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Efficacy of Social Cognitive Interventions on Improving Social Participation in Children with Autism Spectrum Disorder

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INTRODUCTION

Autism spectrum disorder (ASD) is a developmental disability that affects approximately 1 in 54 U.S. children.[1] Individuals with ASD demonstrate persistent impairments in social communication and interaction, including deficits in the following: social-emotional reciprocity, nonverbal communicative behaviors, and developing, maintaining and understanding relationships.[2] In addition, people with ASD may demonstrate repetitive behaviors and highly restricted interests, which may increase social difficulties.[2] Because social impairment is a defining feature of ASD, numerous strategies have been implemented to improve social skills and thereby, social participation in this population.

The evidence for current interventions addressing social skills with this population is mixed. Some studies of sensory-based interventions have demonstrated secondary effects of improving social interaction among children with ASD.[3] To date, most interventions have emphasized a behavioral approach to social skill development, such as modeling and reinforcement, but limited efficacy and poor generalization has been demonstrated with this approach.[4-7] Crooke et al. argue that this may be in part due to the fact that the majority of treatment approaches fail to address the cognitive aspect of social interactions and relatively few studies have explored the efficacy of treatments based on social cognition.[8]

Cognitive-based interventions are presently used by occupational therapists working with children with developmental coordination disorder, ASD, acquired brain injury, attention deficit hyperactivity disorder, and other conditions, in order to enable fine and gross motor skill development, organizational skills, and activities of daily living completion.[9-12] Social cognitive training programs, developed primarily by mental health and educational professionals to teach social skills to children with ASD, may have the potential for implementation in the field of occupational therapy to support social participation among this population. A previous systematic review examining a wide variety of occupational therapy interventions for children with ASD included a brief section on social cognitive skill training, concluding that these interventions had modest positive effects on social skill development.[13] To further explore this topic with up-to-date evidence, this current systematic review was conducted to examine the efficacy of social cognitive interventions to improve social participation in children with ASD.

TERMINOLOGY

Cognition: the ability to acquire and use information in order to adapt to environmental demands

Social cognitive skills: include recognizing the difference between oneself and others, recognizing others' emotions, collaborating, sharing episodic memory, taking perspectives and experiencing theory of mind, and feeling empathy

Social cognitive interventions: include breaking down various cognitive components of social participation and teaching skills related to these components with increasing complexity, skill building, and repetition.[14]

METHODS

An *a priori* protocol was developed prior to conducting this systematic review to increase its validity. The protocol is a step-by-step outline which includes the PICO question, search strategies for each electronic database, inclusion/

exclusion criteria, and search methodology. The protocol was developed by six collaborating reviewers and followed closely to identify, appraise, and synthesize all relevant published studies. Appendix A includes the PICO question (Table 1), a list of the databases searched (Table 2).

Identification of Relevant Studies:

A systematic search of all relevant studies was conducted in February and March 2020 using the following databases: CINAHL, ERIC, PsycINFO, and PubMed. All databases were searched manually. Search restriction included quantitative group studies published in English in peer-reviewed journals. Tables 3 and 4 of the protocol provide the search terms (i.e. combination of keywords and subject headings) used to conduct the search within each electronic database. Boolean sentences used for each database are shown in Table 5 .

To be included in this systematic review, studies retrieved during the search had to meet the following criteria: (1) the population must have been children diagnosed with ASD, Asperger's syndrome, or Pervasive Developmental Disorder – Not Otherwise Specified between ages 0-21 years old; (2) the primary means of intervention must be social cognitive skill training; and (3) the outcomes of the study were based on social participation. Table 6 of the protocol provides a complete list of inclusion and exclusion criteria. In order to ensure the third criteria was met in accordance with the treatment definition, outcomes of included articles were listed and evaluated. All outcomes included in this systematic review were further categorized into three primary outcome lists, as shown in ppendix . Studies whose implementers were caregivers, parents, or teachers were excluded to ensure the highest level of intervention fidelity.

Two independent reviewers searched each database and applied the inclusion/exclusion criteria to each study retrieved during the search. Inclusion criteria was first applied to the titles and abstracts of articles. When determination of the inclusion of an article was uncertain, reviewers applied the inclusion criteria to the full text of the article. The flowchart summarizes the results of t e searc and application of t e inclusion and exclusion criteria (ppendix). Each independent reviewer created a list of included articles per database, these were compared, and discrepancies were resolved through a consensus process with a third reviewer as needed. A final list of included articles across databases was created after all reviewers came to consensus.

Appraisal of Included Studies:

Through the database search, 1,255 research articles were identified, 38 of which re ained after exclusions ere identified according to title and abstract. An in-depth review of these 38 articles identified nine articles that met the full inclusion criteria, as shown in the flowchart (ppendix). Following protocol, two independent reviewers appraised each article with regard to quality evidence, using predetermined criteria relevant for the study level of evidence (ppendix). The two reviewers then compared their independent ratings of the quality of evidence for each study. Any discrepancies were resolved and a consensus was made without the use of a third reviewer. The quality of evidence table (ppendix) compiles the quality of methodology rating for each included study.

The two reviewers worked independently to summarize the objective information in each study to create a description table, and again came to a consensus (ppendix). The consensus table of the study description includes information regarding the study design type and quality level, the data's population, statistical and clinical significance, intervention, relevant outcomes and measurements, and means/standard deviations (ppendix). If there was no measure of clinical significance provided in the article, the minimally detectable difference (MDD) was calculated. Practice recommendations for clinicians were generated via a modified version of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) process.[15]

RESULTS

Of the nine included studies, seven were quasi-experimental studies that compared results before and after the intervention without use of a control group; one of these studies used two

participant groups and the other six used only one group. The remaining two studies were of the highest level of evidence: randomized controlled trials (RCT) in which subjects were randomly assigned to the treatment and control groups and data was collected before and after the intervention.

