ERABI

EVIDENCE-BASED REVIEW of moderate to severe ACQUIRED BRAIN INJURY

COGNITIVE COMMUNICATION

POST ACQUIRED BRAIN INJURY

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Conflict of Interest

In the context of ERABI development, the term "conflict of interest" (COI) refers to situations in which an author or ERABI staff member's financial, professional, intellectual, personal, organizational or other relationships may compromise their ability to independently conduct this evidence-based review. No limiting conflicts were identified.

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Greetings from Dr. Robert Teasell,

Professor and Chair-Chief of Physical Medicine and Rehabilitation

The Collaboration of Rehabilitation Research Evidence (CORRE) team is delighted to present the Evidence-Based Review of moderate to severe Acquired Brain Injury (ERABI) *Cognitive Communication Post Acquired Brain Injury.* Through collaboration of researchers, clinicians, administrators, and funding agencies, ERABI provides an up-to-date review of the current evidence in brain injury rehabilitation. ERABI synthesizes the research literature into a utilizable format, laying the foundation for effective knowledge transfer to improve healthcare programs and services.

We offer our heartfelt thanks to the many stakeholders who are able to make our vision a reality. Firstly, we would like to thank the Ontario Neurotrauma Foundation, which recognizes ERABI's capacity to lead in the field of brain injury evidence-based reviews and is committed to funding it. We would also like to thank the co-chairs of ERABI, Dr. Mark Bayley (University of Toronto) and Dr. Shawn Marshall (University of Ottawa) for their invaluable expertise and stewardship of this review. Special thanks to the authors for generously providing their time, knowledge and perspectives to deliver a rigorous and robust review that will guide research, education and practice for a variety of healthcare professionals. We couldn't have done it without you! Together, we are building a culture of evidence-based practice that benefits everyone.

We invite you to share this evidence-based review with your colleagues, patient advisors that are partnering within organizations, and with the government agencies with which you work. We have much to learn from one another. Together, we must ensure that patients with brain injuries receive the best possible care every time they require rehabilitative care – making them the real winners of this great effort!

Robert Teasell, MD FRCPC

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PREFACE

About the Authors

ERABI is internationally recognized and led by a team of clinicians and researchers with the goal of improving patient outcomes through research evidence. Each ERABI module is developed through the collaboration of many healthcare professionals and researchers.

Dr. Shawn Marshall is a physician specializing in Physical Medicine and Rehabilitation (Physiatrist). He is the Division Head of Physical Medicine and Rehabilitation at the University of Ottawa and The Ottawa Hospital where he manages both in-patients and out-patient clinics for patients with concussion to severe traumatic brain injury. Dr. Marshall has a Master's degree in Clinical Epidemiology and is a Full Professor at the University of Ottawa in the Department of Medicine.

Amber Harnett, MSc, RN (candidate), CNF scholar, completed her MSc in pathology at Western University and is currently a first-year nursing student in the accelerated BScN program at Western University. Passionate about supporting and advocating for those with brain injuries, she also works as a research coordinator to improve the rehabilitation system through research synthesis, guideline development, knowledge translation, education and outreach, in the CORRE lab at Parkwood Institute.

Penny Welch-West has been working as a Speech-Language Pathologist since 1998 and enjoys a very varied practice ranging from Rehabilitation through Complex/Continuing and Palliative Care. This work includes teaching, assessment and treatment in the areas of dysphagia (swallowing), voice, articulation, language, cognitive-communication and Augmentative and Alternative Communication (AAC).

Shannon Janzen, MSc, is a research associate and the project coordinator for the Evidence-Based Review of Acquired Brain Injury (ERABI). Her research interests focus on the integration of best evidence into clinical practice to optimize patient outcomes, with an emphasis on knowledge translation initiatives.

Dr. Robert Teasell is Professor of Physical Medicine and Rehabilitation, Schulich School of Medicine and Dentistry, Western University and a Clinical Researcher at Lawson Research Institute in London, Ontario. He is a clinician at Parkwood Institute, St. Joseph's Health Care London.

Purpose

The Evidence-Based Review of Acquired Brain Injury (ERABI) is a systematic review of the rehabilitation literature of moderate to severe acquired brain injuries (ABI). It is an annually updated, freely accessible online resource that provides level of evidence statements regarding the strength of various rehabilitation interventions based on research studies. The ERABI is a collaboration of researchers in London, Toronto and Ottawa. Our mission is to improve outcomes and efficiencies of the rehabilitation system through research synthesis, as well as from providing the foundational research evidence for guideline development, knowledge translation, and education initiatives to maximize the real-world applications of rehabilitation research evidence.

Key Concepts

Acquired Brain Injury

For the purposes of this evidence-based review, we used the definition of ABI employed by the Toronto Acquired Brain Injury Network (2005). ABI is defined as damage to the brain that occurs after birth and is not related to congenital disorders, developmental disabilities, or processes that progressively damage the brain. ABI is an umbrella term that encompasses traumatic and non-traumatic etiologies.

TABLE 1 | Defining Acquired Brain Injury

Included in ABI definition	Excluded from ABI definition
Traumatic Causes • Motor vehicle accidents • Falls • Assaults • Gunshot wounds • Sport Injuries **Non-traumatic Causes** • Tumours (benign/meningioma only) • Anoxia • Subarachnoid hemorrhage (non-focal) • Meningitis • Encephalitis/encephalopathy (viral, bacterial, drug, hepatic) • Subdural Hematoma	**Vascular and Pathological Incidents** • Intracerebral hemorrhage (focal) • Cerebrovascular accident (i.e., stroke) • Vascular accidents • Malignant/metastatic tumours **Congenital and Developmental Problems** • Cerebral Palsy • Autism • Developmental delay • Down's syndrome • Spina bifida with hydrocephalus **Progressive Processes** • Alzheimer's disease • Pick's disease • Dementia • Amyotrophic Lateral Sclerosis • Multiple Sclerosis • Parkinson's disease • Huntington's disease

Given that 'ABI' can have multiple definitions, studies with an 'ABI' population can be equally heterogeneous in terms of the sample composition. Such studies may include any combination of persons with TBI, diffuse cerebrovascular events (i.e., subarachnoid hemorrhage) or diffuse infectious disorders (i.e., encephalitis or meningitis). The vast majority of individuals with ABI have a traumatic etiology; therefore, much of the brain injury literature is specific to TBI. The terms ABI and TBI have been used intentionally throughout ERABI to provide more information about populations where relevant.

Moderate to Severe Brain Injury

ABI severity is usually classified according to the level of altered consciousness experienced by the patient following injury (Table 2). The use of level of consciousness as a measurement arose because the primary outcome to understand the severity of an injury is the Glasgow Coma Scale. Consciousness levels following ABI can range from transient disorientation to deep coma. Patients are classified as having a mild, moderate or severe ABI according to their level of consciousness at the time of initial assessment. Various measures of altered consciousness are used in practice to determine injury severity. Common measures include the Glasgow Coma Scale (GCS), the duration of loss of consciousness (LOC), and the duration of post-traumatic amnesia (PTA). Another factor used to distinguish moderate and severe brain injury is evidence of intracranial injury on conventional brain imaging techniques which distinguish severity of injury from a mild or concussion related brain injury.

TABLE 2 | Defining Severity of Traumatic Brain Injury, adapted from Veterans Affairs Taskforce (2008) and Campbell (2000)

Criteria	Mild	Moderate	Severe	Very Severe
Initial GCS	13-15	9-12	3-8	Not defined
Duration LOC	< 15minutes*	<6 hours	6-48 hours	>48 hours
Duration PTA	< 1hour*	1-24 hours	1-7 days	>7 days
	*This is the upper limit for mild traumatic brain injury; the lower limit is any alteration in mental status (dazed, confused, etc.).			

Methods

An extensive literature search using multiple databases (CINAHL, PubMed/MEDLINE, Scopus, EMBASE, and PsycINFO) was conducted for articles published in the English language between 1980–March 2020 that evaluate the effectiveness of any intervention/treatment related to ABI. The references from key review articles, meta-analyses, and systematic reviews were reviewed to ensure no articles had been overlooked. For certain modules that lacked research evidence the gray literature, as well as additional databases, were searched in order to ensure the topic was covered as comprehensively as possible.

Specific subject headings related to ABI were used as the search terms for each database. The search was broadened by using each specific database's subject headings, this allowed for all other terms in the database's subject heading hierarchy related to ABI to also be included. The consistent search terms used were "head injur*", "brain injur*", and "traumatic brain injur*". Additional keywords were used specific to each module. A medical staff librarian was consulted to ensure the searches were as comprehensive as possible.

Every effort was made to identify all relevant articles that evaluated rehabilitation interventions/ treatments, with no restrictions as to the stage of recovery or the outcome assessed. For each module, the individual database searches were pooled, and all duplicate references were removed. Each article title/abstract was then reviewed; titles that appeared to involve ABI and a treatment/intervention were selected. The remaining articles were reviewed in full.

