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Review article

Social cognitive interventions for people with schizophrenia: A systematic review

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ABSTRACT

Social cognition is the mental process which underpins social interactions. Increasingly, it has been recognized to be impaired in people with schizophrenia, resulting in functional problems. Correspondingly, the past ten years have seen huge developments in the study of interventions to ameliorate social cognitive deficits among people with schizophrenia. In the present review, we systematically reviewed published studies on social cognitive interventions from 2005 to 2015. Of the 61 studies included in this review, 20 were on broad-based social cognitive interventions, which incorporated neurocognitive training, specialized learning technique or virtual reality social skills training. On the other hand, 31 studies on targeted interventions either focused on specific social cognitive domains, or a range of domains. Improvements in emotion processing and theory of mind were often reported, while social perception and attributional style were less frequently measured. Both broad-based and targeted interventions achieved gains in social functioning, albeit inconsistently. Lastly, nine studies on the use of oxytocin and one study on transcranial direct current stimulation reported positive preliminary results in higher-order cognition and facial affect recognition respectively. This review revealed that a wide range of social cognitive interventions is currently available and most have shown some promise in improving social cognition outcomes. However, there is a need to use a common battery of measurements for better comparisons across interventions. Future research should examine combination therapies and the sustainability of gains beyond the intervention period.

Contents

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1. Introduction

Research on social cognition in schizophrenia has received increased attention over the past ten years, due to the growing body of evidence about the substantial impact of social cognitive deficits on social functioning (Green et al., 2015; Pinkham et al., 2014). Social cognition is defined as the mental operations that underpin perceiving, interpreting, and generating responses during social interactions; including the intentions, dispositions, and behaviors of others (Green et al., 2008). The Social Cognition Psychometric Evaluation (SCOPE) study identified four core domains of social cognition, namely emotion processing, social perception, theory of mind/mental state attribution, and attributional style/bias (Pinkham et al., 2014). Social cognition appears to be a multi-dimensional construct that is overlapping and yet distinct from social skills and neurocognition (Mancuso et al., 2011; van Hooren et al., 2008). It has been found to mediate a significant indirect relationship between neurocognition and functional outcomes (Martínez-Domínguez et al., 2015; Schmidt et al., 2011). Moreover, direct effects of social cognition on functional outcomes have been established in many studies (Cohen et al., 2006; Couture et al., 2006; Sterea, 2015). In addition, poor social cognition has been found to predict maladaptive social mixing behaviors and produce negative effect on community independence (Combs et al., 2011b; Couture et al., 2006).

In view of the significant impact of social cognitive deficits on daily functioning, many interventions have been developed over the past decade to ameliorate social cognitive deficits. Four reviews and one meta-analysis have been conducted to date, which demonstrate promising results of the effectiveness of such interventions on social cognitive deficits and functional outcomes (Choi et al., 2009; Horan et al., 2008; Kurtz and Richardson, 2012; Statucka and Walder, 2013; Wolwer et al., 2010). Interventions cited in these reviews utilized primarily therapist-led group interventions, aided by computer software or photographs of people and social scenes. Their effects on general functional outcomes were examined. However, it is noted that recent social cognitive interventions have attempted to use new treatment modalities, such as virtual reality, online programs, medication and neurostimulation. Hence, this study attempts to review a variety of social cognitive interventions over the past decade as well as to delineate their outcomes on social functioning. Treatment approaches, mode of delivery and outcome measurements used are evaluated and discussed.

2. Methods

2.1. Search strategy

Articles included in the systematic review were identified through a computer-based search of ScienceDirect, PubMed, PsycINFO from January 2005 to August 2015, using combinations of these keywords: social cogn*,cogn*, neurocogn*, training, rehabilitation, remediation, schizophrenia. Besides that, the reference sections of articles identified from database searches were studied for relevant citations. We selected literature from the past ten years, as comprehensive reviews had been done for earlier studies (Choi et al., 2009; Horan et al., 2008; Kurtz and Mueser, 2008; Pfammatter et al., 2006).

2.2. Inclusion criteria

For the purpose of this review, the studies must have the majority of participants diagnosed with schizophrenia and/or schizoaffective disorders, according to an established criterion-based diagnostic system before they were included. The interventions must consist of some type of social cognitive treatment, either as a standalone intervention or in combination with other

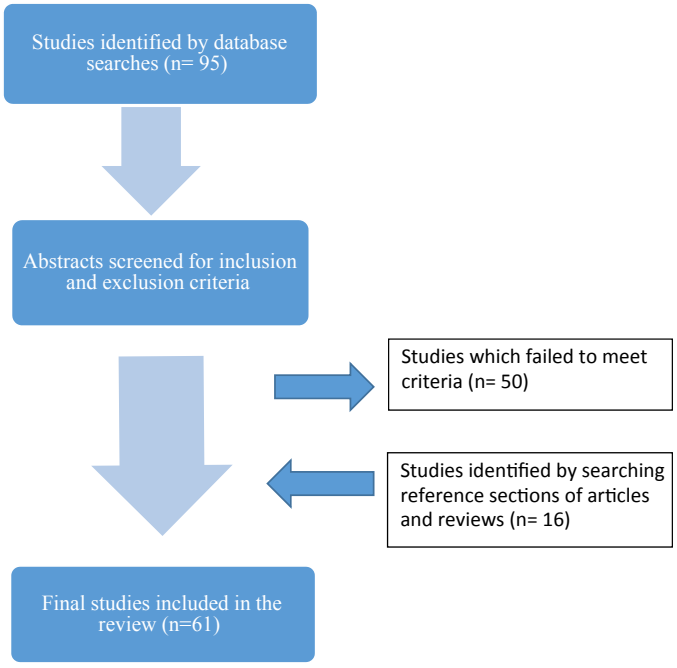

Fig. 1. Flow Chart of the Review Process.

Table 1
Broad- Based Social Cognitive Interventions.

Type of Social Cognitive Intervention	Reference and Country	Experimental Condition [a]	Control Condition [b]	Treatment Modalities/Methods	Duration and Frequency of Training	Social Cognitive Domains Targeted	Outcome Measurements	Results
Cognitive Enhancement Therapy (CET) http://www.cognitiveenhancementtherapy.com/	Hogarty et al. (2004) USA	n = 67, CET M = 37.3 (8.9) for both groups. Outpatients.	n = 54,Enriched Supportive Therapy (EST)	Cognitive software training (in pairs) using PSSCogRehab software and social cognitive group.	75 h software training, 56 sessions (90 min/ session) social cognitive group	Perspective Taking and Social Context Appraisal (Social Perception and Theory of Mind).	Cognitive Styles Eligibility Criteria, Social Cognition Profile, Social Cognitive Deficit Eligibility Criteria	Differential effects (effect size exceeded 1 SD) on cognitive style, social cognition and social adjustment at 24 months, favoring CET.
	Hogarty et al. (2006) USA	n = 61,CET M = 37.3 (8.9) for both groups Outpatients	n = 46,EST Outpatients	Cognitive software training (in pairs) using PSSCogRehab software and social cognitive group.	75 h software training, 56 sessions (90 min/ session) social cognitive group	Perspective Taking and Social Context Appraisal (Social Perception and Theory of Mind).	Cognitive Styles Eligibility Criteria, Social Cognition Profile, Social Cognitive Deficit Eligibility Criteria	Improvements in cognitive style, social cognition and social adjustment which were maintained at 36 months
	Eack et al. (2007) USA	n = 18, CET M = 26.14 (6.54) for both groups Outpatients and inpatients	n = 20, EST Outpatients and inpatients	Cognitive software training (in pairs) using PSSCogRehab software and social cognitive group.	60 h of computer training and 45 sessions (90 min/ session) weekly social-cognitive group.	Perspective Taking, Reading Non-Verbal Cues, Managing Emotions and Appraising Social Context (Emotion Processing, Social Perception and Theory of Mind).	MSCEIT	Significant effects (d= 0.96) in overall emotional intelligence quotient.
	Eack et al. (2009) USA	n = 31, CET M = 25.92 (6.31) for both groups. Outpatients and inpatients.	n = 27, EST Outpatients and inpatients.	Cognitive software training (in pairs) using PSSCogRehab software and social cognitive group.	60 h of computer training and 45 sessions (90 min/ session) weekly social-cognitive group.	Perspective Taking, Reading Non-Verbal Cues, Managing Emotions and Appraising Social Context (Emotion Processing, Social Perception and Theory of Mind).	Social Adjustment Scale-II, Major Role Adjustment Inventory, MSCEIT, Social Cognition Profile, Cognitive Styles and Social Cognition Eligibility Interview	Strong differential effects (effect size d >1.00) on social cognition, cognitive style, and social adjustment composites favoring CET.
	Eack et al. (2010a) USA	n = 31, CET M = 25.92 (6.31) for both groups. Outpatients and inpatients.	n = 27, EST Outpatients and inpatients.	Cognitive software training (in pairs) using PSSCogRehab software and social cognitive group.	60 h of computer training and 45 sessions (90 min/ session) weekly social-cognitive group.	Perspective Taking, Reading Non-Verbal Cues, Managing Emotions and Appraising Social Context (Emotion Processing, Social Perception and Theory of Mind).	Social Adjustment Scale-II, Major Role Adjustment Inventory, MSCEIT, Social Cognition Profile, Cognitive Styles and Social Cognition Eligibility Interview	Social cognition and functional gains maintained one-year post treatment
	Eack et al. (2010b) USA	n = 30, CET M = 26.17 (6.51) for both groups.	n = 23, EST Outpatients and inpatients.	Cognitive software training (in pairs) using PSSCogRehab	60 h of computer training and	Perspective Taking, Reading Non-Verbal Cues, Managing	Structural MRI	CET group: Greater preservation of grey matter volume in parahippocampal, fusiform