TERMINOLOGY

Level of Evidence: hierarchy of studies based on the type of study design[16]

Quality of Evidence: degree of rigor used in study methodology [15]

Effect Size: degree of difference between two interventions or the size of relationship between variables[16]

Minimally detectable difference: the degree of change that must take place to result in an actual difference[16]

As indicated in ppendix the nine included studies consisted of level I and level III evidence.[17] Four of the studies provided low quality evidence and five provided moderate quality evidence. The two RCTs were of level I evidence whereas the seven quasi-experimental studies were of level III evidence.

The interventions within the studies were multi-faceted and overlapping, prohibiting their categorization by intervention type. They included guided learning, coaching, scaffolding, role-playing, and mindfulness training. Instead, the studies have been categorized by outcome, according to the basic processes of neurobiology, as described by Adolphs.[18] In order to achieve social participation, a person must first perceive, then process, then act upon information. The included studies primarily measured change in the following three outcomes: (1) social perception, (2) social cognition, and (3) social behavior, all of which are outlined below.

Social Perception

Seven out of the nine studies evaluated the impact of the interventions on social perception, which includes overall social awareness and recognition of emotion, affect, facial expression, and humor. Of these seven studies, all presented with level III evidence. The studies ranged from low to moderate quality of evidence, with three being of moderate quality and four being of low quality. Fourteen measurement data points were collected and analyzed for statistical and clinical significance. Seven were statistically significant and nine were clinically significant. Eight assessments were used to evaluate social perception measures; seven of these were valid and reliable.

Social Cognition

All nine studies evaluated the impact of the interventions on social cognition, which included interpersonal problem solving (solutions generation), social attribution, executive function, analogical reasoning, metacognition, flexibility, and planning. Of the nine studies, two presented with level I evidence and seven presented with level III evidence. The studies ranged from low to moderate quality of evidence, with five being of moderate quality and four being of low quality. Fifty-four measurement data points were collected and analyzed for statistical and clinical significance. Thirty-six were shown to be statistically significant and 35 were shown to be clinically significant. Twelve of the 16 assessments used to evaluate social cognition measures were valid and reliable.

Social Behavior

Eight out of nine studies evaluated the impact of the intervention on social behavior, such as socialization, maladjusted behavior, interpersonal relationships, play, and behavior regulation. Of these eight studies, two presented with level I evidence, and six presented with level III evidence. The studies ranged from low to moderate quality of evidence, with four being of moderate quality and four being of low quality. Eighteen measurement data points were collected and analyzed for statistical and clinical significance. Fourteen were shown to be statistically significant and 14 were shown to be clinically significant. Five of the six assessments used to evaluate social behavior were valid and reliable.

SYSTEMATIC REVIEW LIMITATIONS

A large range of interventions may be considered social cognitive interventions, prompting the use of broad search terms. This strategy resulted in a high number of results in PsycNET; due to time limitations, only 500 articles were reviewed. As such, it is possible that not all the relevant evidence was found. In addition, the decision to exclude studies implemented by teachers, parents, or caregivers also limited the scope of this review.

PRACTICE RECOMMENDATIONS

All outcomes were evaluated using a modified GRADE system, which considered the level of evidence, quality of evidence, degree of clinical significance, and benefit/cost-burden ratio for each outcome.

Social Perception

Weak Recommendation

As there was a preponderance of Level III studies with positive results measuring this outcome, there is Grade C evidence supporting the use of social-cognitive interventions to improve social perception among children with ASD. The studies measuring this outcome were of low-moderate quality, and they demonstrated low clinical significance and low benefit/cost-burden ratio. Additional research with higher level evidence and higher quality design is needed.

Social Cognition

Weak Recommendation

With a preponderance of Level III studies, there is grade C evidence supporting the use of social cognitive interventions to improve social cognition among children with ASD. There is a preponderance of studies measuring this outcome that meet the moderate quality criteria, however, the studies show a low degree of clinical significance and low benefit/cost-burden ratio. More rigorous research is needed to determine the estimate of effect.

Social Behavior

Weak Recommendation

There is grade C evidence supporting the use of social cognitive interventions to improve social behavior among children with ASD, as there is a preponderance of Level III studies that measure this outcome. Although the studies demonstrated a moderate effect size and moderate benefit/cost-burden ratio, the studies' design and low-moderate quality signifies that higher quality research is needed to determine the estimate of effect.

CLINICAL IMPLICATIONS

The nine included studies in this systematic review evaluated the efficacy of social cognitive interventions in children with high-functioning autism on three outcomes. Overall, the majority of the studies indicate that there is low quality of evidence and low clinical significance to support the effectiveness of social cognitive interventions to improve social participation in children with ASD, making the potential burden and cost on families exceed the expected amount of benefits. Therefore, when considering social cognitive interventions to address social participation in children with ASD, clinicians should be aware of the limited available evidence and consider seeking alternative interventions. Further and more rigorous research should be conducted in order to determine the efficacy of social cognitive interventions on improving social participation in children with ASD.

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Appendix A
***A Priori* Protocol**

Table 1A

PICO Question

PICO question - Does cognitive skill training improve social participation in children with ASD?			
P - #1 children ages 0-21 with Autism Spectrum Disorder	**I - #2** Cognitive **#3** Intervention	**C -** n/a	**O -** Improved social participation

Table 2A

List of the Databases Searched

Databases Included in SR Search	**Planned the Search**		**Conducted the Search**	
	Person 1	**Person 2**	**Person 1**	**Person 2**
CINAHL	Carley	Amanda	Jenna	Anita
PubMed	Jenna	Anita	Steve	Tandi
PsycINFO	Steve	Tandi	Carley	Amanda
ERIC	Carley	Amanda	Tandi	Steve

Table 3A

List of Keywords – Same for All Databases

Facet 1- ASD	Facet 2 - Cognitive	Facet 3 - Intervention
- Asperger* - Autis* - "pervasive developmental disorder"	- metacognit* - cognit* - "problem solving" - coaching - "discovery learning" - "instrumental enrichment"	- training - intervention - strateg* - treatment* - therap* - habilitation - rehabilitation