Studies meeting the following criteria were included: (1) published in the English language, (2) at least 50% of the study population included participants with ABI (as defined in Table 1) or the study independently reported on a subset of participants with ABI, (3) at least three participants, (4) ≥50% participants had a moderate to severe brain injury (as defined in Table 2), and (5) involved the evaluation of a treatment/intervention with a measurable outcome. Both prospective and retrospective studies were considered. Articles that did not meet our definition of ABI were excluded.

Interpretation of the Evidence

The levels of evidence (Table 3) used to summarize the findings are based on the levels of evidence developed by Sackett et al. (2000). The levels proposed by Sackett et al. (2000) have been modified; specifically, the original ten categories have been reduced to five levels. Level 1 evidence pertains to high quality randomized controlled trials (RCTs) (PEDro ≥6) and has been divided into two subcategories, level 1a and level 1b, based on whether there was one, or more than one, RCT supporting the evidence statement.

The evidence statements made in evidence-based reviews are based on the treatment of groups rather than individuals. There are times when the evidence will not apply to a specific case; however, the majority of patients should be managed according to the evidence. Ultimately, the healthcare professional providing care should determine whether an intervention is appropriate and the intensity with which it should be provided, based on their individual patient's needs. Furthermore, readers are asked to interpret the findings of studies with caution as evidence can be misinterpreted. The most common scenario occurs when results of a trial are generalized to a wider group than the evidence allows. Evidence is a tool, and as such, the interpretation and implementation of it must always be done with the known limitations in mind.

TABLE 3 | Levels of Evidence

Level	Research Design	Description
1A	Randomized Controlled Trial (RCT)	More than one RCT with PEDro score ≥6. Includes within subject comparisons, with randomized conditions and crossover designs
1B	RCT	One RCT with PEDro ≥6
2	RCT	One RCT with PEDro <6
	Prospective Controlled Trial (PCT)	Prospective controlled trial (not randomized)
	Cohort	Prospective longitudinal study using at least two similar groups with one exposed to a particular condition
3	Case Control	A retrospective study comparing conditions including historical controls
4	Pre-Post Trial	A prospective trial with a baseline measure, intervention, and a post-test using a single group of subjects
	Post-test	A prospective intervention study using a post intervention measure only (no pre-test or baseline measurement) with one or more groups
	Case Series	A retrospective study usually collecting variables from a chart review
5	Observational study	Using cross sectional analysis to interpret relations
	Clinical Consensus	Expert opinion without explicit critical appraisal, or based on physiology, biomechanics or "first principles"
	Case Reports	Pre-post or case series involving one subject

Strength of the Evidence

The methodological quality of each randomized controlled trial (RCT) was assessed using the Physiotherapy Evidence Database (PEDro) rating scale developed by the Centre for Evidence-Based Physiotherapy in Australia (Moseley et al., 2002). The PEDro is an 11-item scale; a point is awarded for ten satisfied criterion yielding a score out of ten. The first criterion relates to external validity, with the remaining ten items relating to the internal validity of the clinical trial. The first criterion, eligibility criteria, is not included in the final score. A higher score is representative of a study with higher methodological quality.

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SUMMARY OF THE EVIDENCE

Intervention	Key Point Level of Evidence
Verbal and Written Communication	
Interventions for Verbal or Written Communication	Targeted hypnosis may improve memory, attention, and cognitive function in post TBI patients or stroke; however, only as long as the intervention is being administered. - *There is level 1b evidence that targeted hypnosis may transiently improve cognitive function in post TBI patients or stroke.* Attention training programs likely do not improve executive functioning. - *There is level 1b evidence that an attention remediation intervention may not be superior to TBI education alone and improving executive function in patients post TBI.* - *There is level 2 evidence that dual-task training may improve not general cognitive functioning compared to a non-specific cognitive program in patients post TBI.* General cognitive training programs which include problem-solving appear to be effective for improving executive functioning following an ABI. - *There is level 1b evidence that a comprehensive cognitive treatment strategy program (which include problem solving), compared to controls, are effective for improving metacognition and goal achievement post TBI.* Virtual reality does not likely improve executive functioning following an ABI. - *There is level 1b evidence that virtual-reality training is not superior to conventional cognitive training at improving cognitive and executive function outcomes post TBI.* Computer or smartphone software programs (BrainHQ, Parrot Software, ProSolv app) may not be superior to common interventions at improving memory, attention, and problem-solving skills in patients post TBI. - *There is level 1b evidence that the specific cognitive training program ProSolv, compared to standard therapy, does not improve measures of executive functioning following an ABI.* - *There is level 2 evidence that computer or smartphone software programs, such as BrainHQ, Parrot Software, ProSolv app, may not be superior to no intervention at improving problem-solving skills and general functioning in patients post TBI.* Goal management training may be superior to motor skills training at improving everyday skills (meal preparation), but not intelligence or neuropsychological outcomes in patients post TBI. - *There is level 2 evidence that goal management training may be superior (compared to motor skills training or no treatment controls) for improving goal attainment or measures of intelligence following an ABI.* Heart rate variability biofeedback may improve executive functions; however, more controlled studies are required to make further conclusions.

	- *There is level 4 evidence that heart rate biofeedback may improve executive functioning following an ABI, although higher level studies are required to fully determine this.*
Group-Based Interventions	Communicating "yes/no" responses with consistent training and environmental enrichments does not improve communication responses in individuals post ABI. - *There is level 1b evidence that yes/no training and an enriched environment does not significantly improve communication responses in individuals with an ABI.* Retrieval practice is effective for improving verbal communication in individuals with an ABI. - *There is level 4 evidence that retrieval practice is more effective for memory recall in individuals with an ABI than massed restudy (i.e., cramming) and spaced restudy (i.e., distributed learning).* Targeted figurative language therapy improves communication and comprehension in individuals with TBI; although the severity of the injury may moderate these effects. - *There is level 4 evidence that cognitive-communication therapy targeting the interpretation of figurative language is effective for improving language and metaphor comprehension following an ABI.* Text-to-speech technology improves reading rates in individuals with TBI, but not comprehension. - *There is level 4 evidence that text-to-speech technology improves reading rates post ABI but not reading comprehension.*
Social Communication Skills Training for Individuals and Communication Partners	
Social Communication Skills Training	Training in social skills, social communication or pragmatics is effective in improving communication following brain injury. - *There is level 1b evidence that a variety of communication skills training programs improve social communication skills in individuals with an ABI, as well as self-concept and self-confidence in social communications.* Goal-driven interventions may be effective in improving social communication skills and goals following TBI. - *There is level 4 evidence suggesting that a goal-driven, metacognitive approach to intervention may be beneficial in assisting individuals with TBI to achieve social communication goals.* Group Interactive Structured Treatment (GIST) is effective for improving social communication skills following an ABI. - *There is level 2 evidence that the Group Interactive Structured Treatment program (GIST) is effective for improving social communication skills in those with a TBI as well as other neuropsychological comorbidities.* Computer-based game programs which deliver cognitive-communication skills training may be effective for improving social skills.

	- *There is level 4 evidence that interactive touch screen games focused on areas of reasoning, knowledge and action may be effective for improving social skills following an ABI.*
Training Communication Partners	Providing communication training to individuals who interact with people with TBI is effective and encourages two-way dialogue. - *There is level 2 evidence to support the effectiveness of interventions that focus on training communication partners in the community, compared to no training, for improving interactions between responders and those with an ABI.* Providing training to the communication partner and the individual with TBI together is more effective than training the individual with TBI alone. - *There is level 2 evidence that providing training to both the communication partner and the individual with a TBI together is more effective than only training the individual with TBI alone or no training at all.*
Non-Verbal Communication	Facial affect recognition and emotional interference training improves emotional perception post ABI. - *There is level 1b evidence that facial affect recognition training and emotional inference training is beneficial at improving the emotional perception of individuals with ABI.* Short intervention designed to improve emotional prosody is not effective post ABI. - *There is level 1b evidence that short intervention designed to improve the ability to recognize emotional prosody was minimally effective in individuals with ABI.* Cognitive Pragmatic Treatment (CPT) program is effective at improving comprehension and production of a communication act. - *There is level 4 evidence that a Cognitive Pragmatic Treatment (CPT) program is effective in improving communicative-pragmatic abilities in individuals with ABI.* The Treatment for Impairments in Social Cognition and Emotion Regulation and Cogniplus protocols are effective for improving emotional processing and emotional intelligence in individuals with an ABI. - *There is level 1a evidence that the Treatment for Impairments in Social Cognition and Emotion Regulation and Cogniplus protocols are effective for improving emotional processing and emotional intelligence in individuals with an ABI.*
Alternative and Augmentative Communication	Augmentative and alternative communication interventions designed to assist with organization, access, and efficiency of communication may be beneficial for individuals with severe ABI.