Table 1 (*Continued*)

Type of Social Cognitive Intervention	Reference and Country	Experimental Condition [a]	Control Condition [b]	Treatment Modalities/Methods	Duration and Frequency of Training	Social Cognitive Domains Targeted	Outcome Measurements	Results
		Outpatients and inpatients.		software and social cognitive group.	45 sessions (90 min/ session) weekly social-cognitive group.	Emotions and Appraising Social Context (Emotion Processing, Social Perception and Theory of Mind).		gyrus and left amygdala.
	Lewandowski et al. (2011) USA	n = 31, CET M = 25.9 (6.3) for both groups.	n = 27, EST	Cognitive software training (in pairs) using PSSCogRehab software and social cognitive group.	60 h of computer training and 45 sessions (90 min/ session) weekly social-cognitive group.	Perspective Taking, Reading Non-Verbal Cues, Managing Emotions and Appraising Social Context (Emotion Processing, Social Perception and Theory of Mind).	Social Adjustment Scale-II, Major Role Adjustment Inventory, MSCEIT, Social Cognition Profile, Cognitive Styles and Social Cognition Eligibility Interview	Significant improvements (medium to large effects) in Social Cognition Eligibility Interview and Social Adjustment Scale II scores. Similar improvements for both schizophrenia and schizoaffective disorder participants.
Integrated Psychological Therapy (IPT)	Zimmer et al., 2007 Brazil	n = 20, IPT M = 36.05 (7.09)	N = 36, TAU M = 39.31 (8.85)	Condensed version of 5 IPT subprograms, with additional psycheducation on symptom recognition and treatment compliance.	60 min session per week for 3 months.	Social Perception, Verbal Communication, Social Skills, Problem Solving	SOFAS, SAS.	Improvements in social and occupational functioning, general social and family relationships. Large effect size on SOFAS.
	Fuentes et al. (2007) Spain	n = 10, IPT M = 40.4 (7.49)	n = 8, TAU M = 37.75 (8.21)	Social Perception Module of IPT	21 sessions (2 sessions/ week).	Social Perception	SPS, WHO DAS	Large effects on SPS scores post-intervention and 6 month follow-up.
Integrated Neurocognitive Therapy (INT)	Mueller et al. (2015) Switzerland, Germany and Austria	n = 81, INT M = 34.6 (8.5)	n = 75, TAU M = 33.8 (8.7)	4 therapy modules that address neuro and socio-cognitive domains. Consists of group exercises and computer software training.	30 sessions (90 mins/ session), 1 session/ 2 weeks.	Emotion Processing, Social Processing, Theory of Mind, Attributional Style	POFA, Emorec, SCST-R, AIHQ, GAF	Significant improvements in global social cognition, emotion perception and social schema post-therapy. Effects maintained for global social cognition and emotion perception at 9-month follow up. Number needed to treat: 5
Auditory-based training plus Social-cognitive training (AT + SCT) http://www.brainhq.com/ https://www.paulekman.com/product/ekman-library/ http://www.jkp.com/mindreading	Hooker et al. (2012) USA	n = 11, AT + SCT M = 51.2 (5.8) Outpatients	n = 11, computer games M = 41.0 (8.4) Outpatients	Posit Science Auditory Training program and SCT: exercises from Subtle Expressions Training Tool and MindReading software.	50 h over 10 weeks	Emotional Processing	WASI, Global Cognition computed MSCEIT Perceiving Emotions subscale.	AT + SCT group: greater pre-to-post increase in postcentral gyrus activity during emotion recognition, which predicted improvement in MSCEIT: Perceiving Emotions.
	Sacks et al. (2013) USA	n = 19, AT + SCT M-46.37 (10.33) Clinically stable outpatients	No Control Group	Posit Science Auditory Training program. SCT: MicroExpressions Training Tool, the Subtle Expressions Training Tool and MindReading software	50 h of AT, 12 h of SCT (75 min/ day,5 days per week over 10 weeks).	Emotional Processing	MSCEIT: Faces Task; Pictures Task; Emotion Management Task; Emotional Relations Task; Perceiving Emotions Total; and, Managing Emotions Total.	Small to medium effects in MSCEIT Perceiving Emotions, MSCEIT Managing Emotions, and self-referential source memory,
Cognitive Remediation + Mind Reading: Interactive Guide to Emotions (CR+ MRIGE) http://www.markersoftware.com/USA/frames.htm http://www.jkp.com/mindreading	Lindenmayer et al. (2013) Germany	n = 32 CR + MRIGE M = 43.95 (11.12) Inpatients and outpatients with illness duration >5 years	N = 27 CR only M = 42.48 (9.09) Inpatients and outpatients with illness duration >5 years	CogPack neurocognitive software and Interactive MRIGE computerized program practising recognition of emotions and mental states	2 h of CR and 1 h of MRIGE per week over 12 weeks	Emotional Processing,	FEIT, FEDT, MSCEIT-Managing Emotions, PSP	Significant improvement in emotion identification, emotion discrimination and social functioning

NeuroPersonalTrainer-Mental Health (NPT-MH) https://www.gnpt.es/en	Fernandez-Gonzalo et al. (2015) Spain	n = 28, NPT-MH M = 30.9 (5.9) Schizophrenia and Schizoaffective Disoder Outpatients. Duration of Illness <5 years.	n = 25, non-specific computer training M = 30.02 (7.4) Schizophrenia and Schizoaffective Disoder Outpatients. Duration of Illness <5 years.	Adapted from computerized NeuroPersonalTrainers, to include a Cognition Module and a Social Cognition Module.	16–20 weeks, 2 sessions/ week (60 min/ session).	Emotional Processing, Theory of Mind and Cognitive Biases	POFA, TOM, Hinting Task, RMET, IPSAQ, SFS .	Significant time by group interventions in POFA total score, favouring NPT-MH.
Cognitive Behavioral Social Skills Training (CBSST) https://www.psychrehab.com/modules/index.html	Granholm Eric John et al. (2005) USA	n = 33, CBSST M = 54.5 (7.0) Research center and community board and care facilities.	n = 39, TAU M = 53.1 (7.5) Research center and community board and care facilities.	Social skills training based on UCLA Social and Independent Living Skill Series & CBT.	24 weeks, 1 session/ week (120 min/ session).	Insufficient information	ILSS, UPSA, CMT.	CBSST group performed social functioning activities significantly more frequently.
	Granholm et al. (2007) USA 1 year follow-up report	n = 33, CBSST M = 53.6 (7.5) Research center and community board and care facilities.	n = 37, TAU M = 53.6 (7.5) Research center and community board and care facilities.	Social skills training based on UCLA Social and Independent Living Skill Series & CBT.	24 weeks, 1 session/ week (120 min/ session).	Insufficient information	ILSS, UPSA, CMT.	Significant group effect for ILSS and CMT scores, favoring CBSST. Significant group-by-time interaction in ILSS, favoring CBSST.
Errorless Learning	Kern et al. (2005) USA	n = 29, errorless learning M = 44.6 (9.8)	n = 31, symptom management M = 42.6 (11.5)	Group sessions using errorless learning principles, to train identification of social problem (receiving skills), generating appropriate solution (processing skills) and enacting the solution (sending skills)	6 h over 2 days	Social Problem Solving Skills	Assessment of Interpersonal Problem-Solving Skills	Significant group effect favoring errorless learning, which was maintained for 3 months.
Social Skills Training (SST)	Seo et al. (2007) South Korea	n = 34, Social Skills Training M = 38.21 (4.74) Inpatients	n = 32, Routine Nursing Care Treatment M = 35.44 (7.02) Inpatients	Group based, (9–10 patients), manualized intervention https://www.psychrehab.com/modules/index.htm; http://www.guilford.com/books/Social-Skills-Training-for-Schizophrenia/Bellack-Mueser-Gingerich-Agresta/9781572308466.	8 weeks, 2 sessions/ week (60–70 min).	Interpersonal Relationship Skills, Assertiveness Skills, Problem Solving Skills, Self Esteem.	Social Interaction Scale, RCS, RAS, Personal Problem Solving Inventory, Rosenberg Self Esteem Scale.	Improvements(effect size d = 0.7) in conversational skills, assertiveness skills, interpersonal skills and self esteem.
	Park et al. (2011) Korea	n = 46, SST-VR M = 28.1 (7.7) Inpatients	n = 45, SST-TR M = 31.2 (7.7) Inpatients	Group based, (4–5 patients), therapist and co-therapists, manualized intervention http://www.guilford.com/books/Social-Skills-Training-for-Schizophrenia/Bellack-Mueser-Gingerich-Agresta/9781572308466. Virtual reality with a head mounted display.	5 weeeks, 10 semiweekly sessions (90 min/ session).	Social Skills	Trower's Social Behavioural Scales (SBS), RAS, RCS, Social Problem Solving Inventory (SPSI-R), Interest in Participation Questionnaire.	Higher interest in participation, conversational skills.
	Rus-Calafell et al. (2014) Spain	n = 12, VR-SST M = 36.5 (6.01) Outpatients	No control condition	Individual therapy using virtual reality program(Soskitrain), manualized intervention	8 weeks, 2 sessions/ week (60 min).	Social Perception, Processing Social Information, Responding and Sending Skills, Affiliative Skills, Assertive Communication,	Assertion Inventory (AI), Simulated Social Interaction Test(SSIT), SADS, SFS.	Significant improvement in social avoidance, social skill mastery, interpersonal communication and pro-social activities.

