et al (2003)	Training of Affect Recognition (TAR)	16	12	Pictures of Facial Affect (PFA)	PANSS pre and post	not reported	31.9 (7.3)	19%	none
Marsh et al. (2010)	Micro-expression training tool (METT)	39	4	METT faces; Pictures of Facial Affect (POFA); TASIT	none	31%	inpatient= 31.92 (7.31); outpatient= 41.19 (9.38)	28%	1 month
Russell et al., (2006)	Micro-expression training tool (METT)	20	1	EMT (emotion matching task) pre and post; Microexpressions of emotions pre and post	none	0%	38.05 (7.91)	55%	none
	Healthy matched controls	20							

Figure 2(a). The effect of facial affect recognition training on recognition of facial affect at post-intervention, compared to usual care or inactive control

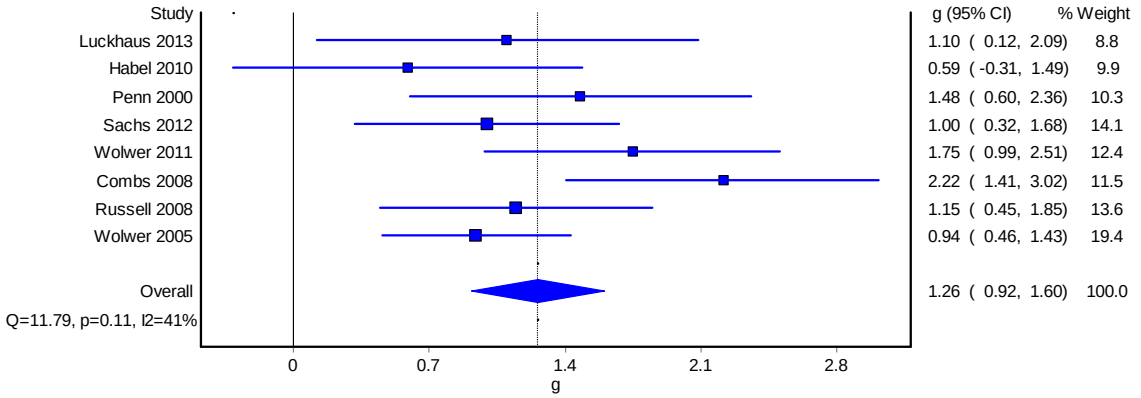

Figure 2(b) The effect of facial affect recognition training on recognition of facial affect at 1-week follow up, compared to usual care or inactive control

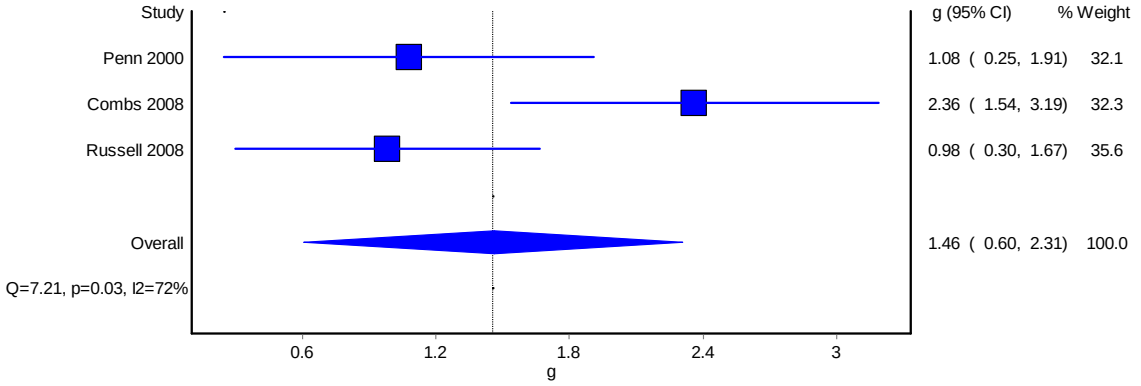

Figure 2 (c) The effect of facial affect recognition training on recognition of facial affect at post-intervention, compared to inactive control only