INTRODUCTION

Communication remediation focuses on one's ability to improve expressive language, speech production, reading, writing, and cognition. Due to impairments in cognitive abilities following an ABI, difficulties in producing proficient discourse is commonplace. Previous treatments have focused on improving narrative and structured conversations post injury (Kilov et al., 2009). Established treatments often focus on the individual's ability to communicate with a clinician or researcher but not in the presence of a friend or family member (Jorgensen & Togher, 2009). Whether an individual communicates with a friend, a family member or community member, rather than a trained clinician post brain injury, has had an effect on the language choices made by both partners (Jorgensen & Togher, 2009).

Group treatment may be an effective intervention for post ABI individuals with cognitive-communication deficits and may be used to target more complex and higher-level skills within the communication domain and with a wide array of communication partners. Within a group treatment setting, patients with ABI gain support and benefit from the experience of their peers within a non-judgmental environment to experiment with compensatory strategies and acquisition of appropriate interaction skills (College of Audiologists and Speech Language Pathologists of Ontario, 2002).

Some specific goals of group treatment post ABI include having individuals focus on having their basic needs met, improving word fluency, word usage and word finding, and, to have tools to help better organize ideas in conversation. Strategies to ensure meeting these goals is possible would be to implement the use of a yes/no response system, alphabet boards to serve as phonemic cueing for word retrieval, and word retrieval strategies. To improve clarity of speech and phonation, patients are encouraged to speak clearly and with vocal effort, all while receiving proper breath support. For clinical use, the Lee Silverman Voice treatment (LSVT®) would be the primary tool when addressing these issues.

Remediation of Verbal and Written Communication

Several authors have reviewed a variety of studies focusing on cognitive-communication therapies used to assist those post ABI (Coelho et al., 1996; Kennedy et al., 2008; MacDonald & Wiseman-Hakes, 2010). In a review conducted by Coelho et al. (1996), the concluding findings suggest that those who sustain an ABI benefit from the work of an SLP. Study authors found evidence to suggest that individuals undergoing therapy showed gains in receptive and expressive language, speech production, reading, writing, and cognition. Further they noted that patients with more severe cognitive-communication deficits are more effectively remediated when treatment is directed toward the development of compensatory rehabilitation strategies such as the use of memory aids (Coelho et al., 1996). Additionally, Coelho and colleagues (1996) reported that although interventions directed at particular cognitive deficits are important, clinicians must attend to broader issues of social skills retraining, timing of treatment during recovery, treatment location and its effectiveness (e.g. hospital, home, school, work). Study results from

Mackay et al. (1992) suggest that intervention programs offered earlier post injury result in shorter rehabilitation stays. Further, for individuals with comparable disabilities, those who receive rehabilitation have better than average cost outcomes compared to those not receiving these services (Aronow, 1987).

TABLE 4 | Interventions for Improving Verbal and Written Communication

Author, Year Country Study Design Sample Size	Methods	Outcome
Barreca et al. (2003) Canada RCT PEDro=6 N=13	**Population:** ABI; Mean Age: 41.3 yr; Gender: Male= 10, Female= 3; Mean Time Post Injury=33 mo; Mean GCS=4.8. **Treatment:** Patients were assigned to an ABAB (n=7) or BABA (n=6) treatment sequence**.** Group A received an enriched stimulus environment, collaborative multi-disciplinary intervention, and additional yes/no response training (30 min, 3x/wk). Group B received standard intervention within a hospital environment. This took place over 8 wk, each interval being 2 wk. **Outcome Measure:** Western Aphasia Battery.	1. No order effect (AB vs BA; F=0.29; p=0.06) but a treatment trend was found for the effectiveness of group A over group B (A vs B; F=3.84; p=0.07). 2. No significant differences in Western Aphasia Battery scores between treatments at admission or 6 mo later (p>0.05).
Sumowski et al. (2014) USA Pre-Post N=10	**Population:** Severe TBI=10; Mean Age=42.8 yr; Gender: Male=6, Female=4; Mean Time Post Injury=8.4 yr. **Intervention:** Participants studied 48 verbal paired associates (VPAs) divided into 3 learning conditions: massed restudy (MR), spaced restudy (SR), and retrieval practice (RP). MR is similar to cramming, whereas SR is distributed learning. RP was similar to SR; however, re-exposure trials were framed as cued recall tests. Recall of VPAs was done at 30 min post intervention, and at 1 wk. Participants performed all 3 methods of learning. **Outcome Measure:** Recall of VPAs.	1. Participants recalled 46.3% of VPAs learned through RP compared with 12.5% through MR (p<0.0001), and 15% through SR (p=0.002). 2. SR did not result in better memory than MR (p=0.0555). 3. At 1wk, participants recalled 11.3% in the RP group compared to 0.0% in the MR (p=0.004), and 1.3% in SR (p=0.011). Again, SR and MR did not differ from each other (p=0.343).
Harvey et al. (2013) USA Pre-Post N=9	**Population:** Severe TBI=9; Mean Age=35.78 yr; Gender: Male=8, Female=1; Mean Time Post Injury=10.89 yr. **Intervention:** Participants read 24 passages in two different scenarios, once without any training and once after receiving 6 sessions of computerized text-to-speech training. **Outcome Measure:** Reading rate, comprehension accuracy.	1. Reading rates were significantly faster after receiving training (p=0.036). 2. No significant difference between text-to-speech and no text-to-speech conditions were noted for comprehension accuracy (p=0.950).
Brownell et al. (2013) USA Pre-Post N=8	**Population:** TBI=8; Mean Age=43 yr; Gender: Male=5, Female=3; Mean Time Post Injury=8.5 yr; Severity: Moderate to severe. **Intervention:** Therapy targeting difficulties interpreting figurative language. Participants were assessed at baseline and then performed	1. As a whole, the group significantly improved on the Oral Metaphor Interpretation following treatment compared to baseline (Mean difference score=5.9, p<0.001).

	metaphor interpretation probes and untrained line orientation tasks during the three study phases: (1) baseline phase (10 session, 2x/wk); (2) training phase with word tasks ranging in difficulty (2x/wk); and (3) post training phase (10 sessions, 2x/wk). The exact number of sessions varied (total 23 to 34). Follow-up conducted at 3 to 4 mo post training. **Outcome Measure:** Oral Metaphor interpretation, Benton Line Orientation-Judgment Task Short Form Q.	2. Scores on the Benton line Orientation task did not improve significantly (Mean difference score=-0.2, p=0.585) from pre to post training. 3. 6 of 8 participants improved significantly on metaphor interpretation following training, 3 of which maintained these improvements at follow-up.
O'Neil-Pirozzi et al. (2010) USA Prospective Control Trial N=94	**Population:** TBI; *Experimental Group*: Mean Age=47.3 yr; Mean Time Post-Injury=11.8 yr; *Control Group*: Mean Age=47.0 yr; Mean Time Post-Injury=13.4 yr **Treatment:** In a non-randomized pre-post study group comparison, participants in the experimental group were trained to use Internal Memory Strategies (I-MEMS; n=54); the intervention consisted of 12 90-min sessions, held 2x/wk for 6 wk. It included memory education and emphasized internal strategy acquisition to improve memory function from encoding, storage and retrieval perspectives; the control group (n=40) consisted of a convenience sample. **Outcome Measure:** Hopkins Verbal Learning Test-Revised (HVLT-R), Rivermead Behavioural Memory Test II (RBMT II). Patients were assessed on Week 1 (pretest), Week 7 (post-test 1), and Week 11 (post-test 2).	1. Pretesting revealed a significant difference between experimental and control groups on the HVLT-R only (p=0.02). 2. Individuals who had had a severe TBI performed more poorly on the HVLT-R than those with moderate injuries. 3. Although those with a severe injury did not improve as much as those with a mild or moderate injury, they did improve more than those in the control group at both post-test 1 (p=0.0002) and post-test 2 (p<0.0001). 4. Similar to what was found with HVLT-R assessments, severe injury predicted worse RMBT II scores than moderate injury. 5. RBMT II scores in the I-MEMS groups revealed significant improvements at both post-test 1 (p=0.045) and post-test 2 (p=0.0013) relative to control. 6. Overall memory performance was improved for all those in the experimental group compared to the control group.

Discussion

The effects of hypnosis, as delivered in a targeted or non targeted manner, on memory, attention, and cognitive function in a mixed TBI and stroke population has been investigated (Lindelov et al. 2017). The researchers showed that working memory, attention, and cognitive function could be transiently increased during targeted hypnosis; however, the benefits of the treatment were not sustained when the treatment was discontinued. With respect to attention process training, it was shown that this intervention may have indirectly improved executive function as individuals with higher vigilance achieved higher executive function scores, but it was not explicitly demonstrated that training resulted in increased vigilance (Sohlberg et al., 2000).