Table 1 (*Continued*)

Type of Social Cognitive Intervention	Reference and Country	Experimental Condition [a]	Control Condition [b]	Treatment Modalities/Methods	Duration and Frequency of Training	Social Cognitive Domains Targeted	Outcome Measurements	Results
						Instrumental Role Skills, Conversational Skills		

Note: AI = Assertion Inventory, AIHQ = Ambiguous Intentions Hostility Questionnaire, CMT = Comprehensive Module Test, Emorec = Emotion Recognition Questionnaire, GAF = Global Assessment of Functioning, ILSS = Independent Living Skills Survey, IPSAQ = Internal, Personal and Situational Attributions Questionnaire, MRI = Magnetic Resonance Imaging, MSCEIT = Mayer–Salovey–Caruso Emotional Intelligence Test, POFA = Pictures of Facial Affect, PSP = Social Performance Scale, RAS = Rathus Assessment Scale, RCS = Relationship Change Scale, RMET = Reading the Mind in the Eyes Test, SADS = Social Avoidance and Distress Scale, SAS = Social Adjustment Scale SBS = Social Behavioural Scales, SCST-R = Schema Component Sequencing Task-Revised, SFS = Social Functioning Scale, SIS = Social Interaction Scale, SOFAS = Social and Occupational Functioning Assessment Scale, SPS = Social Perception Scale, SPSI-R = Social Problem Solving Inventory, SSIT = Simulated Social Interaction Test, TAU = Treatment as Usual, TOM = Theory of Mind, UPSA = University of California San Diego Performance Based Skills Assessment, WASI = Wechsler Abbreviated Scale of Intelligence, WHO- DAS = World Health Organisation- Disability Assessment Schedule.

[a] Sample characteristics: n = x denotes the number of patients in that condition, M = mean age and standard deviation(given in parentheses), sample type.

[b] Sample characteristics: n = x denotes the number of patients in that condition, mean age and standard deviation(given in parentheses), sample type.

interventions (eg: neurocognitive remediation or other skills training). Studies from all countries of origin were considered but non-English publications were excluded in this review. Upon removal of all articles that did not meet our criteria, a final sample of 61 studies was tabulated (See Fig. 1).

3. Results

Using the terminology described by Choi et al. (2009), broad-based interventions were those which included social cognitive training within broad psychosocial approaches to improve social cognition, neurocognition and/or social skills. Twenty studies were under this category and presented in Table 1. Targeted interventions on the other hand, focused on delivery of social cognitive treatment without any other intervention components. Thirty-one studies were under this category and listed in Table 2. Lastly, ten studies which utilized medication and neurostimulation specifically to improve social cognition were also reviewed and presented in Table 3.

3.1. Broad-based interventions

Integrated Psychological Therapy (IPT) was one of the earliest interventions which combined neurocognitive, social cognitive and social skills training. The manualized group-based treatment consisted of five subprograms and was based on the assumption that basic neurocognitive deficits had a pervasive effect on higher levels of behavioral organization, including social skills and social functioning (Roder et al., 2006). Hence, the first subprogram sought to improve attention, verbal memory and concept formation through strategy learning (Roder et al., 2011). The second subprogram addressed deficits in social cognition, while the last few subprograms focused on social competence through practice of interpersonal skills. Studies on IPT showed that the social perception subprogram alone or a condensed version of IPT could lead to improvement in social perception and social functioning respectively (Fuentes et al., 2007; Zimmer et al., 2007). The developers of IPT had since moved on to develop Integrated Neurocognitive Therapy (INT), which aimed to improve all the eleven neuro- and social-cognitive domains defined by the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) workgroup. Unlike IPT which was originally developed for chronic inpatients, INT was more suitable for outpatients with fewer psychosocial impairments, as it placed greater cognitive and emotional demands (Mueller et al., 2015). A recent trial showed that INT patients displayed significant improvements in several neurocognitive and social cognitive measurements, as well as improvement in Global Assessment of Functioning Scale (GAF) scores (Mueller et al., 2015). Unfortunately, a social functioning scale was not used.

Similarly, Cognitive Enhancement Therapy was developed with the hypothesis that neurocognitive deficits in selective attention, inhibition, working memory and problem-solving resulted in the failure for people with schizophrenia to encode, remember, interpret and respond to subtle cues regarding context-specific rules or affect (Hogarty and Flesher, 1999a,b). Intervention combined approximately 75 h of progressive computer software training with 1.5 h per week of social cognitive group exercises for 56 sessions (Hogarty et al., 2004). The full programme was originally for outpatients in full or partial remission from psychotic symptoms and took up to two years to complete, with positive results in social cognitive profile and social adjustment maintained at one year post-intervention (Hogarty et al., 2006). A condensed one-year CET for patients with early course schizophrenia produced similar significant improvements in social cognition and social adjustment, and gains were maintained one year post-treatment (Eack et al., 2010a,b, 2009; Lewandowski et al., 2011).

Table 2
Targeted Social Cognitive Interventions.