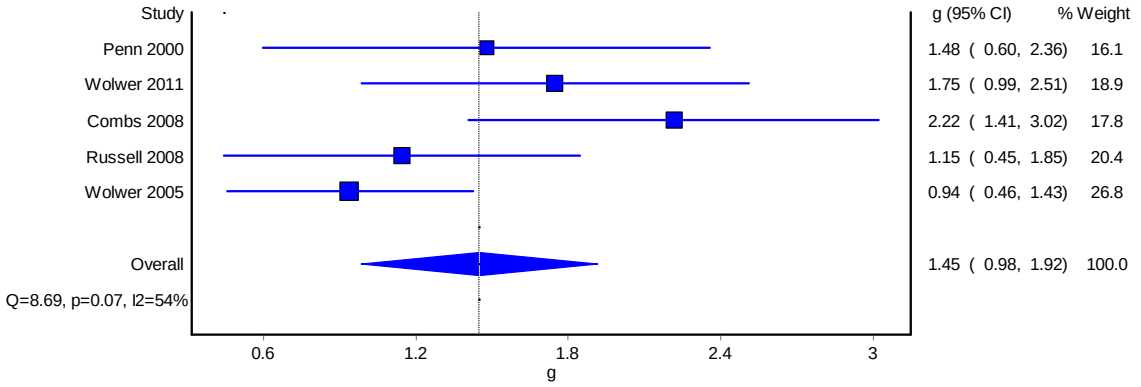

Figure 3 (a) The effect of facial affect recognition training on negative symptoms at post-intervention, compared to usual care or inactive control

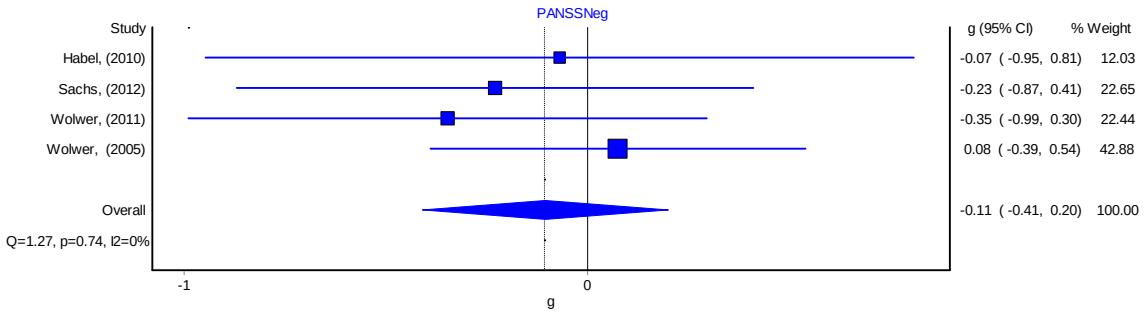

Figure 3 (b) The effect of facial affect recognition training on positive symptoms at post-intervention, compared to usual care or inactive control

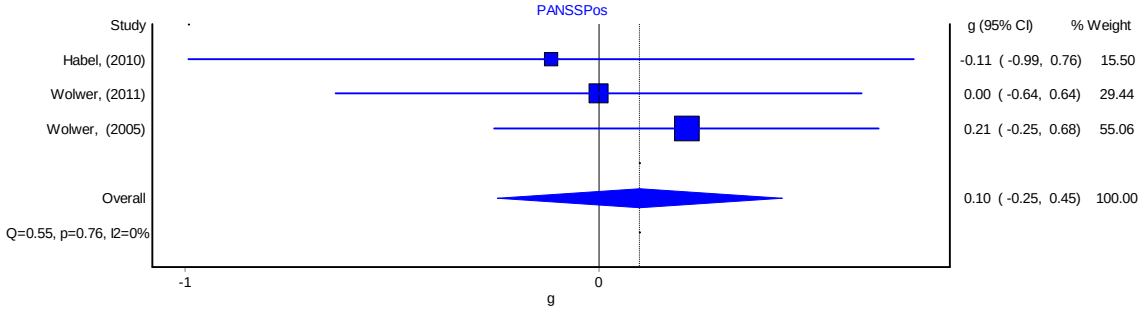

Figure 3 (c) The effect of facial affect recognition training on general psychopathology at post-intervention, compared to usual care or inactive control