Siponkoski et al. (2020) investigated the effects of 20 sessions of music therapy (rhythmical training, structured cognitive-motor training and assisted music playing) on measures of executive function. Compared to the control group, significant improvements on measures of executive function were observed for those receiving music therapy.

Dual-task training which is also used as a form of attention training was also evaluated in another RCT and although individuals were improved on measures of attention to a significantly greater extent than controls, no such relationship was found for measures of executive function (Couillet et al., 2010).

With the development of technology, the use of virtual-reality training and computer programs have gained traction as an intriguing tool used for improving executive function in patients post TBI. In terms of cognitive functioning, two RCTs found varying results for executive functioning outcomes after training in a virtual environment (Jacoby et al., 2013; Man et al., 2013). One RCT focusing on vocational problem-solving skills (Man et al., 2013) identified significant improvements in both VR intervention and conventional psychoeducation control groups; however, there were no significant between-group differences for cognitive or vocational outcomes except on WCST % errors and % conceptual level response (Man et al., 2013). Conversely, Jacoby et al (2013) found that patients receiving virtual reality training improved more on multi-tasking measures and executive function when compared to the control group who received general cognitive re-training treatment. In a pre-post study, Dadah et al. (2017) investigated virtual reality interventions in a mixed ABI population. The researchers found that repetition of the Stroop test in different virtual reality environments showed limited improvement in performance on those specific tests (Dahdah et al., 2017). As a result of the mixed results reported on the efficacy of virtual reality training post ABI, it is difficult to make a conclusive decision on what aspects of executive functioning virtual reality benefits, and to what degree.

As previously mentioned, computer software programs have also been investigated for their efficacy in improving executive dysfunctions post TBI. Recently, BrainHQ, a commercially available online computerized cognitive exercise program, showed mixed results for improving executive function post ABI (O'Neil-Pirozzi & Hsu, 2016). Although individuals self-reported improvements in daily functioning, no significant results were seen on objective measures (O'Neil 2016). Parrot Software is another computer-based cognitive retraining program, and was investigated by a pre-post study assessing the efficacy of using eight modules focussed on attention and memory (Li et al., 2015; Li et al., 2013). While significant post-treatment improvements in attention and memory on the Cognistat assessment were found in a pilot study (Li et al., 2013), a subsequent study did not find significant improvements on the Montreal Cognitive Assessment (MoCA) or a medication-box sorting task despite significantly improved overall MoCA scores (Li et al., 2015). This lack of improvement compared to a control group was also reported by Powell et al. (2017) when the ProSolv smartphone application was used to improved pressure management and problem-solving skills. Finally, Chen et al. (1997) studied the effect of computer assisted cognitive rehabilitation versus traditional therapy methods. While measures of attention significantly improved in both groups after treatment, no significant differences were observed between groups on any measures related to executive function (Chen et al., 1997). Cumulatively, by observing studies from across a period of nearly 20 years, the literature reveals little support for the use of computer software programs for the improvement of executive function post TBI.

In an RCT, Spikman et al. (2010) randomly divided a group of individuals who had sustained a TBI to either a multifaceted strategy training group or a control group. Those in the treatment group were taught a comprehensive cognitive strategy which allowed them to tackle the issues and problems of daily living, compared to the control group which received a computerized training package that was aimed at improving general cognitive functioning. Overall, results indicate both groups improved on many aspects of executive functioning; however, those in the treatment group showed greater improvement in their ability to set and accomplish realistic goals and to plan and initiate real life tasks (Spikman et al., 2010). The findings of the previous experiment agree with the findings of the study by Laatsch et al. (1999) and Freeman et al. (1992), where cognitive rehabilitation therapy was found to increase productivity and everyday functioning. This older study (Laatsch et al., 1999) also had the benefit of reporting SPECT imaging results, which revealed increases in cerebral blood flow during the intervention. It should be noted that one study has found mixed results on measures of executive functioning after administering a cognitive training program, with individuals improving on some measures of executive functioning, such as metacognition, but not others (Fong & Howie, 2009). It should be noted that none of the above studies were completed by the same groups or had overlapping methodology and although the results suggest cognitive training programs are effective for improving executive functioning following an ABI, programs themselves should be considered unique.

A specific cognitive program (Categorization Program) was evaluated in an RCT by Constantinidou et al. (2008). The authors found that after 13 weeks of therapy (mean 4.5 hr/day), individuals significantly improved on measures of executive functioning such as object recognition. Although the Categorization Program treatment group and standard therapy therapy group showed improvement on the community reintegration questionnaire and adaptability measures, there were greater executive function gains in the treatment group (Constantinidou et al., 2008). The Intensive NeuroRehabilitation Programme investigated by Holleman et al. (2018) resulted in significantly reduced depression and anxiety compared to the control group but did not improve measures of executive functioning. Similarly, a novel program – Cognitive Applications for Life Management, did not find significant improvements in measure of executive functioning (Elbogen et al., 2019). Although the program did improve measures of emotion and behavioural regulation (Elbogen et al., 2019).

Another unique study used heart rate variability biofeedback in an attempt to increase awareness and cognitive control (Kim et al., 2018). In this study it was noted that individuals who underwent heart rate biofeedback significantly improved scores of executive functioning on the Category Test. However, this study consisted of a pre-post design and lacked a control group for comparison, and as such results should be interpreted with caution. Only one study evaluated the effects of repetitive transcranial magnetic stimulation on executive function; however, no significant improvements were observed between groups (Neville et al., 2019).

Levine et al. (2000) completed an RCT comparing a group of patients using goal management training strategies to a control group who were received only motor skills training. The treatment group improved on paper and pencil everyday tasks as well as meal preparation-which the authors used as an example of a task heavily reliant on self-regulation in comparison to the motor treatment group. It is important to note, however, that the motor group performed superiorly on timed neuropsychological tests, and no differences were found between treatments in terms of intelligence. Two other studies evaluated goal management training and did not find any significant results suggesting that goal management training improves executive functioning following an ABI (Cizman Staba et al., 2020; Levack et al., 2009). A single older study reported positive affects of a goal setting program in its ability to help an individual achieve goals (Webb & Glueckauf, 1994). The execution of goals themselves requires executive functioning; however, no objective measures of executive function were directly evaluated in this study.

Conclusions

There is level 1b evidence that targeted hypnosis may transiently improve cognitive function in post TBI patients or stroke.

There is level 1b evidence that an attention remediation intervention may not be superior to TBI education alone and improving executive function in patients post TBI.

There is level 2 evidence that dual-task training may improve not general cognitive functioning compared to a non-specific cognitive program in patients post TBI.

There is level 1b evidence that a comprehensive cognitive treatment strategy program (which include problem solving), compared to controls, are effective for improving metacognition and goal achievement post TBI.

There is level 4 evidence that cognitive rehabilitation may increase productivity in everyday functioning, and cerebral blood flow during treatment in patients post TBI.

There is level 1b evidence that virtual-reality training is not superior to conventional cognitive training at improving cognitive and executive function outcomes post TBI.

There is level 1b evidence that the specific cognitive training program ProSolv, compared to standard therapy, does not improve measures of executive functioning following an ABI.

There is level 2 evidence that the Intensive NeuroRehabilitation programme, compared to no treatment, does not improve executive functioning following an ABI.

There is level 2 evidence that computer or smartphone software programs, such as BrainHQ, Parrot Software, ProSolv app, may not be superior to no intervention at improving problem-solving skills and general functioning in patients post TBI.

There is level 4 evidence that heart rate biofeedback may improve executive functioning following an ABI, although higher level studies are required to fully determine this.

There is level 2 evidence that goal management training may be superior (compared to motor skills training or no treatment controls) for improving goal attainment or measures of intelligence following an ABI.

KEY POINTS

- Targeted hypnosis may improve memory, attention, and cognitive function in post TBI patientsor stroke; however, only as long as the intervention is being administered.
- Attention training programs likely do not improve executive functioning.
- General cognitive training programs which include problem-solving appear to be effective for improving executive functioning following an ABI.
- Virtual reality does not likely improve executive functioning following an ABI.
- Computer or smartphone software programs (BrainHQ, Parrot Software, ProSolv app) may not be superior to common interventions at improving memory, attention, and problem-solving skills in patients post TBI.
- Goal management training may be superior to motor skills training at improving everyday skills (meal preparation), but not intelligence or neuropsychological outcomes in patients post TBI.
- Heart rate variability biofeedback may improve executive functions; however, more controlled studies are required to make further conclusions.

Group-based Interventions

Although executive function deficits are a common there is little overall research directly addressing the impact of rehabilitation on executive function. However, community integration and other similar group-based interventions are highly related to executive function and it is possible that programs and interventions presented in a group-based setting may in fact be focusing efforts on instrumental activities of daily living which may reflect (or are dependent on) executive functions. The efficacy of group-based interventions on cognitive and executive function are discussed below.