Type of Social Cognitive Intervention	Reference and Country	Experimental Condition [a]	Control Condition [b]	Treatment Modalities/ Methods	Duration and Frequency of Training	Social Cognitive Domains Targeted	Outcome Measurements	Results
Attentional Shaping	Combs et al. (2006) USA	N = 12 Attentional Shaping	N = 10 Repeated Practice.	Computerized version of FEIT used. Large cross appeared to direct attention to eye and mouth areas of the face.	One-off intervention	Emotion Perception	FEIT, BLERT	Significantly more improvements in FEIT and BLERT scores.
	Combs et al. (2008) USA	n = 20, Attentional-shaping M = 38.7 (13.7) Inpatients	n = 20, monetary reinforcement M = 38.7 (13.7) n = 20, repeated practice M = 38.7 (13.7) Inpatients	As above	One-off intervention	Emotion Perception	FEIT, BLERT, SBS	Improvements on FEIT and BLERT and trend level for social behaviour.
	Combs et al. (2011a) USA	n = 15 M = 39.0 (10.9) Outpatients	n = 14 M = 23.2 (4.0) Impaired college student controls.	Images from The Montreal Facial Displays of Emotion series. Similar shaping technique as before.	Participants randomly assigned to 1, 3, or 5 sessions	Emotion Perception	FEIT, BLERT	Largest improvements on the BLERT and FEIT found for persons assigned to 5 sessions
Training of Affect Recognition (TAR)	Wölwer et al. (2005) Germany	n = 28, TAR M = 31.5 (6.9) Inpatients/ Outpatients	n = 24, Cognitive Remediation Training (CRT) M = 36.7 (11.4) n = 25, TAU M = 35.2 (11.1) Inpatients/ Outpatients	Computer-aided group based (2 patients), 1 therapist, manualized intervention http://www.markersoftware.com/USA/frames.htm	6 weeks, 2 sessions/ week (45 mi/session).	Facial Affect Recognition	POFA, BFRT	Improvements in facial affect recognition for those on TAR.
	Frommann et al. (2008) Germany	N = 20, TAR Insufficient information on age and characteristics of sample	n = 20, CRT	Computer-aided group based(2 patients), 1 therapist, manualized intervention described in Frommann et al., 2003.	6 weeks, 2 sessions/ week (45 min/session).	Facial Affect Recognition	POFA, BFRT	Improvements in facial and prosodic affect recognition that persisted after 4 weeks of treatment.
	Habel et al. (2010)	n = 10, TAR M = 31.4 (7.8) Inpatients/ Outpatients	n = 10, TAU M = 33.7 (10.65) Inpatients/ Outpatients n = 10, healthy subjects M = 31.6 (8.8)	Computer-aided group based(2 patients), 1 therapist, manualized intervention based on Frommann et al., 2003.	6 weeks, 2 sessions/ week (45 min/session).	Facial Affect Recognition	Emotion Discrimination Task, Age Discrimination Task.	Improvements in performance of facial affect recognition.
	Wolwer and Frommann (2011) Germany	n = 20 TAR,; Inpatients Mean age of whole sample = 36.7 (13.1)	n = 18 CRT, Inpatients	Computer-aided group based(2 patients), 1 therapist, manualized intervention.	6 weeks, 2 sessions/ week (45–60 min/ session).	Facial Affect Recognition	POFA, BFRT, Geneva Vocal Emotion Expression Stimulus (GVEESS49), Brune's ToM questionnaire, SOFAS	Improvement in prosodic affect Recognition (interaction F = 8.0, p = 0.009). Trend effect on global social functioning (d = 0.58).
	Sachs et al. (2012) Germany	n = 20, TAR M = 27.2 (7.17) Inpatients/ Outpatients	n = 18, TAU M = 31.72 (9.35) Inpatients/ Outpatients	Computer-aided group based(2 patients), 1 therapist, manualized intervention based on Frommann et al. (2003)	6 weeks, 2 sessions/ week (45 min/session).	Facial Affect Recognition	Vienna Emotion Recognition Task (VERT-K), WHOQOL-BRIEF	Improvements(effect size, d = 1.01) in facial affect recognition and QOL (social functioning domain).
	Drusch et al. (2014)	n = 16, TAR, M = 36.69 (11.67) Post-acute inpatients	n = 16, CRT M = 33.69 (8.82) Healthy controls	Computer-aided group based(2 patients),	6 weeks, 2 sessions/ week (45 min/session).	Facial Affect Recognition	BFRT, infrared oculography	Improved facial affect recognition (F(1,30) = 6.248, p = 0.018), with

Table 2 (*Continued*)

Type of Social Cognitive Intervention	Reference and Country	Experimental Condition [a]	Control Condition [b]	Treatment Modalities/ Methods	Duration and Frequency of Training	Social Cognitive Domains Targeted	Outcome Measurements	Results
				1 therapist, manualized intervention.				increased gaze fixations on feature areas ($T(1,24) = -2.611$, $p = 0.015$).
Social Cognitive & Interaction Training (SCIT)	Penn et al. (2005) USA	n = 7, SCIT. M = 43.6 (10.3)	No control condition	Group based manualized intervention modified for inpatient setting. 2 therapists	3 months, 5 sessions/ week (60 min/session)	Emotion Perception, Attributional Style, Theory of Mind.	FEIT, Hinting Task, AIHQ	Significant improvements in Theory of Mind (ηp: 0.70).
	Combs et al. (2007) USA	n = 18,SCIT M = 41.3 (11.2) Forensic inpatients	n = 10,coping skills M = 44.0 (10.6) Forensic Inpatients	Group based (6–8 patients), manualized intervention http://penn.web.unc.edu/social-cognition-and-interaction-training-scit/	18–24 weeks, 1 session/ week (60 min/session).	Emotion Perception, Attributional Style, Theory of Mind.	FEIT, FEDT, SPS, Hinting Task, AIHQ, Need for Closure Scale, SFS, Number of aggressive incidents.	Improvements in social and emotional perception, ToM, attributions for ambiguous situations, self reported social relationships and reduction in aggressive behaviors
	Combs et al. (2009) USA 6-month follow up	n = 18,SCIT M = 41.3 (11.2) Forensic inpatients	N = 18 Age, gender, and ethnicity matched non-psychiatric community controls	Group based (6–8 patients), manualized intervention.	18–24 weeks, 1 session/ week (60 min/session).	Emotion Perception, Attributional Style, Theory of Mind.	FEIT, SFS-Social Engagement and Interpersonal Contact Subscale, BLERT, social skill composite rating	Scores on FEIT ($\eta p^2 = 0.05$) and SFS ($\eta p^2 = 0.04$– 0.07) did not differ significantly between patients and healthy controls.
	Roberts and Penn (2009) USA	n = 20, SCIT + TAU M = 36.8 (12.3) Outpatients	n = 11, TAU M = 41.1 (12.3) Outpatients	Group based (4–11 patients), 2 co-facilittators, manualized intervention http://penn.web.unc.edu/social-cognition-and-interaction-training-scit/	20 weeks.	Emotion Perception, Theory of Mind, hasty judgment making, biased social attributions	FEIT, BLERT, Hinting Task, TASIT, AIHQ-A, SSPA	Improvements in emotion perception(effect size, d = 0.50) and social skills(effect size, d = 1.17) for those on SCIT + TAU.
	Roberts et al. (2010) USA	n = 50, SCIT M = 53.1 (11.8) Community rehabilitation centres	No control condition	2 facilitators, manualized intervention http://penn.web.unc.edu/social-cognition-and-interaction-training-scit/	20 weeks.	Emotion Perception, Theory of Mind, Attributional Bias.	FEIT, Hinting Task, AIHQ-A.	Improvements in emotion perception(effect size, d = 0.33) and Theory of mind(effect size, d = 0.43).
	Wang et al. (2013) China	n = 22,SCIT + TAU M = 43.86 (11.65) Outpatients	N = 17, TAU M = 40.88 (10.15) Outpatients	2 facilitators, manualized intervention that was translated into Chinese http://penn.web.unc.edu/social-cognition-and-interaction-training-scit/	20 weeks.	Emotion Perception, Attributional Style, Theory of Mind.	PSP- Chinese version, FEIT, Eyes Task, Attributional Style Questionnaire-Chinese version(ASQ).	Improvements in emotion perception, theory of mind, attributional style and social functioning(effect size, $n_p^2 > 0.24$).
	Roberts et al. (2014) USA	n = 33, SCIT M = 40.0 (12.2) Outpatients	n = 33, TAU M = 39.4 (10.8) Outpatients	Group based(4–8 patients), 2 facilitators, manualized intervention http://penn.web.unc.edu/social-cognition-	20–24 weeks, 60 min/ session.	Emotion Perception, Theory of Mind, Attributional Bias.	FEIT, AIHQ, Observable Social Cognition, A Rating Scale (OSCARS), SSPA.	Improvements in social functioning(effect size, d = 0.31) and attributional bias(effect size, d = 0.25).