Limiters:

CINAHL – Search keywords within abstracts; Peer review, English, Humans

PubMed – Search keywords within Title/Abstract, Sort by: Best Match, Filters: Humans; English

PsycINFO – search keywords within abstract; Filters: peer-reviewed journal articles, humans

ERIC – Search keywords within abstract; Filters: Peer-reviewed journal articles, English

Table 4A

List of Subject Headings

Database	Facet 1- ASD	Facet 2 - Cognitive	Facet 3 - Intervention	Limiters
CINAHL	Autistic disorder, Asperger Syndrome, Pervasive Developmental Disorder-Not Otherwise Specified	Bandura's Social Cognitive Theory	None were found	English, Peer-reviewed
PubMed	Child development disorders, pervasive	Cognitive remediation	None were found	English, Peer-reviewed, Journal articles, Humans; sort results by "best match"
PsycINFO	Autism Spectrum Disorders	Social Cognition	Intervention	Peer-reviewed Journal articles
ERIC via OVID	Autism, Asperger Syndrome, Pervasive Developmental Disorder	Social Cognition, Cognitive Restructuring	Intervention	English, Peer-reviewed, Journal articles

ERIC – You must go through OVID and select "ERIC." Select "Multi-field search," click the blue triangle next to "Limits" to expand that section and select limits. Search subject headings by using the dropdown "ERIC Subject Headings" and search keywords by using the dropdown "All Fields"

PsycINFO – Under "select databases" at the top, select PsycINFO only. To search subject headings, select "APA Thesaurus" in the main dropdown to reach "APA Thesaurus of Psychological Index Terms" page. Click on definition of desired term, and then select term to add to search. Click on "recent searches" drop down. This function provides the user to combine search terms.

PubMed – Under the "All Databases" dropdown menu at the top, select MeSH. If you are using the new PubMed website, there are two ways to get to MeSH. First option - click on "Advance" under the search bar. On the next page in "All Fields" dropdown menu, click on "MeSH Terms." Second option - on the main page, scroll down to the "Explore" icon, then select "MeSH Database" below. Click on "Advance" under search bar. On the next page on the "All Fields" dropdown menu, click on "MeSH Terms." Type and search your subject heading. Then click "Add to search builder" and "Search PubMed" on the right. For both the old and new PubMed website, search keywords by using the dropdown "All Fields."

CINAHL – Use Advanced Search to find limits. Using the dropdowns, choose "MH Exact Match Subject Heading" to search subject headings and "AB Abstract" to search keywords

Table 5A

Boolean Sentence for Each Database

Database Name	Boolean Sentence
CINAHL	(**Autistic disorder** OR **Asperger Syndrome** OR **Pervasive Developmental Disorder-Not Otherwise Specified** OR Asperger* OR Autis*OR "pervasive developmental disorder") AND (**Bandura's Social Cognitive Theory** OR metacognit*OR cognit* OR "problem solving" OR coaching OR "discovery learning" OR "instrumental enrichment") AND (training OR intervention OR strateg* OR treatment* OR therap* OR habilitation OR rehabilitation)
PubMed	(**Child development disorders, pervasive** OR Asperger* OR Autis* OR "pervasive developmental disorder") AND (**Cognitive remediation** OR metacognit* OR cognit* OR "problem solving" OR coaching OR "discovery learning" OR "instrumental enrichment") AND (training OR intervention OR strateg* OR treatment* OR therap* OR habilitation OR rehabilitation)
PsycINFO	(**Autism Spectrum Disorders** OR Autis* OR Asperger* OR "pervasive developmental disorder") AND (**Social Cognition** OR cognit* OR metacognit* OR "problem solving" OR coaching OR "discovery learning" OR "instrumental enrichment") AND (**Intervention** OR training OR intervention OR strateg* OR treatment* OR therap* OR habilitation OR rehabilitation)
ERIC	(**Autism** OR **Asperger Syndrome** OR **Pervasive Developmental Disorder** OR Asperger* OR Autis* OR "pervasive developmental disorder") AND (**Social Cognition** OR **Cognitive Restructuring** OR metacognit* OR cognit* OR "problem solving" OR coaching OR "discovery learning" OR "instrumental enrichment") AND (**Intervention** OR training OR intervention OR strateg* OR treatment* OR therap* OR habilitation OR rehabilitation)