TABLE 5 | The Effects of Group therapy on Executive Function Post ABI

Author, Year Country Study Design Sample Size	Methods	Outcome
Tornas et al. (2016) Norway RCT PEDro=9 $N_{Initial}$=70, N_{Final}=67	**Population:** TBI=45, Stroke=15, Tumour=6, Anoxia=2, Other=2. Mean Age=42.89 yr; Gender: Male=38, Female=32; Mean Time Post Injury=97.47 mo. **Intervention:** Participants were randomized to receive Goal Management Training (TG) or Brain Health Workshop (CG) group sessions.	1. In the TG, significant improvements were found on BRIEF-A, DEX, and CFQ at T3 (p<0.010). 2. In the CG, significant improvements were found on only BRIEF-A at T2 (p<0.050).

	GMT group (n=33) discussed distinctions between absentmindedness/presentmindedness, slip-ups in daily life, habitual responding, stopping and thinking, working memory, importance of goals, defining/splitting goals into subtasks, and checking. BHW control group (n=37) discussed brain function/dysfunction, brain plasticity, memory, executive function, and attention. Treatment was received one day every second week, for a total of eight two-hour sessions distributed over four days. Outcomes were assessed at baseline (T1), after treatment (T2), and at six-month follow-up (T3). **Outcome Measures:** Behaviour Rating Inventory of Executive Function–Adult (BRIEF-A); Dysexecutive Questionnaire (DEX); Cognitive Failures Questionnaire (CFQ); Continuous Performance Test II (CPT-II); UCSD Performance-Based Skills Assessment (UPSA); Delis-Kaplan Executive Function System Battery–Colour-Word Interference Test (CWI), Verbal Fluency Test (VFT), and Tower Test (TT); Trail Making Test (TMT); Hotel Task (HT).	3. The TG showed significant improvements on BRIEF-A and DEX (p<0.010), but not CFQ, compared to the CG over time 4. In the TG, significant improvements were found on CPT-II, CWI, TT, and HT at T2 and T3 (p<0.050), VFT at T3 (p<0.050), and UPSA at T2 (p<0.001). 5. In the CG, significant improvements were found on CPT-II, TT, and HT at T2 and T3 (p<0.050), and VFT and UPSA at T2 (p<0.050). 6. The TG showed a significant improvement on CWI, VFT, and TT (p<0.050), but not CPT-II, UPSA, and HT, compared to the CG over time. 7. No significant differences were found on TMT within or between groups over time.
Tornas et al. (2019) Norway $N_{Initial}$=67, N_{Final}=50 **5yr Follow-up to:** Tornas et al. (2016) Norway RCT PEDro=9 NInitial=70, NFinal=67	**Population:** TBI=29, Stroke=13, Tumor=6, Anoxic/other=2. Mean Age=45.8±10.9yr; Gender: Male=27, Female=23; Mean Time Post Injury=104.9±128.1mo. **Intervention:** Participants were randomized to receive Goal Management Training (GMT) or Brain Health Workshop (BHW) group sessions. GMT group (n=33) discussed distinctions between absentmindedness/ present mindedness, slipups in daily life, habitual responding, stopping and thinking, working memory, importance of goals, defining/splitting goals into subtasks, and checking. BHW control group (n=37) discussed brain function/dysfunction, brain plasticity, memory, executive function, and attention. Treatment was received one day every second week, for a total of eight, two-hour sessions distributed over four days. Outcomes were assessed at baseline (T1), after treatment (T2), and at six-month follow-up (T3). This was a 5-year follow-up. **Outcome Measures:** Behavior Rating Inventory of Executive Function- Adult Version (BRIEF-A), the Quality of Life after Brain Injury (QOLIBRI).	1. A significant main effect of time was found for all BRIEF-A indexes between baseline and 6mo follow-up. 2. A significant time by group interaction for the Behavioural Regulation Index; the GMT-group showed a significant increase in behavioural regulation index symptoms that the BHW group did not 3. There was no significant difference found between baseline and 5yr follow-up in either group on the BRIEF-A or QOLIBRI.
Cantor et al. (2014) USA RCT PEDro=6 N=98	**Population:** TBI; Mean Age=45.3 yr; Gender: Male=37, Female=61; Mean Time Post Injury=12.6 yr; Severity: Mild=49, Moderate=19, Severe=30. **Intervention:** Participants were randomly assigned to either immediate start (IS; n=49) or waitlist control (WL; n=49) groups. Participants	1. There was a significant treatment effect for the EF index favoring the IS group (p=0.008). 2. There was no significant difference between groups in the DERS of ARMS. 3. Secondary analysis revealed a significant treatment effects for the FeSBe scale (p=0.049) and the PSI (p=0.016).

	received group sessions of emotional regulation (2 sessions, 45 min) and an individual problem-solving session of attention training (1 session, 60 min) per day (3 days/wk for 12 weeks). Group sizes were generally 4-6 participants. **Outcome Measure:** Attention Rating and Monitoring Scale (ARMS), Behavioural Assessment of the Dysexecutive Syndrome, Difficulties in Emotion Regulation Scale (DERS), Executive Function Composite from Factor Analysis (EF index), Problem Solving Inventory (PSI), Frontal System Behavioural Scale (FrSBe).	4. There were no other significant treatment effects. Variance of depression, age, severity and time since injury did not change treatment effects.
Vas et al. (2011) USA RCT PEDro=6 N=28	**Population:** TBI: *Strategic Memory and Reasoning Training (SMART) Group* (n=14): Mean Age=39 yr; Gender: Male=9, Female=5; Mean Time Post Injury=16.71 yr. *Brain Health Workshop Group* (n=14): Mean Age=47 yr; Gender: Male=7, Female=7; Mean Time Post Injury=16.35 yr. **Intervention:** Participants were randomly assigned to the SMART group or the BHW group. Participants received a total of 12 group sessions over an 8 wk period. The SMART group learned about strategies they could apply in their daily lives; homework was given at the end of each session. The BHW group sessions were designed to be information-based and reading assignments were given each week. Participants were assessed at baseline, post-training (3 weeks) and at a 6 month follow-up. **Outcome Measure:** Test of Strategic Learning (TOSL); Working memory listening span task; Community Integration Questionnaire (CIQ); Wechsler Adult Intelligence Scale III (WAIS III).	1. The SMART group had significantly greater TOSL scores compared to the control group post-training (SMART *Mean*=19.76, BHW *Mean*=13.69, p=0.030). 2. The SMART group had significant improvements in TOSL scores: post-training (*Mean*=19.76, p=0.007) and at 6-month follow-up (*Mean*=21.15, p=0.004) from baseline (*Mean*=14). 3. The SMART group had significantly greater improvements than the control group on the working memory listening span task post-training (SMART *Mean*=4.23, BHW *Mean*=2.59, p<0.001). 4. The SMART group had significant improvements post-training in the working memory listening span task (*Mean*=4.23, *p*=0.005) and at 6-month follow-up (*Mean*=4.96, P=0.0001) compared to baseline (*Mean*=2.76). 5. The SMART group had significantly greater improvements on CIQ compared to the BHW group (SMART *Mean*=18.73, BHW *Mean*=16.45, p=0.020). 6. The SMART group had significant improvements in the CIQ at the 6-month (*Mean*=19.88, p=0.010) follow-up from baseline (*Mean*=15.19). Those in the SMART group showed significant improvement on 3 executive functions following training (inhibition: p=0.010; nonverbal reasoning: p=0.001; and cognitive flexibility: p=0.010) on the WAIS-III.
Chen et al. (2011) USA RCT PEDro=5 N=12	**Population:** TBI=9, Other=3: Mean Age=48 yr; Gender: Male=5, Female=7; Time Post-Injury Range=6 mo-6 yr. **Intervention:** Participants were randomized to receive either the goals training intervention (n=7) or education intervention (n=5) for 5 wk, after which they switched to the other condition for another 5 wk. The goals training	1. On the domain of attention and executive functions, all participants in the goal training intervention showed an increase from pre to post goals training; while only 7/12 in the education intervention showed an increase from pre to post education (p<0.0001). 2. For learning and memory performance scores increased an average of 0.70 units after