				and-interaction-training-scit/				
Social Cognitive Skills Training (SCST)	Horan et al. (2009) USA	n = 15, SCST M = 50.7 (5.8) Outpatients (VA)	n = 16,illness self-management & relapse prevention skills M = 45.9 (7.5) Outpatients(VA)	Group based(6 patients), 2 facilitators	6 weeks, 2 sessions/ week (60 min/session).	Affect Perception, Social Perception, Attributional Style, Theory of Mind.	FEIT, half-PONS, AIHQ, TASIT-Part 3.	Improvements in facial affect recognition(effect size $n_p^2 = 0.21$) for those on SCST.
	Horan et al. (2011) USA	n = 16, SCST M = 51.0 (7.1) Outpatients (VA + comm)	n = 19, NR M = 46.6 (7.4) n = 19, standard illness management skills training M = 45.1 (11.2) N = 14, Hybrid M = 50.4 (10.1) Outpatients (VA + comm)	Group based (6–8 patients), 2 co-facilitators,manualized intervention described in paper.	12 weeks, 2 sessions/ week (60 min/session).	Emotional Processing, Social Perception, Attributional bias, Theory of Mind.	FEIT, MSCEIT-Managing Emotions subtest, half- PONS, AIHQ, TASIT- Part 3, UPSA, MASC.	Improvement in emotion processing for SCST.
	Gohar et al. (2013) Egypt	n = 22, SCST M = 32.95 (10.86) Outpatients	n = 20, illness management training control M = 30.75 (10.58) Outpatients	Group based(6 patients), 1 group leader, adapted from Horan et al., 2011.	8 weeks, 2 sessions/ week (60 min/session).	Emotion Processing, Social Perception, Attributional bias, Theory of Mind.	MSCEIT 2.0- Arabic version	Improvement in emotion processing(effect size, $n_p^2 = 0.38$) for SCST.
Online Social Cognitive Training Program	Nahum et al. (2014) USA	n = 17 M = 23.8 (3.2) Outpatients	n = 17 M = 23.6 (3.6) Healthy Controls	Online program, 19 exercise http://www.brainhq.com/why-brainhq/about-the-brainhq-exercises	6–12 weeks, 2–5 sessions/week (60 min/ session).	Affect Perception (visual/vocal), Social Cue Perception, Theory of Mind, Self-Referential Processing	Penn Facial Memory Test, Prosody Identification Test, MSCEIT- perceiving emotions and managing emotions, Global Functioning: Social and Role Scales, SFS	Improvements in prosody identification(effect size, d = 0.71), facial memory(effect size, d = 0.6) and social functioning(effect size, d = 0.4).
Social Cognition Enhancement Training (SCET)	Choi and Kwon, 2006 South Korea	n = 17, SCET M = 30.88 (6.15) Rehabilitation Centres	n = 17,Standard psychiatric rehabilitation training M = 34.07 (7.53) Rehabilitation Centres	Group based, manualized intervention based on Kwon, 2003.	24 weeks, 2 sessions/ week (90 min/session).	Context appraisal and perspective-taking	Picture Arrangement, Social Behaviour Sequencing Task (SBST), Emotion Recognition Task(ERT)	Improvement in social cognitive performance on picture arrangement and SBST.
Metacognitive and Social Cognition Training (MSCT)	Rocha and Queirós (2013) Portugal	n = 19, MSCT M = 38.63 (8.88) Outpatients	n = 16, TAU M = 35.94 (8.69) Outpatients	Hybrid of SCIT, SCST and group metacognitive training described in paper.	10 weeks, 18 sessions.	Emotion Recognition, Emotion Regulation, Theory of Mind, Attributional Style, Social Perception,	FEIT, MSCEIT- Managing Emotions section, Hinting Task, AIHQ, SPS, Fish Task.	Improvement in theory of mind (effect size, $n_p^2 = 0.15$), social perception(effect size, $n_p^2 = 0.15$), emotion recognition(effect size, $n_p^2 = 0.22$) and social functioning (effect size, $n_p^2 = 0.17$).
Mental-State Reasoning Training for Social Cognitive Impairment' (SoCog-MSRT)	Marsh et al. (2013) Australia	n = 14, SoCog-MSRT M = 29.86 (10.44) Outpatients	No control condition	Groups of 3–6 people, using manually-driven suite of activities including games	10 twice-weekly sessions, for 5 weeks	Theory of Mind and attribution style	The Reading the Mind in the Eyes Test (RMET), Hinting Task, False-Belief Picture Sequencing Test (FBPST), Internal, Personal and Situational Attributions Questionnaire (IPSAQ), Empathy Quotient,	Significant improvements in Theory of Mind, inferring complex mental states from the eyes; and self-reported measure of social understanding.
Mary/Eddie/ Bill (MEB)	Roberts et al. (2012) USA	N = 24 MEB Age not reported	No control condition	Groups which consist of viewing and Comedies to associate	6 sessions (1 h each), weekly,	Theory of Mind and attribution style	The Awareness 90 of Social Inference Task-Abbreviated (TASIT-A), The Social Cognition Screening	Significant improvements in Theory of Mind (effect size d = 0.15), social cognitive overconfidence (effect size d = 0.93) and self-

Table 2 (*Continued*)

Type of Social Cognitive Intervention	Reference and Country	Experimental Condition [a]	Control Condition [b]	Treatment Modalities/ Methods	Duration and Frequency of Training	Social Cognitive Domains Targeted	Outcome Measurements	Results
				with three prototypical characters			93 Questionnaire (SCSQ), The Relational Interactivity Measure (RIM)	reported social engagement (effect size d = 0.53)
Micro-Expression Training Tool (METT) http://www.paulekman.com/product/micro-facial-expressions-training-tool/	Russell et al. (2006) England and Australia	n = 20, METT M = 38.05 (7:91) Outpatients	n = 20, M = 34.35 (9:21) Healthy controls	Computer-based microexpressions emotion recognition training	Single session	Facial Emotion Recognition	METT images and Emotion Recognition Task (EMT)	Improved to the level of untrained controls
	Russell et al. (2008) Australia	n = 26, METT M = 40.0 (10.0) Outpatients	n = 14, Repeated Exposure M = 44.0 (9.0) Outpatients	Computer-based microexpressions emotion recognition training	Single session of three sub-sections (video, practice with feedback, and review video)	Facial Emotion Recognition	METT images and Emotion Recognition Task (EMT)	Improvements in emotion recognition accuracy, which was maintained after one week.
	Marsh et al. (2010) Australia	N = 39 schizophrenia: M = 40.32 (9.64); schizoaffective M = 30.63 (5.40) Inpatients and Outpatients	No control condition	Computer-based microexpressions emotion recognition training	40–60 min of METT	Facial Emotion Recognition	METT Emotion Recognition Task, POFA, Benton Identity Recognition Task, Birchwood Social Functioning Scale	Improved recognition of novel faces 1 month after training (effect size d = 0.94)
	Marsh et al. (2012) Australia	34 patients of the Marsh et. al.2010 study. Inpatients: n = 24 M = 32.70 (7.82) Outpatients n = 10 M = 41.17 (9.51)	No control condition	Computer-based microexpressions emotion recognition training	40–60 min of METT	Facial Emotion Recognition	Visual scanpath (VSP) recordings	Changes in foveal attention to the features of facial expressions of emotion
Social Cognition Training Program (SCTP)	Gil Sanz et al. (2009) Spain	n = 7, SCTP M = 33.29 (8.36) Rehabilitation center patients	n = 7, control M = 41.43 (9.03) Rehabilitation center patients	Hybrid of TAR, Emotion Training Program, SCIT and social perception subprogram of IPT	36 sessions, across 2 phases (45 min/session).	Emotion Recognition, Social Perception	Computerised facial emotion recognition test, Spanish Social Perception Scale(EPS)	Improvements in social perception (effect size, d = 1.32) but not emotional recognition.
Emotion and ToM Imitation (ETIT)	Mazza et al. (2010) Italy	n = 17, ETIT M = 24.37 (2.12)	n = 16, PST M = 24.71 (2.17)	Group based intervention.	12 weeks, 2 sessions/ week (50 min/session).	Emotion Recognition, Theory of Mind	Adapted Theory of Mind Scale, Emotion Attribution Task, EEG, Personal and Social Performance Scale (PSP), Empathy Questionnaires (EQ), Electrophysiological data on Event-related potentials (ERPs)	Improvements in emotion recognition(effect size = n_p^2 = 0.58) and theory of mind(effect size, n_p^2 = 0.98). Increase in electroactivity of medio-frontal areas
Theory of Mind Intervention (ToMI)	Bechi et al. (2013) Italy	n = 28,SCT M = 37.14 (10.02) Outpatients	n = 24, SRT M = 38.0 (8.73) n = 24, NT M = 40.2 (8.99) Outpatients	Group based, therapist and facilitators, method described in paper.	12 weeks, 1 session/ week (60 min).	Emotion Processing, Theory of Mind	POFA, Theory of Mind Picture Sequencing Test (PST), Theory of Mind Questionnaire	Improvements in Theory of Mind (effect size, d > 0.64).

Note: AIHQ = Ambiguous Intentions Hostility Questionnaire, AIHQ-A = Ambiguous Intentions Hostility Questionnaire- Ambiguous Items, BFRT = Benton Face Recognition Test, BLERT = Bell-Lysaker Emotion Recognition Task, CRT = Cognitive Remediation Training, EEG = Electroencephalography, EQ = Empathy Questionnaires, FEDT = Facial Emotion Discrimination Task, FEIT = Facial Emotion Identification Task, Half-PONS = The Half Profile of Nonverbal Sensitivity, IU = International Units, MASC = Maryland Assessment of Social Competence, MSCEIT = Mayer-Salovey-Caruso Emotional Intelligence Test, POFA = Pictures of Facial Affect, PSP = Personal and Social Performance Scale, RMET = Reading the Eyes in the Mind Test, SBS = Social Behaviour Scale, SFS = Social Functioning Scale, SOFAS = Social and Occupational Functioning Assessment Scale, SPS = Social Perception Scale, SSPA = Social Skills Performance Assessment, TASIT = The Awareness of Social Inferences Test, UPSA = USCD Performance Based Skills Assessment, WHOQOL-BRIEF = WHO Quality of Life- short version.

[a] Sample characteristics: n = x denotes the number of patients in that condition, M = mean age and standard deviation (given in parentheses), sample type.

[b] Sample characteristics: n = x denotes the number of patients in that condition, mean age and standard deviation (given in parentheses), population characteristics.

Table 3
Medication and Neurostimulation.