***Bolded terms = subject headings**

Table 6A

Inclusion and Exclusion Criteria

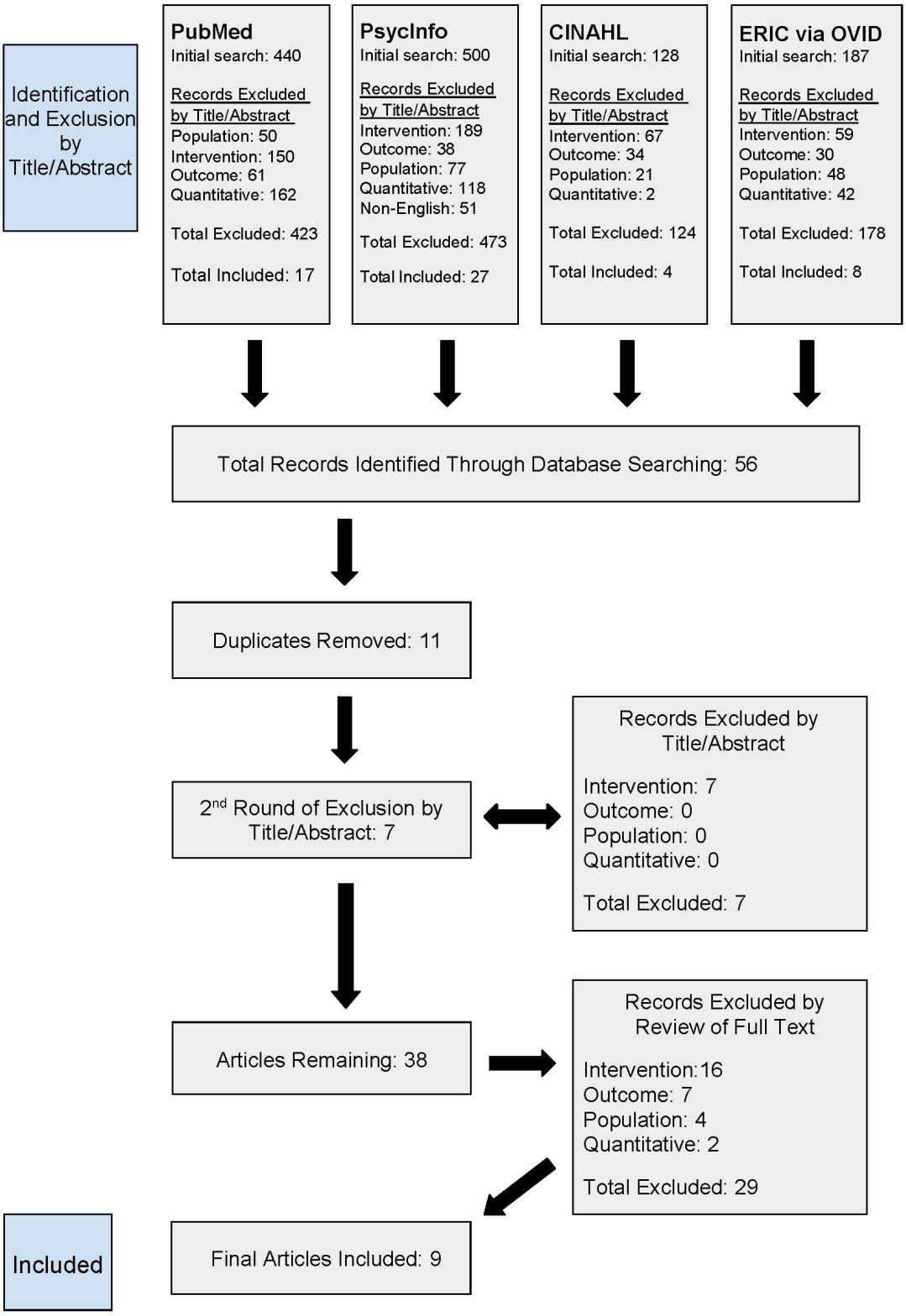
Inclusion Criteria			
Population	**Intervention and Comparison**	**Outcome**	**Other**
Autism Spectrum Disorder Asperger Syndrome PPD-NOS All levels of Autism Any gender Ages 0-21	Coaching Scaffolding Priming Discovery Learning Role playing Instrumental Enrichment Social problem-solving Cognitive orientation to (daily) occupational performance Self-management Social-cognitive training Metacognitive strategies	Social Participation, as defined by at least one of the following: Increased communication with others Increased attendance in social activities Increased prosocial behaviors, including: maintaining conversation eye contact turn taking orienting body to face peer initiating and ending conversations interpreting social cues and responding effectively maintaining socially accepted (i.e. arm's length) distance from others using effective approaches to join in activities generating or reciprocating effective facial expressions generating or reciprocating effective body language or gestures	All types of Quantitative intervention studies Peer-reviewed

Exclusion Criteria			
Population	**Intervention and Comparison**	**Outcome**	**Other**
Caregiver/ Parent/ Teacher training Caregiver/ Parent/ Teacher implemented/mediated	Social stories Social skills training without a cognitive component Video modeling Cognitive Behavioral Therapy Early Start Denver Model		Non-English language Non-human

Appendix B
Flowchart

Figure 1

Flowchart



Appendix C
Outcome Designations

Outcomes		
Social Perception	**Social Cognition**	**Social Behavior**
Social awareness	Interpersonal problem-solving ability	Socialization
Affect Recognition	Social cognition, abilities, attribution	Maladjusted behavior
Facial Expression	Theory of mind	Play
Emotion recognition	Executive function and metacognition	Interpersonal relationships
Perception	Analogical reasoning	Social communication
Humor	Flexibility and planning	Behavior regulation
Human relatedness	Making inferences and problem-solving	Social thinking
	Listening skills	
	First and second order beliefs	
	Understanding humor	

Appendix D
Quality and Level of Evidence Table

		Quality Criteria											
Citation	**Type of design**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Quality Level**	**Evidence Level**
Bonete et al., 2016[19]	#6 Quasi-experimental (2 groups pre/post)	0	1	0	0	1	1	1	1	N/A	N/A	Moderate	Level III
de Bruin et al., 2015[20]	#6 Quasi-experimental (1 group pre/post + f/u)	1	1	0	0	1	1	0	0	N/A	N/A	Moderate	Level III
Didehbani et al., 2016[21]	#6 Quasi-experimental (1 group pre/post)	1	1	0	0	1	0	0	1	N/A	N/A	Moderate	Level III
Gevers et al., 2016[22]	#6 Quasi-experimental (1 group pre/post)	0	1	0	0	1	0	0	0	N/A	N/A	Low	Level III
Kenworthy et al., 2014[23]	#3 RCT	0	0	1	1	1	0	0	0	0	1	Moderate	Level I
Lee et al., 2016[6]	#6 Quasi-experimental (1 group pre/post)	1	1	0	0	0	0	1	0	N/A	N/A	Low	Level III
Soorya et al., 2015[24]	#3 RCT	1	1	1	1	0	0	0	1	0	1	Moderate	Level I
Stichter et al., 2010[25]	#6 Quasi-experimental (1 group pre/post)	1	1	0	0	0	1	0	0	N/A	N/A	Low	Level III
Stichter et al., 2012[26]	#6 Quasi-experimental (1 group pre/post)	1	1	0	0	0	0	0	0	N/A	N/A	Low	Level III