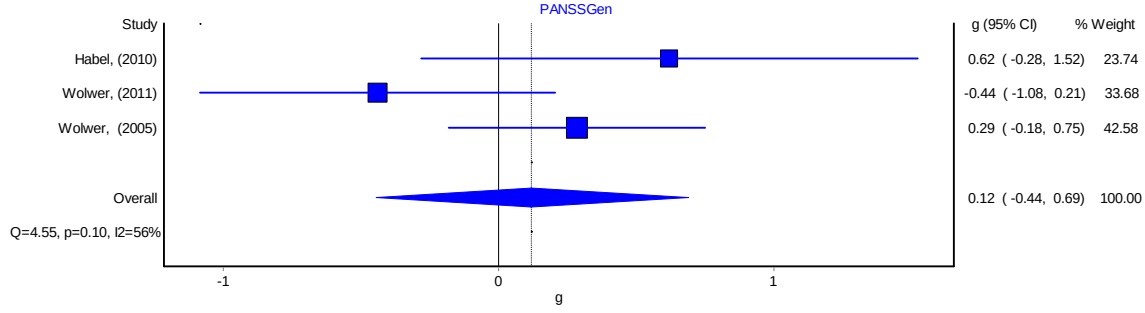

Figure 4. The effect of facial affect recognition training on social functioning at post-intervention or follow-up, compared to usual care or inactive control

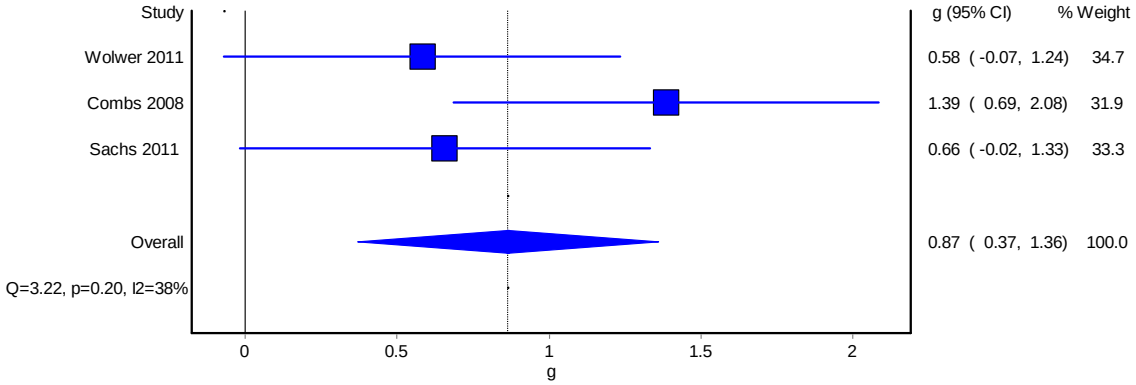

Figure 5. The association between facial affect recognition training and facial affect recognition ability in non-randomised or uncontrolled studies