Type of Intervention	Reference and Country	Experimental Condition [a]	Control Condition [b]	Study Design	Mode of Intervention	Social Cognitive Domains Targeted	Outcome Measurements	Results
Transcranial Direct Current Stimulation (tDCS)	Rassovsky et al. (2015) USA	n = 12, anodal tDCS M = 45.8 (11.2) n = 12, cathodal tDCS M = 47.8 (7.48) Outpatients	n = 12, sham cathode M = 41.6 (10.3) Outpatients	Randomized study.	120 min stimulation session.	Managing Emotions, Identification of Facial Emotion, Social Perception, Theory of Mind	MSCEIT,FEIT, PONS,TASIT.	Anodal tDCS improved on facial emotion recognition.
	Averbeck et al. (2012) England	n = 21 M = 38.2 (1.8) Outpatients	n = 29 M = 34.34 (2.43) Outpatients	Double blind placebo-controlled cross-over design	1 session of intranasal 24 IU oxytocin and 1 session of placebo	Emotion recognition	Hexagon emotion discrimination task,	Improved ability to recognize emotions [F(1, 264) = 7.74, p = 0.006]
	Goldman et al. (2011) USA	n = 5 M = 53(3) Schizophrenia patients with polydipsia. n = 8, M = 44(9) Schizophrenia patients without polydipsia	n = 11 M = 38(13) Healthy controls	Double blind design: order of different doses was randomized across subjects	Three sessions(held 7 days apart) of intranasal oxytocin(10/20 IU).	Facial affect discrimination	BFDT	Emotion recognition improved following 20 IU in polydipsic relative to nonpolydipsic patients (Z = 2.55, P < 0.01).
	Pedersen et al. (2011)	n = 11, Oxytocin M = 39.00 (11.18) Outpatients	n = 9 Placebo, M = 35.78(9.52) Outpatients	Randomized, double blind, placebo-controlled 2-week treatment trial.	Self-administered 24IU intranasal twice daily over 14 days	Theory of Mind and Social Perception	Brüne Theory of Mind Picture Stories Task, Trustworthiness Task	Improved Brune Task and Trustworthiness Task scores
Oxytocin	Davis et al. (2013) USA	n = 11, oxytocin M = 48.6 (6.6) Male outpatients	n = 12, placebo M = 48.6 (9.1) Male outpatients	Randomized, double-blind, placebo-controlled study.	1 visit, 40IU intranasal oxytocin.	Theory of Mind, Empathy, Social Perception, facial Affect Recognition	TASIT-Part 3, Emotional Perspective Taking Task(EPTT), Half-PONS, FEIT.	Administration of oxytocin led to improvements in higher order social cognition.
	Davis et al. (2014) and Marder et al. (2014) USA	n = 13, M = 42.8 (9.1) oxytocin + Social Cognitive Skills Training (SCST) Male outpatients	n = 14, M = 37.0 (10.8) placebo + SCST. Male outpatients	Randomized, double-blind, placebo-controlled study.	12 sessions SCST, twice a week for 6 weeks. Oxytocin nasal spray (40IU) or placebo given 30 min before each session	Facial affect recognition, social perception, empathy	Ekman's digital facial images, PONS, Empathic Accuracy Task, MSCEIT-Managing Emotions, TASIT.	Significant improvement in empathic accuracy (effect size d = 0.98). Significant increase in N170 amplitude for emotion identification.
	Woolley et al. (2014) USA	n = 31 M = 44.6 (10.7) Male Outpatients	n = 29 M = 42.5 (14.1) Healthy Male Controls	Randomized, double-blind, placebo-controlled, cross over study.	2 testing days/1 week apart, 40IU intranasal oxytocin.	Automatic Social Cognition, Controlled Social Cognition.	RMET, TASIT.	Administration of oxytocin led to improvements in controlled social cognition in patients.
	Gibson et al. (2014) USA	n = 8, OT M = 38.88 (7.22) Outpatients	n = 6, placebo M = 35.67 (9.00) Outpatients	Randomized, double-blind, placebo-controlled study.	6 weeks, 2 times/day 24IU intranasal oxytocin.	Emotion Recognition, Theory of Mind, Empathy, Social Perception, Attributional Style, Social Skills	The Emotion Recognition-40(ER-40), Theory of Mind Picture Stories Test, The Eyes Test, The Trustworthiness Task, AIHQ, social skills role play.	Administration of oxytocin led to improvements in fear recognition(effect size, d = 1.04) and perspective taking(effect size, d = 1.18).
	Horta de Macedo et al. (2014) Brazil	N = 20 M = 29.6 (6.83) Male outpatients	N = 20 M = 29.7(9.29) Healthy male controls	Randomly assigned to sequence of oxytocin and placebo sessions	2 sessions(between 15 days), 48 IU intranasal oxytocin or placebo.	Facial emotion recognition	Facial emotion matching task	No improvement in facial affect processing

Table 3 (*Continued*)

Type of Intervention	Reference and Country	Experimental Condition [a]	Control Condition [b]	Study Design	Mode of Intervention	Social Cognitive Domains Targeted	Outcome Measurements	Results
	Guastella et al. (2015) Australia	n = 11 M = 37.42 (11.14) Male outpatients	n = 11 M = 37.42 (11.14) Male outpatients	Randomized, double-blind, within-subjects crossover study.	2 visits, 24 IU intranasal oxytocin.	Lower and Higher order Social Cognition Tasks	Diagnostic Analysis of Non-Verbal Accuracy(DANVA), Facial Expressions of Emotions Test(FEEST), RMET, False Belief Picture Sequencing Task(FBPST), Hinting Task, The Faux-Pas Recognition Task	Administration of oxytocin led to improvements in higher level social cognition (effect size, $n_p^2 > 0.22$).

Note: AIHQ = Ambiguous Intentions Hostility Questionnaire, BFRT = Benton Face Recognition Test, BLERT = Bell-Lysaker Emotion Recognition Task, FEIT = Facial Emotion Identification Task, PONS = Profile of Nonverbal Sensitivity, IU = International Units, MSCEIT = Mayer-Salovey-Caruso Emotional Intelligence Test, RMET = Reading the Eyes in the Mind Test, TASIT = The Awareness of Social Inferences Test.

[a] Sample characteristics: n = x denotes the number of patients in that condition, M = mean age and standard deviation (given in parentheses), sample type.

[b] Sample characteristics: n = x denotes the number of patients in that condition, mean age and standard deviation (given in parentheses), population characteristics.

Since condensed versions of IPT and CET showed favorable results, one issue was whether broad-based interventions were practical for patients with schizophrenia who had lower tolerance towards high intensity treatment (Choi et al., 2009). One study also found that improvement in neurocognition was not a pre-requisite for social cognitive improvement (Wölwer et al., 2005). More research is needed to determine if neurocognitive improvement needs to reach a certain threshold to effect gains in social cognition. Recent broad-based interventions were shorter in duration and did not focus on extensive neurocognitive and social cognitive domains. For example, the Auditory Training with Social Cognitive Training (AT + SCT) sought to improve social cognition through computerized training of very basic neuro-cognitive and social cognitive operations, in the absence of strategy learning and interpersonal therapeutic interventions. Participants displayed improvement in emotional processing and social perception, but not functional outcomes (Hooker et al., 2012; Sacks et al., 2013). In addition, gains in neurocognition were not found to be associated with gains in social cognition (Sacks et al., 2013). Another program using an adapted NeuroPersonal-Trainer software comprised neurocognitive and social cognitive modules delivered over 20 weeks (Fernandez-Gonzalo et al., 2015). Participants with early stage of illness also achieved significant gains in emotional processing, particularly facial affect recognition. However, no significant improvements were noted in other social cognitive domains and social functioning. On the other hand, Lindenmayer et al. (2013) combined computerized cognitive remediation with a computerized Mind Reading: Interactive Guide to Emotions (CR+ MRIGE) program and found significant improvements in emotional processing and social functioning compared to cognitive remediation alone. It appeared that combining neurocognitive and social cognitive training had not consistently led to social functioning improvement. More research is needed to determine the active ingredients for combination interventions and the minimal intensity of treatment required to effect functional change.

Six studies investigated broad-based social skills training that incorporated novel technique to improve social competence, without targeting specific social cognitive domains. Two studies used virtual reality as part of social skills training, to enable participants to practise social interactions with virtual avatars. The study by Park et al. (2011) used a head mounted display with position tracker so that participants can move their heads and direct their gaze in a natural manner, while Rus-Calafell et al. (2014) used 3D glasses and headphones to provide an immersive virtual environment. Improvements in emotion perception, assertiveness, conversation skills and social functioning were found. Participants appeared motivated and reported a high degree of treatment satisfaction (Park et al., 2011; Rus-Calafell et al., 2014). The Cognitive Behavioral Social Skills Training (CBSST) modified components of communication role-play and problem-solving social skills training modules from Psychiatric Rehabilitation Consultants (Granholm Eric John et al., 2005). Its CBT components were developed specifically to address negative attributions and self-efficacy beliefs that interfered with functional behaviors (Granholm et al., 2007). On the other hand, Errorless Learning trained identification of social problem, generating appropriate solution and enacting the solution. Participants demonstrated improvement in Assessment of Interpersonal Problem-Solving Skills scores upon completion of training (Kern et al., 2005). It was difficult to determine if social cognitive deficits could have been indirectly addressed in these training programs.