Appendix E

Study Description: Included Studies

Study	Design Type, # Criteria, Quality	Population n per group Treatment/ Control	Outcome(s)	Measurement (include units)	Means and (Standard Distributions)	Statistical significance * p≤.05, **p≤.001	Clinical significance * denotes significance
Bonete et al., 2016[19]	6 – Quasi 2 group pre/post 4/8 Moderate	Study 1 **n**=22 **Age:** 7-12 **Sex:** 21M 1F **Dx:** Aspergers Study 2 **n**=15 **Age:** 7-12 **Sex:** 12M 3F **Dx:** Aspergers Interpersonal Problem-Solving Skills Programme for Children No comparison	**1.** interpersonal relations play/leisure time coping **2.** internalized and externalized maladjusted bx **3.** emotion recognition **4.** causes attribution (for interpersonal problems) **5.** solutions generation (for interpersonal problems) **6.** interpersonal problem-solving ability (total)	**1. VABS - Socialisation subscale** 0-124; >= improved socialization ‡ **2. VABS - Maladaptive Behavior subscale** 0-44; < = less maladaptive behavior ‡ **3. ESCI** : **Emotion recognition subscale** (ESCI-E) † **4.ESCI: Causes attribution** subscale (ESCI-C) **5. ESCI: Solutions subscale** (ESCI-S) **6. ESCI: Total** (ESCI-T) ‡ Based on VABS-III; VABS-II not available † Could not find scoring information	**1. S1** Pre:128.09 (10.35) Post: 133.41 (11.35) **S2** Pre: 119.07 (11.37) Post: 126.33 (12.86) **2. S1** Pre: 24.22 (8.22) Post: 18.00 (8.03) **S2** Pre: 29.33(12.83) Post: 24.73 (9.81) **3. S1** Pre: 12.81 (2.70) Post: 12.95 (2.77) **S2** Pre: 13.40 (2.53) Post: 14.07 (1.87) **4. S1** Pre: 36.55 (6.79) Post: 37.09 (6.80) **S2** Pre: 35.20 (7.61) Post: 37.40 (5.88) **5. S1** Pre: 8.77 (3.43) Post: 9.81 (2.72) **S2** Pre: 9.07 (1.83) Post: 9.40 (1.55) **6. S1** Pre: 58.14 (11.53) Post: 59.86 (10.27) **S2** Pre: 58.00 (8.85) Post: 60.87 (8.31)	**1. S1** p=.04* **S2** p=.01* **2. S1** p=.002* **S2** p=.04* **3. S1** p=.88 **S2** p=.88 **4. S1** p=.22 **S2** p=.16 **5. S1** p=.02* **S2** p=.56 **6. S1** p=.04* **S2** p=.09	**1. S1** r=.30* **S2** r=.46* **2. S1** r=.47* **S2** r=.37* **3. S1** r=.02 **S2** r=.03 **4. S1** r=.18* **S2** r=.26* **5. S1** r=.34* **S2** r=.11* **6. S1** r=.30* **S2** r=.31*
de Bruin et al., 2015[20]	6 – Quasi 1 group pre/post w/ f/u 4/8 Moderate	**n**=23, **Age:** 11-23 **Sex:** 17 M 6F **Dx:** Aspergers, ASD, or PDD-NOS Mymind: Mindfulness training for Youth with ASD No comparison	**1.** Social abilities	**6a. SRS Total** (> = poorer) **6b. SRS Social Awareness** **6c. SRS Social Cognition** **6d. SRS Social Communication** **6e. SRS Social Motivation**	**6a.** Post: 0.01, f/u: -0.33 **6b.** Post: -0.02, f/u: -0.14 **6c.** Post: 0.10, f/u: -0.17 **6d.** Post: -0.07, f/u: -0.40 **6e.** Post: -0.08, f/u: -0.23	**6a.** Post: N.G. f/u: p<.001** **6b.** Post: N.G. f/u: N.G. **6c.** Post: p<.10 f/u: p<.01* **6d.** Post: N.G. f/u: p<.001** **6e.** Post: N.G. f/u: p<.10	**6a.** Post: d= .01 f/u: d= -.33* **6b.** Post: d= -.02 f/u: d= -.14 **6c.** Post: d= .10 f/u: d= -.17 **6d.** Post: d= -.07 f/u: d= -.40* **6e.** Post: d= -.08 f/u: d= -.23*
Didehbani et al., 2016[21]	6 – Quasi 1 group pre/ post 4/8 Moderate	**n**=30, **Age:** 7-16 **Sex:** 26M 4F **Dx:** n=17 ASD n=13 ADHD+ASD **Other:** average or higher IQ Real-time feedback from the "coach" clinician. No comparison	**1.** Affect recognition (AR) **2.** Social attribution/ theory of mind **3.** Executive function **4.** Analogical Reasoning	**1a. NEPSY-II Affect Recognition:** 1-19, >=better AR **1b. Ekman60:** 0-60, > = better AR **2a. Triangles** Total: 0-36, >=better social attribution **2b.** Intentionality **3a. NEPSY-II Auditory Attention (AA)** **3b. NEPSY-II Response Test (RT)** 1-19, >=better executive function **4. Fluid Reasoning - Analogical Reasoning Task (ART)** 0-24, >=better executive function	**1a.** Pre 8.9 (2.6), Post 10.4 (2.1) **1b.** Pre 38.9 (6.6), Post 40.8 (5.8) **2a.** Pre 18.5 (3.1) 19.6, Post (3.2) **2b.** Pre 11.5 (3.3), Post 13.3 (3.5) **3a.** Pre 7.9 (4.6) Post 8.7 (4.2) **3b.** Pre 8.3 (2.6) Post 9.5 (2.9) **4.** Pre 81.2 (11.9), Post 85.7 (11.1)	**1a.** p=.001** **1b.** p=.046* **2a.** p=.033* **2b.** p=.016* **3a.** p=.248 **3b.** p=.132 **4.** p=.016*	**1a.** 1.5>1.3* **1b.** 1.9<3.3 **2a.** 1.1<1.55 **2b.** 1.8>1.65* **3a.** 0.8<2.3 **3b.** 1.2<1.3 **4.** 4.5<5.95 (MDD)