	was spread over 5 wk and involved: group, individual and home-based training. The education program was a 5 wk didactic educational instruction regarding brain injury. **Outcome Measures:** Letter number sequencing, Wechsler Adult Intelligence Scale-III, Auditory consonant trigrams, Digit Vigilance Test, Design and Verbal Fluency Switching, Trails B, Stroop Inhibition, Hopkins Verbal Learning Test, Brief Visual Memory Test Revised, Trails A test, Visual Attention Task.	participation in goals training than after participation in education intervention (p=0.020). 11/12 participants improved in the goals training group while 4/12 improved in the education group (p=0.009). 3. Tests of motor speed of processing showed no significant differences between the two interventions with a non-significant trend for greater improvements in goal-training compared to education (p=0.070).
Novakovic-Agopian et al. (2011) USA RCT Crossover PEDro=5 N=16	**Population:** TBI=11, Stroke=3, Other=2: Mean Age=50.4 yr; Gender: Male=7, Female=9; Time Post Injury Range=1-23 yr. **Intervention:** Participants were randomized to 5 wk interventions consisting of a goals training program (n=8) or an educational instruction group (n=8). Goal training focused on mindfulness-based attentional regulation and goal management strategies for participant-defined goals. Educational training was didactic instructional sessions about brain injury. At the end of 5 wk, participants were switched to the other intervention. All participants were assessed at baseline, Week 5 and again at Week 10. **Outcome Measure:** Auditory Consonant Trigrams, Letter Number Sequencing (working memory); Digit Vigilance Test (sustained attention); Stroop Inhibition Delis-Kaplan Executive Function System (Inhibition); Trails B, Design Fluency-switching (mental flexibility), Hopkins Verbal Learning Test-Revised, Brief Visual Memory Test-Revised.	1. At the end of wk 5 participants in the goals-edu group showed significant improvement on measures of attention and executive function from baseline (p<0.0001), while the edu-goals group showed no change or minimal change (p>0.050). 2. The goals-edu group had significantly greater improvements than the edu-goals group on the following at wk 5: working memory (M*ean* 1.12 vs -0.12, p<0.0001); mental flexibility (*Mean* 0.64 vs 0.04, p=0.009); inhibition (*Mean* 0.62 vs 0.04, p=0.005); sustained attention (*Mean* 0.96 vs 0.27, p=0.010); learning (*Mean*=0.51 vs 0.08, p=0.020); and delayed recall (*Mean* 0.39 vs -0.27, p=0.010). 3. At wk 10, the edu-goals group significantly improved compared to wk 5 on: attention and executive function (0.79 vs 0.03, p<0.0001); working memory (1.31 vs -0.12, p<0.0008); mental flexibility (0.66 vs 0.04, p<0.0008); inhibition (0.50 vs 0.04, p=0.010); sustained attention (0.44 vs 0.27, p=0.010); memory (0.609 vs -0.10, p=0.020); learning (0.66 vs 0.08, p=0.050); and delayed recall (0.55 vs -0.27, p=0.020). Those in the goals-edu group who had completed the training session were able to maintain their gains and there were significant improvements in attention and executive function (p<0.040) and working memory (p<0.020).
Ownsworth et al. (2008) Australia RCT PEDro=9 N=35	**Population:** TBI=21, Other=14; Mean Age=43.89yr; Gender: Male=19, Female=16; Mean Time Post Injury=5.29yr. **Treatment:** Participants were randomized to receive one of three 8wk intervention groups for goal attainment: individual (n=10), group (n=11), or combined (n=10). Individual treatment occurred in participant homes and community while also focusing on client-centered goals. Group-based treatment involved education, peer and facilitator feedback, and goal setting. The combined group received the equivalent amount of individual and group therapy.	1. There were significant improvements on performance self-ratings between pre-post intervention for the individual (4.08 to 6.78, p<0.01) and combined interventions (5.04 to 6.98, p<0.01) but not the group intervention (4.68 to 6.10, p=0.029). At follow-up, all interventions had significant improvements from pre-intervention (p<0.01). 2. There were significant improvements on the satisfaction self-ratings between pre-postintervention for all three interventions: individual (3.75 to 7.22, p<0.001), group (4.51 to 5.95, p<0.025) and combined (4.35 to 7.47, p<0.01).

	Outcome Measure: Canadian Occupational Performance Measure (COPM): performance self-rating, satisfaction self-ratings, relatives' performance ratings, and relatives' satisfaction ratings.	3. There were significant improvements for relatives' rating of performance between pre-post intervention for the individual (3.94 to 6.53, p<0.01) and combined interventions (4.37 to 5.32, p<0.025) but not the group intervention (4.78 to 5.93, p=0.028). At follow-up, all interventions had significant improvements (p<0.01).
Rath et al. (2003) USA RCT PEDro=2 N=46	**Population:** TBI: Mean Age=43.6 yr; Gender: Male=23, Female=37; Mean Time Post Injury=48.2 mo. **Intervention:** Patients were randomized into the innovative (n=32) or conventional (n=28) treatment groups. The innovative group received 24, 2 hr sessions focusing on emotional self-regulation and clear thinking. The conventional group received 24, 2-3 hr sessions focusing on cognitive remediation and psychosocial groups. **Outcome Measure:** Weinberg Visual Cancellation Test, Stroop Color–Word Task, FAS—Controlled Oral Word Association Test, Will-Temperament Scale, Visual Reproduction, Immediate and Delayed recall, Watson-Glaser Critical Thinking Appraisal, Wechsler Adult Intelligence Scale—III.	1. The innovative group showed significant improvements in visual memory immediate recall (p<0.001). 2. The conventional and the innovative group showed significant improvements: on logical memory recall (p<0.001), logical memory delayed recall (p=0.010), and visual memory delayed recall (p=0.010). 3. The conventional group had significant improvements in reasoning (p<0.050). 4. The innovative group had significant improvements in executive function (p<0.050); problem-solving self-appraisal (p=0.005); self-appraised clear thinking and emotional self-regulation (p<0.010); and observer ratings of roleplayed scenarios (p<0.005).
Copley et al. (2015) Australia Pre-Post N=8	**Population:** ABI; Mean Age=44.5 yr; Gender: Male=5, Female=3; Mean Time Post Injury=12 mo; Severity: Moderate-Severe. **Intervention:** All participants completed a treatment consisting of metacognitive strategy instruction (MSI) during 3 components. 1) Individualized sessions (IS) consisted of identifying language based goals and strategies to accomplish them (2 hr x2 sessions). 2) Group sessions (GS) where participants work on their goals in a group setting completing auditory and written comprehension tasks (1.5 hrs). 3) Daily home practice sessions (HS) involved transferring the skills learnt in the first 2 components into everyday life by teaching the significant other how to implement MSI. **Outcome Measure:** Measure of Cognitive-Linguistic Abilities Subtests: Paragraph Comprehension, Story Recall, Verbal Abstract Reasoning, Functional Reading, Factual Comprehension, Inferential Reasoning Skills (Low Level and High Level).	1. There was no significant difference in pre-post scores for paragraph comprehension (p=0.340). 2. There was no significant difference in pre-post scores for story recall (p=0.028). 3. There was no significant difference in pre-post scores for verbal abstract reasoning (p=0.111). 4. There was no significant difference in pre-post scores for functional reading (p=0.204). 5. There was no significant difference in pre-post scores for factual comprehension (p=0.891). 6. There was no significant difference in pre-post scores for inferential reasoning skills, both low level (p=0.125) and high level (p=0.020).
Gabbatore et al. (2015) Italy Pre-Post $N_{Initial}$=20, N_{Final}=15	**Population:** TBI; Mean Age=36.7 yr; Gender: Male=10, Female=5; Mean Time Post Injury=76.1 mo; Mean GCS=4.5. **Intervention:** Participants completed a cognitive group rehabilitation program focussed on mental representations underlying	1. No significant improvements in ABaCo (production and comprehension) were observed from T0 to T1. 2. Participants showed significant improvements from T1 to T2 for ABaCo comprehension (p<0.001), production (p<0.001), linguistic

	one's behaviours (2 x/week for 3 months). Each session consisted of comprehension activities (discussing specific communication modalities) and production activities (role-playing activities). Participants were assessed at T0 (3 months before intervention (regular activities during this time), T1 (before intervention), T2 (after intervention) and T3 (3 month follow-up – regular activities during this time). Total study duration was 9 months. **Outcome Measure:** : Assessment Battery for Communication (ABaCo-comprehension, production, linguistic, extralinguistic, paralinguistic, and context), Verbal Span Task (VST), Spatial Span Task (SST), Attentive Matrices Test (AMT), Trail Making Test (TMT), Tower of London Test (TOL), Colored Progressive Matrices Raven (CPM Raven), Aachener Aphasie Test-Denomination Scale (AAT), Sally-Ann Task, Strange Stories Task, Immediate and Deferred Recall Test (IDR), Wisconsin Card Sorting Test (WCST).	(p=0.005), extralinguistic (p=0.008), paralinguistic (p=0.02), and context (p=0.01). 3. The improvements made during the treatment period were stable between T2 and T3 for both Comprehension (p=0.86) and Production (p=0.32). At T3, AbaCo scores did not show significant differences from T2. 4. There was no significant difference between T1 and T2 on the VST (p=0.49), SST (p=0.74), AMT (p=0.35), TMT (p=0.45), TOL (p=0.50), CPM Raven (p=0.09), AAT (p=0.22), Sally-Ann (p=0.58), or strange stories task (p=1.00). 5. There was a significant improvement between T1 and T2 on the IDR (p=0.01) and WCST (p=0.003).
Llorens et al. (2012) Spain Pre-Post N=10	**Population:** ABI=10; Mean Age=41.1yr; Gender: Male=7, Female=3; Mean Time Post Injury=402.2d. **Intervention:** Participants underwent sessions (1hr/wk for 8mo) using an interactive touch screen based game asking questions related to knowledge, reasoning, action, and cohesion in groups of ≤4. Testing of participants occurred at baseline and post intervention. **Outcome Measure:** Self-Awareness Deficits Interview (SADI), Social Skills Scale (SSS).	1. On the SADI, after treatment all participants perceived their deficits properly compared to only 4 participants at baseline; 2 participants had difficulty perceiving their disability post treatment compared to 7 participants at baseline and 5 participants had difficulty establishing realistic goals post treatment compared to 7 at baseline. 2. On the SSS at baseline, 6 participants showed altered levels in social skills, compared to 2 following treatment.
Parente & Stapleton (1999) USA Case-Control N=33	**Population:** ABI. **Intervention:** A one year measure of group cognitive skills (CSG) training module. **Outcome Measure:** Return to work.	1. Ten of 13 CSG clients who completed the training program by the end of the year had maintained full employment for >60 days (76%) - versus 58% of the control group. Significance not calculated.