In summary, broad-based interventions that target an extensive range of neurocognitive and social cognitive domains appear to yield benefits in social cognition and social functioning.

3.2. Targeted interventions

A number of targeted interventions addressed all the four core social cognitive domains identified by SCOPE, while others focused on one or two of the domains.

3.2.1. Interventions that addressed a range of social cognitive domains

Social Cognition and Interaction Training (SCIT) was developed as a 20-week, manualized group intervention that targeted problems with emotion perception, ToM and attribution bias (Penn et al., 2007). The treatment comprised three phases. The first phase of 'Emotion Training' sought to improve emotion perception via commercial computerized software. The second phase of 'Figuring Out Situations' addressed attributional biases and ToM dysfunction, while the last 'Integration' phase allowed participants to practise learned skills on interpersonal problems in their own lives (Roberts and Penn, 2009). Initial pilot at two inpatient settings demonstrated medium effect sizes on ToM and attributional bias (Combs et al., 2007; Penn et al., 2005) and a six-month follow-up on one of the studies found sustained effects on social functioning (Combs et al., 2009). Subsequent studies conducted at outpatient community rehabilitation centres had mixed results. While the preliminary quasi-experimental outpatient study and the pre-post community study found benefits of SCIT on emotion perception, a subsequent randomized controlled trial (RCT) did not show significant improvement in this domain (Roberts and Penn, 2009; Roberts et al., 2014, 2010). This RCT also reported reduction in attributional bias within the intervention group as well as improved ToM among lower functioning participants, which were not found in the earlier studies (Roberts et al., 2014). However, significant effects on social functioning and positive feedback from participants were consistent across the studies (Roberts and Penn, 2009; Roberts et al., 2014, 2010). When translated and implemented in Chinese healthcare institutions, SCIT was also able to yield improvements in the domains of emotion perception, ToM, attributional style and social functioning (Wang et al., 2013).

The Social Cognitive Skills Training (SCST) developed by Horan et al. (2009) addressed all four social cognitive domains and drew from both SCIT and Wolwer and colleagues' Training of Affect Recognition (TAR) (Penn et al., 2007; Wölwer et al., 2005). The first phase focused on identifying six basic emotions using computerized facial affect exercises from TAR. Training then progressed to social cue perception and social context appreciation. The second training phase utilized SCIT's exercises on distinguishing facts, guesses, and feelings; as well as 'checking out' the evidence for one's beliefs. The final phase emphasized integration of social clues to evaluate non-literal speech or deception in various social contexts. An initial 12 sessions of SCST produced improvement in facial affect perception, when compared against an active control (Horan et al., 2009). An expanded 24 sessions of SCST was subsequently investigated alongside neurocognitive remediation, illness management skills training and a hybrid of SCST and neurocognitive remediation. Participants in SCST showed significant improvements in facial affect perception and emotional management (Horan et al., 2011). Interestingly, the hybrid program did not show any clear benefits on social cognition, highlighting no synergistic advantage of combining social cognitive and neurocognitive treatment. However, it was unclear whether this was due to the relatively fewer number of sessions dedicated to each component as a result of combining the two interventions. Although SCST covered all social cognitive domains, improvement was seen only in the emotion processing domain. Similar results were found when the program was translated and implemented in Egypt (Gohar et al., 2013).

The Metacognitive and Social Cognition Training (MSCT) was a hybrid of SCIT and SCST, while incorporating a Portuguese version of an existing metacognitive program (Rocha and Queirós, 2013). The inclusion of metacognitive training was to build awareness on the susceptibility to make false assumptions based on facial expressions when contextual information was scarce (Moritz et al., 2011). Compared to treatment-as-usual, the MSCT group achieved improvements in ToM, social perception, emotion recognition and social functioning (Rocha and Queirós, 2013).

One pilot study examined the initial efficacy of an online training program called SocialVille, which aimed to treat social cognitive deficits in young schizophrenia adults using the principles of neuroplasticity-based learning (Nahum et al., 2014). These exercises targeted stimulus representation and processing speed in specific neural systems affecting social cognition, rather than the impaired social behaviors. Given this rationale, intervention was carried out by participants individually either at home or in the clinic, which was distinct from other intervention programs. The pilot study reported improvements in prosody identification, facial memory and social functioning (Nahum et al., 2014). Participants also rated medium to high range in enjoyment and ease of use. A multi-site, randomized controlled trial (called TRuSST) with a target sample of 128 patients with schizophrenia had recently commenced, to compare 30 h of SocialVille to an active computer game control (Rose et al., 2015).

3.2.2. Interventions that addressed specific social cognitive domains

Attentional Shaping (AS) was one of the simplest and shortest facial affect recognition programs. Computerized images from Face Emotion Identification Test (FEIT) were presented with a large cross over the center of each image, to direct attention to eye and mouth areas of the face (Combs et al., 2006). This single-session training was shown to be effective in improving FEIT and Bell-Lysaker Emotion Recognition Test (BLERT) scores, compared to monetary reinforcement and repeated practice (Combs et al., 2008). A further enhanced version found that five sessions of AS led to more efficient scanning of facial affect (Combs et al., 2011a).

Instead of using passive prompts adopted in AS, Micro-Expression Training Tool (METT) directed participants to relevant facial features of commonly confused emotional expressions and explained important distinctions between them (Marsh et al., 2010). Participant viewed a neutral face, saw a "flash" of the emotion, before the face returned to be neutral. They then verbally labeled each expression and had to repeat if responses were incorrect (Russell et al., 2008). Initial studies found improved ability in recognising facial affect of trained images as well as novel ones (Marsh et al., 2010; Russell et al., 2006). A further study reported changes in foveal attention that correlated with better recognition of surprise, disgust, fear and happiness, but reduced foveal attention to sad and neutral faces that indicated the need for more intensive instructions for these expressions (Marsh et al., 2012).

Studies on the Training of Affect Recognition (TAR) explored whether a 12-session intervention that targeted facial emotional recognition could have effects on other social cognitive domains and social functioning. Its manualized, computer-aided 12-session program employed errorless learning, information processing strategies, positive feedback and feature abstraction (Wolwer and Frommann, 2011). Earlier reports showed improvements in facial and prosodic affect recognition which persisted beyond four weeks (Frommann et al., 2008). TAR participants also demonstrated increased gaze fixations to salient facial features and were able to achieve comparable performance with healthy controls (Drusch et al., 2014; Habel et al., 2010). These improvements were independent of improvement in neurocognition when TAR was compared with Cognitive Remediation Training (CRT) (Wölwer et al., 2005). However, treatment effects on ToM and social competence were not established, although there were trend

effects on global social functioning (Sachs et al., 2012; Wolwer and Frommann, 2011).

Two interventions targeted ToM in addition to emotion processing. Emotion and ToM Imitation (ETIT) comprised four phases, which included observing the gaze of people in photographs, imitating facial expressions, inferring a character's mental state in a social situation and attributing intentions through observing people's actions in a sequence of comic strips (Mazza et al., 2010). A distinct feature of this program was the emphasis on action observation and imitation training. Treatment effects on emotion recognition, ToM and social functioning were reported, with the corresponding increase in electro-activity of medio-frontal areas associated with emotion recognition (Mazza et al., 2010). Theory of Mind Intervention (ToMI), on the other hand, used comic strips and faux pas stories to train cognitive and affective ToM (Bechi et al., 2013). One study demonstrated improvement in ToM post intervention (Bechi et al., 2013).

Other programs, such as Mental-State Reasoning Training for Social Cognitive Impairment (SoCog-MSRT) and Mary/Eddie/Bill (MEB), targeted mainly ToM and attributional style (Marsh et al., 2013; Roberts et al., 2012). One study each was conducted on these two programs and found improvements in ToM and self-reported measure of social functioning (Marsh et al., 2013; Roberts et al., 2012). Social Cognition Training Program (SCTP) consisted of group emotional recognition sessions (derived from TAR, Emotion Training Program and SCIT) and social perception module of IPT (Gil Sanz et al., 2009). Improvement in social perception but not emotional recognition was reported. Lastly, Social Cognition Enhancement Training (SCET) used cartoon strips to enhance context appraisal and perspective-taking, with improvement in contextual processing shown in one study (Choi and Kwon, 2006).