Gevers et al., 2006[22]	6 – Quasi 1 group pre/ post 2/10 Low	**n**=18 **Age:** 8-11 **Sex:** 13M 5F **Dx:** PDD-NOS **Other:** verbal IQ 85 Theory of Mind training No comparison	**1a.** perception & imitation; pretense; recognition of emotions; distinction physical–mental **1b.** first order belief, understanding false belief **1c.** second order belief, understanding humor **2.**Socialization - Interpersonal relationships, Play/leisure and Social skills	**1. TOM Test** - (0-72, >=better TOM) **1a. TOM 1, 1b. TOM 2, 1c. TOM 3, 1d. Total TOM** **2. VABS - Socialisation** **2a. Interpersonal relationships** **2b. Play/Leisure** **2c. Social Skills**	**1a.** Pre 18.4 (2.4), Post 20.9 (1.2) **1b.** Pre 27.0 (4.8), Post 32.3 (3.0) **1c.** Pre 7.7 (2.4), Post 9.5 (1.9) **1d.** Pre 52.8 (7.8), Post 62.7 (5.2) **2a.** Pre 0.36 (0.09), Post 0.42 (0.14) **2b.** Pre 0.39 (0.10), Post 0.47 (0.10) **2c.** Pre 0.51 (0.13), Post 0.61 (0.15)	**1a.** p=.000** **1b.** p=.001** **1c.** p=.001** **1d.** p=.000** **2a.** p=.021* **2b.** p=.013* **2c.** p=0.000**	**1a.** 2.5>1.2* **1b.** 5.3>2.4* **1c.** 1.8>1.2* **1d.** 9.9>3.9* **2a.** 0.06>0.045* **2b.** 0.08>0.05* **2c.** 0.1>0.065* (MDD)
Kenworthy et al., 2014[23]	3 – RTC 4/10, Moderate	**n T**=47 (10 schools) **n C**=20 (4 schools) **Age:** 7-11 **Sex:** all male **Dx:** PDD, ASD Unstuck and On Target (**UOT**) Comparison: Social Skills (**SS**)	**1.** Problem-solving **2.** Flexibility, Planning, & Social Appropriateness **3.** Executive Functioning Shift, Plan/Organize **4.** Executive Functioning Shift, Plan/Organize **5.** ASD-related social, communication, and repetitive bx **6.** ASD-related social, communication, and repetitive bx	**1. WASI block design** (> = better performance) **2. Challenge Task** (> = more impairment) **2a. Flexibility, 2b. Plan, 2c. Social** **3. BRIEF - Teacher Rated** (> = more impaired) **3a. EF Shift,** **3b. Plan/Organize** **4. BRIEF - Parent Rated** **4a. EF Shift,** **4b. Plan/Organize** **5. SRS - Teacher Rated** **6. SRS - Parent Rated**	**1.** UOT: 3.00 (1.03), SS: -0.94 (1.11) **2a.** UOT: -0.53 (0.07), SS: -0.15 (0.14) **2b.** UOT: -0.33 (0.07), SS: -0.22 (0.06) **2c.** UOT: 0.47 (0.16), SS: 0.26 (0.30) **3a.** UOT: -24.00 (3.30), SS: -9.78 (3.59) **3b.** UOT: -19.14 (2.39) SS: -11.72 (3.16) **4a. Shift** UOT: -9.56 (2.31), SS: -0.16 (2.99) **4b. Plan/Org** UOT: -5.17 (2.0), SS: 0.61 (2.90) **5. SRS Teacher Rated (TR):** UOT: -5.4 (1.34) SS: -4.79 (2.05) **6. SRS Parent Rated (PR):** UOT: -7.31 (1.65), SS: -4.11 (2.97)	**1.** p<.05* **2a.** p<.05* **2b.** N.G. **2c.** N.G **3a.** p<.01* **3b.** p<.05* **4a.** p<.01* **4b.** p<.05* **5.** N.G. **6.** N.G.	**1.** d= 0.65* **2a.** d= -0.72* **2b.** d= -0.27* **2c.** d= 0.17* **3a.** d= -0.89* **3b.** d= -0.57* **4a.** d= -0.66* **4b.** d= -0.45* **5.** d = -0.08 **6.** d = -0.28*
Lee et al., 2016[6]	6 – Quasi 1 group pre/post 3/8 Low	**n**=39 **Age:** 12 -15 yo **Sex:** 30M 9F **Dx:** 33 with ASD 6 without ASD (all had social communication impairments) Social Thinking Training No comparison	**1.** Social thinking - Overall **2.** Initiation **3.** Listening with Eyes/Brain **4.** Abstract & Inferential Language **5.** Understanding Perspective **6.** Gestalt Processing **7.** Humor and Human Relatedness	**1.Social Thinking ILAUGH Rating Scale** **2. Initiation Subscale** **3. Listening with Eyes/Brain Subscale** **4. Abstract and Inferential Language Subscale** **5. Understanding Perspective Subscale** **6. Gestalt Processing Subscale** **7. Humor and Human Relatedness** All scores 1-5, >= greater frequency of prosocial bx)	**1.** pre m =2.74 (.56), post m= 3.14 (.48) **2.** pre m = 2.87 (.85), post m = 3.28 (.77) **3.** pre m= 2.70 (.69), post m = 3.21 (.63) **4.** pre m= 2.68 (.76), post m = 3.07 (.69) **5.** pre m = 2.72 (.66), post m = 3.15 (.57) **6.** pre m = 2.70 (.69), post m = 3.06 (.54) **7.** pre m = 3.14 (.67), post m = 3.24 (.62)	**1.** p<.001** **2.** p<.001** **3.** p<.001** **4.** p<.001** **5.** p<.001** **6.** p<.001** **7.** p=.217	**1.** d = .50* **2.** d = .72* **3.** d = .52* **4.** d = .67* **5.** d = .57* **6.** d = .14 **7.** d = .72*