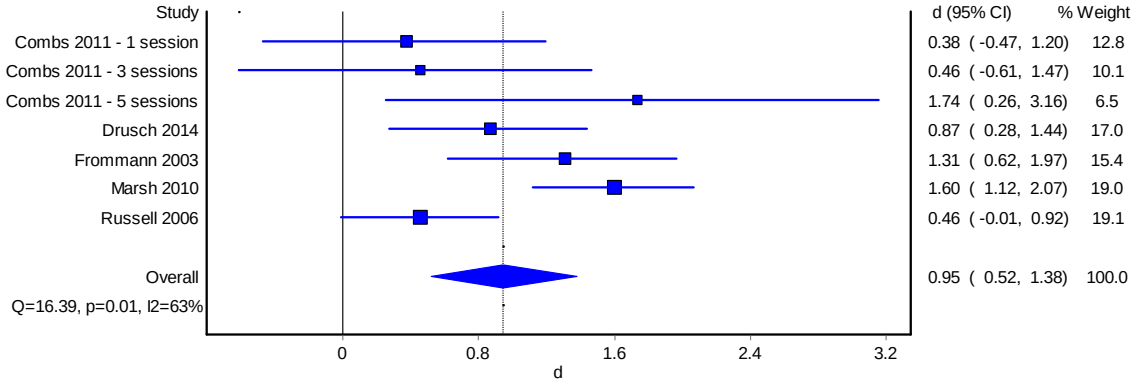

Table 2. Summary of meta-analytical estimates (randomised controlled trials only)

Outcome	No. of treatment sessions	No. of included studies	Intervention, n	Control, n	Hedges g (95% CI)	Heterogeneity	Quality
FAR improvement, post-intervention	1-12	8	152	148	1.26 (0.92, 1.60)	I^2= 41%	Low
FAR improvement, 1-week follow up	1	3	64	44	1.46 (0.60, 2.31)	I^2= 72%	Low
FAR improvement vs inactive control group, post-treatment	1-12	5	112	86	1.45 (0.98, 1.92)	I^2= 54%	Low
Improvement in negative symptoms, post-treatment	12	4	78	95	-0.11 (-0.41, 0.20)	I^2= 0%	Very low
Improvement in positive symptoms, post-treatment	12	3	58	77	0.10 (-0.25, 0.45)	I^2= 0%	Very low
Improvement in general psychopathology, post-treatment	12	3	58	77	0.12 (-0.44, 0.69)	I^2=56%	Very low
Improvement in social functioning, post-treatment or follow-up	1-12	3	59	55	0.87 (0.37, 1.36)	I^2=38%	Low

Table 3. Risk of bias ratings for randomised controlled trials

Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data addressed (attrition bias)	Incomplete outcome data addressed (attrition bias) (Follow-up)	Selective reporting (reporting bias)
Combs 2008	Unclear	Unclear	High	High	Low	Low	Low
Habel 2010	Unclear	Unclear	High	High	High	N/A	Low
Luckhaus 2013	Unclear	Unclear	High	High	High	High	Low
Penn 2000	Unclear	Unclear	High	High	Low	High	Low
Sachs 2012	Low	High	High	High	High	N/A	Low
Russell 2008	Unclear	Unclear	High	High	Low	High	Low
Wolwer 2005	Unclear	Unclear	High	High	Low	N/A	Low
Wolwer 2011	Unclear	Unclear	High	Low	High	N/A	High

Table 4. GRADE assessment of meta-analytical estimates

Outcome	Quality	Inconsistency	Indirectness	Imprecision	Publication Bias	Other factors	Overall
FAR improvement after intervention	-2	0	0	-1	0	+1	1 (Low)
FAR improvement at follow up	-2	0	0	-1	0	+1	1 (Low)
FAR improvement vs active control group	-2	0	0	-1	0	+1	1 (Low)
Improvement in negative symptoms	-2	0	0	-1	0	0	(0) Very low
Improvement in positive symptoms	-2	0	0	-1	0	0	(0) Very low
Improvement in general psychopathology	-2	-1	0	-1	0	0	(0) Very low
Improvement in social functioning	-2	0	0	-1	0	+1	(1) Low

Note: For assessment of outcome quality, 1 point was deducted if >50% of studies contributing to that outcome had at least one 'high risk' rating according to the Cochrane Risk of Bias assessment and 2 points if >50% of studies has at least two ratings of 'high risk'. For inconsistency, a study was downgraded by 1 point if the I^2 statistic was >40% in the context of an unclear direction of effect or >75% in the context of a clear direction of effect. If the I^2 statistic was >75% in the context of no clear direction of effect, a downgrade of 2 points was made. For imprecision, an outcome was downgraded if "a recommendation or clinical course of action would differ if the upper versus the lower boundary of the CI represented the truth"(Guyatt et al., 2011). An outcome was upgraded by 1 point if a very large effect size was found (Higgins et al., 2011).