In summary, emotional processing appeared to be the most frequently targeted social cognitive domain, with much success. Interventions that addressed specific or a range of social cognitive domains were able to report positive outcomes, but their effects on social functioning were often not investigated.

3.3. Medication and neurostimulation

Nine studies examined the effects of oxytocin on domains of social cognition, given that it was found to function centrally as a neurotransmitter involved in multiple aspects of social behaviour (Heinrichs et al., 2009; Meyer-Lindenberg et al., 2011). In studies that utilized single dose paradigms over one or two visits, oxytocin was administered through an intranasal spray (24IU-48IU) and social cognitive assessments were conducted about 30–60 min thereafter (Averbeck et al., 2012; Davis et al., 2013; Guastella et al., 2015; Horta de Macedo et al., 2014; Woolley et al., 2014). Four of these studies reported significant effects on high-level social cognition (comprehension of indirectly expressed emotions/thoughts based on complex integration of social contextual information) but not on low-level social cognition (emotional perception and social cue detection) (Davis et al., 2013; Guastella et al., 2015; Horta de Macedo et al., 2014; Woolley et al., 2014). This was in contrast with two earlier studies which obtained treatment effects on emotional recognition (Averbeck et al., 2012; Goldman et al., 2011). Two other studies investigated self-administration of intranasal oxytocin twice a day over two or six weeks and found improvements in ToM, fear recognition and perspective taking (Gibson et al., 2014; Pedersen et al., 2011). Oxytocin was also administered 30 min before each session of SCST in one study and was found to yield benefits in empathic accuracy and emotion identification (Davis et al., 2014; Marder et al., 2014). However, many of these studies did not include female participants and none of them reported any impact on social skills and social functioning.

One recent study explored the effect of transcranial direct current stimulation (tDCS), where anodal or cathodal tDCS were applied bilaterally over the dorsolateral prefrontal cortex in 36 individuals with schizophrenia (Rassovsky et al., 2015). Studies postulated that anodal-tDCS could enhance cortical excitability, by modulating spontaneous neuronal network activity (Nitsche and Paulus, 2000; Priori et al., 2009). When compared to cathode and sham tDCS, participants who underwent a single 20-min session of anodal tDCS showed significant improvement in emotion identification (Rassovsky et al., 2015). More research would be needed to support this finding.

In summary, there was potential in the use of medication and neurostimulation to improve social cognition. However, their optimal treatment intensity and specific benefits to social cognitive domains have yet been ascertained.

4. Discussion

Both broad-based and targeted interventions appear to yield treatment effects on social cognition at varying degrees. A couple of studies found no synergies between neurocognitive and social cognitive gains (Horan et al., 2011; Wölwer et al., 2005), despite their overlapping constructs (Schmidt et al., 2011). However, it is not known if more robust and sustainable improvements in social functioning can be achieved by combination of neurocognitive and social cognitive training, rather than targeted social cognitive interventions alone. There are suggestions that neurocognitive training may improve patients' ability to apply lessons learned in social cognitive training, via improved memory to recall strategies and enhanced executive function to apply skills flexibly (Roberts and Velligan, 2012). A direct comparison between broad-based and targeted interventions on social functioning may be needed to ascertain this. However, it was noted that only 13 of 20 broad-based intervention studies, as well as 14 of 31 targeted intervention studies included some form of social functioning measurements. More studies that adopt measurements of real-world social functioning are needed.

On the other hand, interventions that used virtual reality, cognitive behavioural techniques and errorless learning in social skills training showed positive outcomes in social functioning, without targeting social cognition specifically (Granholm et al., 2007; Kern et al., 2005; Park et al., 2011; Rus-Calafell et al., 2014; Seo et al., 2007). Given that social cognition contributes significant variance to models of functioning (Green et al., 2015), it brings to question whether social cognitive deficits have been indirectly addressed via these social skills training programs, or if social functioning can be substantially improved through skills training without ameliorating social cognitive deficits.

Targeted interventions hold much promise in improving social cognition, particularly in the domains of emotion processing and theory of mind. Improvement in emotion perception has been reported in 24 of the 31 studies, particularly in facial affect recognition. Most of these targeted interventions, such as TAR, attention shaping, METT, focus primarily on training affect recognition with good outcomes. Theory of Mind (ToM) is the second most commonly targeted domain, with SoCog-MSRT, MEB, ETIT and TOMI developed to provide effective in-depth training. While SCTP incorporates the social perception subprogram of IPT, social perception is usually addressed in programs that target multiple domains, such as SCST. Similarly, attributional style is only specifically targeted in SoCog-MSRT and MEB. Social perception and attributional style appear to be more difficult to measure and train, as evidenced by a meta-analysis that showed no significant effects on these two domains upon social cognitive training (Kurtz and Richardson, 2012). One possible explanation is that social perception is a complex construct and tends to be

culturally specific (Hong et al., 2003), which makes generalization of strategies difficult across various contexts for people with schizophrenia (Paquin et al., 2014). On the other hand, training to reduce attributional bias often emphasizes conscious, careful deliberation to avoid jumping to conclusions (Roberts and Velligan, 2012). Such skill in 'cognitive restructuring' is thus more challenging for people with schizophrenia to acquire, compared to emotion perception training which comprises drills and practice to achieve implicit learning and automation (Paquin et al., 2014; Roberts and Velligan, 2012). More research into enhancing training efficacy for these two social cognitive domains may be necessary.

Majority of the reviewed studies involved outpatients in remission, while a small number of them targeted patients experiencing early psychosis. It will be useful to compare the efficacy of social cognitive interventions with early psychosis patients against those with long duration of illness. There is also a dearth of studies that investigate treatment effects of targeted interventions beyond six months. With the exception of one study (Roberts et al., 2014), the other targeted intervention studies had sample sizes not exceeding 30 on each arm. Larger trials with longer follow up will be needed to ascertain treatment effects and treatment stability. There is also a need to determine optimum treatment frequency and duration for specific social cognitive domains, as well as generalizability of treatment to other domains and social functioning.

Oxytocin shows some promise as an adjunctive therapy to improve higher-order social cognition. However, further research is needed to better understand the relationship between dosing, duration and efficacy of intranasal oxytocin. It will be useful to explore the efficacy of augmenting existing social cognitive training programs with oxytocin, as well as its distal effects on social functioning. tDCS, as compared to pharmacology, has relatively fewer side effects and is tolerable, portable and inexpensive. More studies are needed to determine if it confers benefits beyond facial affect recognition.

Besides video clips, cartoon comic strips and photographs, computerized online social cognitive games and virtual reality have recently been utilized with high patient satisfaction (Nahum et al., 2014; Park et al., 2011; Rus-Calafell et al., 2014). As virtual reality was utilized primarily in skills training in the two studies, it will be useful to explore the possibility of harnessing this technology to train the four social cognitive domains. Home-based social cognitive intervention is also a novel approach which can benefit young adults who have poor compliance in clinic-based group interventions (Nahum et al., 2014). There may be potential in augmenting this program with a social group intervention, to enhance social functioning outcomes.

Meta-analyses on cognitive remediation found stronger treatment effects when neurocognitive remediation was provided as an adjunct to a psychiatric rehabilitation program (Mcgurk et al., 2007; Wykes et al., 2011). Cognitive remediation is now provided in clinical settings and included in clinical practice guidelines (Ministry of Health, 2011). It will be useful to investigate if social cognitive interventions should be routinely provided as part of a comprehensive psychiatric rehabilitation program.

There are a few limitations to our review. Firstly, non-English studies, as well as unpublished works and theses were not included. Secondly, there were only four studies from Asia, which limited the generalisability of findings to this region. As social cognitive domains are culturally specific, it is not known if all elements of social cognitive interventions developed in America and Europe can be applied successfully in the Asian context. Thirdly, the review did not study the impact of social cognitive interventions on other areas of functioning such as vocation and community independence, which have been shown to be amenable to social cognitive interventions (Kurtz and Richardson, 2012). Lastly, we are aware of new social cognitive programs that are currently being developed, such as the Cognitive Remediation of Social Cognition (RC2S) (Peyroux and Franck, 2014). However, there is no published data for inclusion at the point of this review.

5. Conclusion

Various types of social cognitive interventions have produced positive outcomes either on specific social cognitive domains or across domains. It is hoped that with SCOPE's recent efforts in evaluating a list of recommended social cognitive measurements (Pinkham et al., 2015), future studies will be able to adopt a standard battery of measurements for better outcome comparisons. There is also a need for more studies to measure intervention effects on real-world social functioning. In addition, there is potential in incorporating learning technique (i.e cognitive behavioral principles and errorless learning) and harnessing technology (i.e virtual reality and home-based online training) to improve distal outcomes of social competence and social functioning. Finally, further studies on the use of oxytocin are warranted, to affirm its treatment efficacy on higher-order social cognition.

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