Soorya et al., 2015[24]	3 – RCT 6/10 Moderate	**n T**=35, **n C**=34 **Age:** 8-11 **Sex:** 19M 1 F **Dx:** ASD and a verbal IQ of 70 Treatment (T): Seaver-NETT (Nonverbal communication, Emotion recog-nition, and Theory of mind Training) Comparison (C): Child-directed play "stations". Use of reflective state-ments to foster communication.	**1.** Social cognition **2.** Social behavior	**1a. Social Cognition Composite** **1b. DANVA2** (> = greater ability) **1c. Strange Stories Task (SST),** 0-12, >=more social cognition **1d. Reading the Mind in the Eyes Test (RMET)** 5-25, (> = greater ability to interpret mental states from facial cues) **2a. Social Behavior Composite,** <=better social behavior **2b. Griffith Empathy Measure (GEM),** 65-185, >=better social behavior **2c. SRS** **2d. Children's Communication Checklist–2 (CCC),** 0-18, >=better social behavior	**1a. Tx** Pre: 0.15 (0.84), Post: 0.27 (0.92) **C** Pre: -.14 (0.78), Post: -.02 (0.76) **1b. Tx** Pre: 84.53 (11.89), Post: 87.58 (13.51) **C** Pre: 80.08 (12.74), Post: 81.97 (11.88) **1c. Tx** Pre: 6.00 (3.08), Post: 6.06 (3.05) **C** Pre: 5.17 (2.76), Post: 5.76 (2.37) **1d. Tx** Pre: 17.03 (3.88), Post: 17.58 (4.44) **C** Pre: 16.08 (4.6), Post: 16.03 (4.58) **2a. Tx** Pre: 0.04 (1.00), Post: 0.34 (0.64) **C** Pre: 0.05 (0.70), Post: -0.01 (0.73) **2b. Tx**Pre: 129.67 (25.81), Post: 132.72 (24.31) **C** Pre: 123.62 (19.28), Post: 123.96 (20.55) **2c. Tx** Pre: 9.34 (4.55), Post: 7.69 (3.06) **C** Pre: 9.58 (3.02), Post: 9.22 (3.58) **2d. Tx** Pre: 10.03 (4.78), Post: 8.88 (3.84) **C** Pre: 10.07 (3.54), Post: 9.96 (3.46)	For all measures p <.05 NETT Social Bx p = .04 No significant effect on the social cognition composite No significant interaction effect at follow-up on social behavior (p=.38) or social cognition composites (p=.79).	**1a.** d = 0.56 **2a.** d =0.88 Cohen's d n.g.for other assessments
Stichter et al., 2010[25]	6 – Quasi 1 group pre/post 3/8 Low	**n**=27 **Age:** 10.83–14.75 **Sex:** all male **Dx:** ASD, PDD-NOS, Aspergers Social Competence Intervention – Adolescent (SCI-A) No comparison	**1.** Social abilities **2.** Executive functioning, behavioral regulation, metacognition **3.** Executive functioning, making inferences, and problem-solving **4.** Facial expression recognition **5.** Facial expression and emotions recognition **6.** Theory of mind	**1a. SRS Total** **1b. Social awareness (SA)** **1c. Social Cognition (SCog)** **1d. Social communication (SComm)** **1e. Social Motivation (SM)** **1f. Autistic mannerisms (AM)** **2a. BRIEF Global Executive (GE)** **2b. Behavioral Regulation (BR)** **2c. Metacognition (MC)** **3a. TOPS total** (> = stronger abilities) **3b. Making Inferences (MI)** **3c. Problem Solving (PS)** **4. DANVA** **5. RMET** **6. Faux Pas Stories (FPS):** (10 short narratives) (> = greater accuracy of faux pas identification	**1a.** Pre: 107.4 (18.5), Post: 85.4 (16.7) **1b.** Pre: 13.0 (3.0), Post: 11.2 (3.1) **1c.** Pre: 20.1 (3.4), Post: 15.7 (3.7) **1d.** Pre: 35.4 (7.9), Post: 29.1 (7.5) **1e.** Pre: 16.2 (5.6), Post: 12.9 (3.4) **1f.** Pre: 21.6 (5.6), Post: 16.4 (5.1) **2a.** Pre: 72.9 (8.2), Post: 67.1 (8.0) **2b.** Pre: 76.6 (8.7), Post: 68.7 (8.4) **2c.** Pre: 69.4 (11.4), Post: 64.0 (8.9) **3a.** Pre: 89.4 (16.8), Post: 95.8 (15.2) **3b.** Pre: 90.0 (18.4), Post: 95.8 (16.4) **3c.** Pre: 90.7 (18.7), Post: 96.6 (15.2) **4.** Pre: 19.5 (2.2), Post: 20.7 (1.8) **5.** Pre: 17.3 (3.4), Post: 18.5 (3.8) **6.** Pre: 8.5 (1.5), Post: 9.0 (1.1)	**1a.** p <.001** **1b.** p <.01* **1c.** p<.001** **1d.** p <.001** **1e.** p <.01* **1f.** p <.001* **2a.** p <.001** **2b.** p <.001** **2c.** p <.001** **3a.** p<.001** **3b.** p < .05* **3c.** p < .05* **4.** p<.05* **5.** p <.05* **6.** p <.05*	**1a.** SRS Total **1b.** SA* **1c.** SCog* **1d.** SCom* **1e.** SM* **1f.** AM* **2a.** BRIEF GE* **2b.** BR* **2c.** MC **3a.** TOPS Total **3b.** MI **3c.** PS **4.** DANVA* **5.** RME **6.** FPS MDD Calculated Using SD