Table 5. Summary of findings from observational studies

Outcome	Study	Pre-treatment mean (sd)	Post-treatment mean (sd)	Reported results	Cohen's d (95% CI)
Facial affect recognition ability at end of treatment	Combs 2011	1 session (N=6) 10.60 (1.20)	11.30 (1.80)		d=0.38[2] (-0.47, 1.20)
		3 sessions (N=4) 11.70 (1.20)	12.70 (2.20)		d=0.46[2] (-0.61, 1.47)
		5 sessions (N=5) 9.40 (2.80)	14.40 (1.90)		d=1.74[2] (0.26, 3.16)
	Drusch 2014 (N=16)	68.00 (8.00)	77.00 (10.00)	t= -3.50, p=0.003	d=0.87[2] (0.28, 1.44)
	Frommann 2003 (N=16)	17.06 (2.75)	20.00 (3.10)	t= -5.26, p<0.001	d=1.31[3] (0.62, 1.97)
	Marsh 2010 (N=39)	75.00 (not reported)	93.00 (not reported)	t=-10.01, p<0.005	d=1.60[3] (1.12, 1.92
	Russell 2006 (N=20)	75.60 (11.78)	79.50 (9.21)	t=2.05, p<0.02	d=0.46[3] (-0.01, 0.92)
Facial affect recognition ability at follow-up	Marsh 2010 (1 month) (N=10)	Not reported	Not reported	t=-6.69, p<.0005	d=1.84[4] (0.78, 2.86)
Positive symptoms	Drusch 2014 (N=16)	12.50 (4.23)	12.00 (4.71)		d=-0.09[2] (-0.58, 0.40)
	Frommann 2003 (N=16)	13.80 (6.40)	10.10 (2.90)	t=2.63, p<0.02	d=-0.66[3] (-1.19, -0.11)
Negative symptoms	Drusch 2014 (N=16)	11.90 (4.49)	12.20 (6.89)		d=0.04[2] (-0.45, 0.53)

Outcome	Study	Pre-treatment mean (sd)	Post-treatment mean (sd)	Reported results	Cohen's d (95% CI)
General psychopathology	Frommann 2003 (N=16)	21.10 (7.80)	16.60 (6.70)	t=3.67, p<0.003	d=-0.92[3] (-1.50, -0.32)
	Drusch 2014 (N=16)	25.90 (6.17)	26.50 (6.49)		d=0.08[2] (-0.41, 0.57)
	Frommann 2003 (N=16)	33.20 (9.90)	24.70 (3.50)	t=3.94, p<0.001	d=-0.98[3] (-1.57, -0.37)

[1]Confidence intervals for Cohen's d were calculated using the procedures outlined in Cumming and Finch (2001); [2]Based on an estimated moderate correlation of 0.3 between pre and post means; [3]Computed as difference in means divided by standard deviation of difference in means. The latter was derived from reported t-test values: SD of mean difference = (difference in means / t) x √N; [4]As reported in paper.

Table 6. Quality ratings for observational studies

Study	Unbiased selection of cohort	Selection minimises baseline differences in prognostic factors	Sample size justification report	Sufficient power	Adequate description of the cohort	Validated method for measuring facial affect recognition	Outcome assessment blind to exposure	Analytic methods appropriate
Frommann 2003	No	Can't tell	No	No	No	Partially	Can't tell	Partially
Drusch 2014	Partially	Partially	No	No	Yes	Partially	Can't tell	Partially
Marsh 2010	Partially	Can't tell	No	No	Yes	Partially	Can't tell	Partially
Combs 2011	Partially	Partially	No	No	Yes	Partially	Can't tell	Partially
Russell 2006	Partially	Yes	No	No	Yes	Partially	Can't tell	Partially

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Contributors

NB designed the study, carried out the procedures, analysed and interpreted the results, and prepared drafts of the final manuscript. SOR and PH contributed to the the design of the study, supervised the procedures and contributed to the interpretation of the results and drafts of the final manuscript.

Conflict of interest

The authors report no conflicts of interest.

Role of the funding source

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