Discussion

Barreca et al. (2003) compared two rehabilitation approaches that attempted to establish correct responses to yes/no questions. In addition to providing an enriched environment to the first group, a communicative disorders assistant provided yes/no training to the individuals. In addition, the assistant trained healthcare team members and families to follow scripted procedures to increase arousal/attention and to elicit yes/no responses. This was compared against standard care. Despite no significant differences on the Western Aphasia Battery, families reported on a satisfaction questionnaire that they were better able to communicate with their loved one (Barreca et al., 2003).

Another study examined retrieval practice, administered in person, compared to massed restudy and spaced restudy (Sumowski et al., 2014). In the retrieval practice intervention, the participants were first exposed to a verbal paired associate; the subsequent trials for that verbal paired associate were structured as cued recall tests. For individuals with severe TBI and memory-impairments, this retrieval practice was significantly more effective for memory recall than the massed restudy and spaced restudy interventions both immediately following the intervention and at 1 week post (Sumowski et al., 2014).

Technology interventions have also been used to improve communication post TBI. In a study conducted by Harvey et al. (2013) participants completed six sessions of computerized text-to-speech training. Results showed a significant improvement in reading rates during the text-to-speech conditions compared to the no text-to-speech conditions (Harvey et al., 2013). These findings suggest that text-to-speech technology is a useful tool in improving reading rates among individuals with a TBI. However, the authors note that while reading rates improved, comprehension of the written material was not affected.

Brownell et al. (2013) utilized therapy targeting deficiencies in figurative language. All participants completed 10 sessions of word task training resulting in significant improvements in oral metaphor interpretation (Brownell et al., 2013). Participants in the study were approximately eight years post injury suggesting that post TBI individuals are capable of advanced improvements in non-literal language even after the period of rapid and pronounced spontaneous recovery.

In a study by O'Neil-Pirozzi et al. (2010), individuals with ABI participated in twelve 90-minute sessions which were held twice a week. The intervention included memory education, and to improve memory function the study emphasized internal strategy acquisition. Primary emphasis was placed on semantic association followed by semantic elaboration/chaining and imagery. Results from the Hopkins Verbal Learning Test (HVLT) indicated significant differences between the groups and those with a severe ABI performed more poorly than those with a moderate injury. Despite this finding, those with severe ABIs did perform better than those in the control group. In all, memory performance was seen to improve for all in the intervention group compared to the control group, however this relationship was slightly modified by injury severity.

Conclusions

There is level 1b evidence that yes/no training and an enriched environment does not significantly improve communication responses in individuals with an ABI.

There is level 4 evidence that retrieval practice is more effective for memory recall in individuals with an ABI than massed restudy (i.e., cramming) and spaced restudy (i.e., distributed learning).

There is level 4 evidence that targeted therapy towards figurative language improves communication in chronic TBI individuals.

There is level 4 evidence that text-to-speech technology improves reading rates post ABI but not reading comprehension.

There is level 4 evidence that cognitive-communication therapy targeting the interpretation of figurative language is effective for improving language and metaphor comprehension following an ABI.

KEY POINT

- Communicating "yes/no" responses with consistent training and environmental enrichments does not improve communication responses in individuals post ABI.
- Retrieval practice is effective for improving verbal communication in individuals with an ABI.
- Targeted figurative language therapy improves communication and comprehension in individuals with TBI; although the severity of the injury may moderate these effects.
- Text-to-speech technology improves reading rates in individuals with TBI, but not comprehension.

Social Communication Skills Training for Individuals and Communication Partners

After an ABI, issues may present in either verbal or nonverbal communication skills; difficulties with conversation may include topic introduction, topic maintenance, topic choice, turn taking and perspective taking (College of Audiologists and Speech Language Pathologists of Ontario, 2002)

Pragmatics describe "a person's ability to perceive, interpret and respond to the contextual and situational demands of conversation" (Wiseman-Hakes et al., 1998). In other words, pragmatics refers to the interaction between language behavior and the context in which language occurs (Strauss HM & RS, 1994). Studies have shown that the conversations of individuals with ABI, compared to individuals without injury, have been rated as significantly less interesting, less appropriate, less rewarding, more effortful, and more reliant on conversation partners to maintain the flow of the conversation (Bond & Godfrey, 1997; Coelho et al., 1996). Since it is through conversation that we form and maintain relationships, impaired communication can have a significant negative impact on social competence, vocational competence and academic competence. Social communication deficits in ABI can result in social isolation, frustration, and a sense of helplessness (Kilov et al., 2009; Sarno et al., 1986).

Social Communication Skills Training

ABI can influence every aspect of life including physicality, cognitive function, emotional responses, and social functioning. Social communication training more specifically addresses social competence and removing barriers to returning to a meaningful and productive life, which includes having the ability to sustain interpersonal relationships (Braden et al., 2010). Communication remediation focuses on one's ability to improve expressive language, speech production, reading, writing, and cognition.

TABLE 6 | The Effectiveness of Social Communication Skills Training Post ABI

Author, Year Country Study Design Sample Size	Methods	Outcome
Westerhof-Evers et al. (2017) Netherlands RCT PEDro=7 $N_{Initial}$=61 N_{Final}=56	**Population:** TBI; Mean Age=43.2 yr; Gender: Male=83, Female=17; Severity: Moderate to severe. **Treatment:** Participants were randomly assigned to receive Treatment for Impairments in Social Cognition and Emotion Regulation (T-ScEmo, n=30) protocol or Cogniplus (n=29) training. The TScEmo protocol is aimed at enhancing emotion perception, perspective taking, theory of mind, goal-directed social behaviour through 20 individual treatment sessions offered 1-2x/wk by neuropsychologists. Cogniplus is an individually administered computerized attention training aimed at improving general cognition. Outcomes were assessed baseline (T0), post-intervention (T1), and 3-5 mo follow-up (T2). **Outcome Measure:** The Awareness of Social Inferences Test (TASIT-short), Sixty faces test (FEEST), Cartoon test, Faux Pas test (FP), Wechsler Adult Intelligence Scale (WAIS-III digit span), Trail Making Test (TMT A and B/A), Test of Everyday Attention Lottery (TEA lottery), Dysexecutive Questionnaire-Social scales (DEX-Soc-self, DEX-Soc-proxy), Brock's Adaptive Functioning Questionnaire-Social monitoring scale (BAFQ-SM-self, BAFQ-SM-proxy), BAFQ empathy scale (BAFQ-Emp-self, BAFQ-Emp-proxy), Role Resumption List (RRL), Quality of Life after Brain Injury (QOLIBRI satisfaction, QOLIBRI burden), Treatment Goal Attainment (TGA), Relationship Quality Scale (RQS-self, RQS-life partner).	1. For the primary outcome of TASIT-short, there was no significant improvements over time in either group or no significant differences between groups. 2. Significant Time x Group interactions from T0 to T1 were observed for FEEST (p=0.01), CT (p=0.02), RRL (p<0.01), and TGA (p<0.01). No significant interactions from T0 to T1 were observed for FP, DEX-Soc-self, DEX-Soc-proxy, BAFQ-SM-self, BAFQ-SM-proxy, BAFQ-Emp-self, BAFQ-Emp-proxy, QOLIBRI satisfaction, QOLIBRI burden, RQS-self, RQS-life partner, WAIS-III digit span, TMT A, TMT B/A, or TEA lottery. 3. Significant Time x Group interactions from T0 to T2 were observed for FEEST (p<0.01), CT (p=0.02), BAFQ-Emp-proxy (p=0.02), RRL (p<0.01), QOLIBRI burden (p=0.04), RQS-life partner (p=0.02), and TGA (p<0.01). No significant interactions from T0 to T2 were observed for FP, DEX-Soc-self, DEX-Soc-proxy, BAFQ-SM-self, BAFQ-SM-proxy, BAFQ-Emp-self, QOLIBRI satisfaction, RQS-self, WAIS-III digit span, TMT A, TMT B/A, or TEA lottery.
Dahlberg et al. (2007) USA RCT PEDro=6 N=52	**Population:** TBI; Mean Age=41.17 yr; Gender: Male=44, Female=8; Mean Time Post Injury=9.67 yr; Severity: Severe=40, Moderate to mild=12. **Treatment:** Patients were randomly assigned to either the experimental (n=26) group or the control group (n=26). Individuals receiving the training focused on listening to others, communicating needs, and regulating their emotions during social interactions. There were 12 sessions each lasting 1.5 hr. The control group waited 3 mo before undergoing	1. Results of the PFIC rating scale showed significantly greater improvements on 7 of the subscales included on the PFIC: general participation (p=0.001), quantity (p=0.024), internal relation (p=0.009), external relation (p=0.005), clarity of experience (p=0.024), social style (p<0.001) and aesthetics (p=0.014). 2. The SCSQ-A showed significant improvement (p=0.005) for the treatment group compared to the control, pre- and post-intervention. 3. Over time significant improvement were noted between baseline scores and post-treatment