Stichter et al., 2012[26]	6 – Quasi 1 group pre/ post 2/8 Low	**n**=20 **Age:** 6-10 **Sex:** 19M 1 F **Dx:** Autism, Aspergers, PDD-NOS, ASD (not specified) Social Competence Intervention – Elementary (SCI-E) No Comparison	**1.** Social abilities	**1a. SRS - Parent Rated** **1b. Social awareness (SA)** **1c. Social Cognition (SCog)** **1d. Social communication (SCom)** **1e. Social Motivation (SM)** **1f. Autistic mannerisms (AM)** **1g. SRS - Teacher Rated** **1h. Social awareness (SA)** **1i. Social Cognition (SCog)** **1j. Social communication (SCom)** **1k. Social Motivation (SM)** **1l. Autistic mannerisms (AM)**	**1a.** Pre 95.75 (24.42), Post 77.40 (24.99) **1b.** Pre: 12.65 (3.63), Post: 11.45 (3.53) **1c.** Pre: 18.20 (5.76), Post: 14.70 (8.80) **1d.** Pre: 33.60 (8.86), Post: 27.00 (7.91) **1e.** Pre: 13.85 (5.72), Post: 10.40 (5.76) **1f.** Pre: 17.55 (6.90), Post: 13.85 (5.71) **1g.** Pre: 73.94 (29.03), Post: 62.72 (24.96) **1h.** Pre: 9.33 (4.00), Post: 8.11 (2.91) **1i.** Pre: 12.78 (5.11), Post: 11.39 (4.94) **1j.** Pre: 26.50 (10.55), Post: 22.28 (9.61) **1k.** Pre: 11.78 (5.69), Post: 9.44 (4.62) **1l.** Pre: 13.56 (7.18), Post: 11.50 (6.08)	**1a.** p<.001** **1b.** p < .05* **1c.** p<.001** **1d.** p<.001** **1e.** p <.001** **1f.** p <.01* **1g.** p < 0.05* **1h.** N.G. **1i.** N.G. **1j.** p<.05* **1k.** p<.05* **1l.** p<.05*	**1a.** d= 0.75* **1b.** d= 0.33* **1c.** d= 0.61* **1d.** d= 0.74* **1e.** d= 0.60* **1f.** d= 0.54* **1g.** d= 0.39* **1h.** d= 0.31* **1i.** d= 0.27* **1j.** d= 0.40* **1k.** d= 0.41* **1l.** d= 0.29*
			2. Executive functioning	**2a. BRIEF-GE** **2b. Behavioral Regulation (BR)** **2c. Metacognition (MC)**	**2a.** Pre: 66.37 (13.47), Post: 61.68 (11.94) **2b.** Pre: 65.05 (14.54), Post: 61.74 (13.27) **2c.** Pre: 69.4 (11.4), Post: 64.0 (8.9)	**2a.** p<.01* **2b.** p<.05* **2c.** p<.01*	**2a.** d= 0.35* **2b.** d= 0.23* **2c.** d= 0.42*
			3. Executive functioning and problem solving	**3a. TOPS Total** **3b. Making Inferences (MI)** **3c. Problem Solving (PS)** **3d. Sequencing (SQ)** **3e. Negative Questions (NQ)** **3f. Predicting (PD)** **3g. Determining Cause (DC)**	**3a.** Pre: 80.80 (18.40), Post: 83.65 (19.90) **3b.** Pre: 84.25 (20.83), Post: 84.25 (19.76) **3c.** Pre: 85.55 (18.02), Post: 89.35 (16.83) **3d.** Pre: 83.70 (19.06), Post: 88.60 (17.73) **3e.** Pre: 81.50 (16.39), Post: 83.75 (15.64) **3f.** Pre: 77.85 (18.36), Post: 84.05 (20.47) **3g.** Pre: 82.45 (15.04), Post: 84.35 (19.55)	**3a.** N.G. **3b.** N.G. **3c.** N.G. **3d.** p< .05* **3e.** N.G. **3f.** N.G. **3g.** N.G.	**3a.** d= 0.15 **3b.** d= 0.00 **3c.** d= 0.21* **3d.** d= 0.26* **3e.** d= 0.14 **3f.** d= 0.34* **3g.** d= 0.69*
			4. Facial expression recognition	**4. DANVA**	**4.** Pre 16.63 (4.00), Post 16.89 (4.49)	**4.** N.G.	**4.** d= 0.07
			5. Facial expression and emotions recognition	**5. RMET**	**5.** Pre: 14.90 (4.20), Post: 15.45 (3.35)	**5.** N.G.	**5.:** d= 0.13
			6. Theory of mind	**6. Faux Pas Stories (FPS)** (> = better)	**6.** Pre: 5.20 (3.65), Post: 6.65 (3.42)	**6.** p<.01*	**6.** d= 0.40*

Key: **BRIEF:** Behavior Rating Inventory of Executive Function, **Bx:** Behaviors, **CCC:** Children's Communication Checklist – 2, **DANVA2:** Diagnostic Analysis of Nonverbal Accuracy**, ESCI:** Evaluation for the Solutions to Interpersonal Conflicts, **FPS:** Faux Pas Stories, **GEM:** Griffith Empathy Measure, **ILAUGH:** Social Thinking ILAUGH Rating Scale, **NEPSY-II, ART:** Analogical Reasoning Task, **RMET:** Reading the Mind in the Eyes Test, **SB:** Social Behavior, **SBC:** Social Behavior Composite, **SC**: Social Cognition, **SCC:** Social Cognition Composite, **Seaver-NETT**: Nonverbal communication, Emotion recognition, and Theory of mind Training, **SP:** Social Perception, **SRS:** Social Responsiveness Scale, **SST:** Strange Stories Task, **ToM:** Theory of Mind Test**, WASI:** WASI Block Design, **TOPS:** Test of Problem Solving, **VABS:** Vineland Adaptive Behavior Scale

According to Cohen (1988), the effect size is low if the value of *r* varies around 0.1, medium if r varies around 0.3, and large if more than 0.5.[19]
Cohen d is used to measure the size of effect. Small effect d = .2, medium effect d = .5, and large effect d = .8.