	treatment. Patients were assessed 5 times: baseline (wk 0), end of treatment (wk 12), at wk 24, 36 and 48. **Outcome Measure:** Profile of Functional Impairment in Communication (PFIC), Social Communication Skills Questionnaire-Adapted (SCSQ-A), Goal Attainment Scale (GAS).	scores for all participants receiving training on the PFIC (21 of the 30 subscales: p<0.001). Significant improvement was noted on the SCSQ-A (p<0.001) as well. 4. Significant improvements were made on the GAS from baseline to all post-treatment evaluations (p<0.001).
Rietdijk et al. (2020) Australia Cohort N=51	**Population:** Moderate to Severe TBI. *Telehealth Group (N= 19):* Mean Age= 42yr; Gender: Male=17, Female=2; Mean Time Post Injury= 53mo. *In person Group (N= 17):* Mean Age= 54yr; Gender: Male=13, Female=4; Mean Time Post Injury= 12mo. *Control Group (N= 15)*: Mean Age=36yr; Gender: Male=13, Female=2; Mean Time Post Injury= 91mo. **Intervention:** Participants allocated to the following groups: (1) In-person TBIconneCT at home, (2) telehealth TBIconneCT via Skype and (3) historical control group. Both intervention arms had 10 sessions (1.5hr each) delivered by a speech-language pathologist and focused on activities related to social communication skills (clinical modeling, feedback, rehearsal and role-play). **Outcome Measures:** Conversation samples (purposeful and casual conversations): Adapted Measure of Support in Conversation (MSC) and Adapted Measure of Participation in Conversation (MPC).	1. There was a significant difference between the training groups (In-person and Telehealth) compared to the control group on the MSC Reveal Competence (p=0.04); those in the trained groups improved whereas controls declined. 2. There was also a significant difference between training groups and controls on MPC Interaction, MPC Transaction, and MSC Acknowledge competence subscales (p<0.05) from pre to post-treatment for casual conversations and MPC transaction in purposeful conversation; training groups improved and controls declined. 3. There was a significant between group difference between training groups for MPC Transaction, favoring the in-person group for purposeful conversations.
Rietdijk et al. (2020) Australia Cohort N=51	**Population:** Moderate to Severe TBI. *Telehealth Group (N= 19):* Mean Age= 42yr; Gender: Male=17, Female=2; Mean Time Post Injury= 53mo. *In person Group (N= 17):* Mean Age= 54yr; Gender: Male=13, Female=4; Mean Time Post Injury= 12mo. *Control Group (N= 15)*: Mean Age=36yr; Gender: Male=13, Female=2; Mean Time Post Injury= 91mo. **Intervention:** Participants allocated to the following groups: (1) In-person TBIconneCT at home, (2) telehealth TBIconneCT via Skype and (3) historical control group. Both intervention arms had 10 sessions (1.5hr each) delivered by a speech-language pathologist and focused on activities related to social communication skills (clinical modeling, feedback, rehearsal and role-play). **Outcome Measures:** La Trobe Communication Questionnaire (LCQ).	1. There were no significant between group differences found pre and post treatment on the LCQ total scores when comparing training groups (in-person and telehealth) to controls, or in-person to telehealth groups. 2. There were no significant between group differences found from post-treatment to follow-up on the LCQ total scores when comparing training groups (in-person and telehealth) to controls, or in-person to telehealth groups.
Behn et al., (2019b) UK PCT $N_{Initial}$=21, N_{Final}=21	**Population:** TBI=13; *Treatment Group (n=11):* Mean Age=43.55±14.39yr; Gender: Male=6, Female=5; Mean Time Post Injury=12.27±12.54yr; Severity: Mild=0, Moderate=1, Severe=7.	1. Conversational interaction significantly improved in the treatment group compared to the waitlist group (MPC-Interaction, p=0.04). 2. The communication skills of communication partners significantly improved in the treatment group (MSC, p=0.02).

	Control Group (n=10): Mean Age=48.30±14.91yr; Gender: Male=5 Female=5; Mean Time Post Injury=11.60±13.52yr; Severity: Mild=0, Moderate=0, Severe=5. **Intervention:** Participants were allocated to a treatment or waitlist control group. The treatment group attended a project-based group session for ten 2h sessions over 6wk. Participants worked on projects aimed at helping others, improving communication skills and quality of life. Outcome measures were assessed at baseline, 1-2wk before the commencement of treatment, 1-2wk post treatment and 6-8wk post-treatment at follow-up. **Outcome Measures:** Adapted Measure of Participation in Conversation (MPC), Satisfaction With Life Scale (SWLS), Adapted Measure of Support in Conversation (MSC), Conversation Impression Scales (Appropriate, Effortful, Interesting, Rewarding), La Trobe Communication Questionnaire (LCQ), Goal Attainment Scaling (GAS), Quality of Life in Brain Injury (QOLIBRI).	3. GAS and conversation effort significantly improved in the treatment group (GAS, p<0.0011; Effortful Conversation Impression Scale, p=0.03). 4. No other outcome measures significantly improved in the treatment group compared to controls (p>0.05).
Cizman et al., (2020) Slovenia Pre-Post $N_{Initial}$=7, N_{Final}=7	**Population:** TBI=6; Mean Age=34±18.6yr; Gender: Male=5, Female=2; Mean Time Post Injury=4±1.25mo; Severity: Mild=0, Moderate=2, Severe=4. **Intervention:** Participants completed a Goal-Orientated Attentional Self-Regulation (GOALS) training program consisting of ten 2h group sessions twice a wk, 3h of individual therapy with a psychologist and 20h of self-training at home. The program focused on cognitive and social skill training, as well as psychoeducation. Outcome measures were assessed at baseline and conclusion of the program. **Outcome Measures:** Alertness and Distractibility, Mobility Version of Test of Attentional Performance (TAP-M), Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), Letter Fluency Test, Tower of London Test, Stroop Interference Test, Clinical Assessment of Depression (CAD).	1. No significant differences in reaction times were observed on the Alertness and Distractibility task when compared to baseline (p>0.05). 2. No significant improvements were observed in measures of executive function (Tower of London, STROOP and Verbal Fluency; p>0.05). However, TAP-M performance significantly worsened when compared to baseline (p<0.05). 3. List learning and story delayed recall measures of the RBANS significantly improved from baseline (p=0.028, p=0.043), while the remainder of RBANS measures were not significant (p>0.05). 4. No significant differences in ratings of depression or anxiety were observed from baseline (p>0.05).
Behn et al., (2019a) UK Pre-Post $N_{Initial}$=21, N_{Final}=21	**Population:** TBI=13; Mean Age=45±14.47yr; Gender: Male=12, Female=9; Mean Time Post Injury=11.95±12.69yr; Severity: Mild=0, Moderate=1, Severe=12. **Intervention:** Individuals participated in a group treatment program focused on enhancing social and cognitive skills. Group interventions were facilitated by a speech and language therapist and consisted of ten 2h	1. All participants were able to set goals with their communication partners within one session. 2. One participant was unable to recall their goals independently post-treatment. 3. For the remaining participants, goal recall improved as treatment progressed. Initially, 38% of participants were able to recall their goal correctly, compared to 95% in the final

	sessions over a 6wk period for a total of 20h. Participants were taught techniques to improve their conversational skills, as well as methods to set and achieve social communication goals. Outcome measures for participants and their communication partners were assessed at baseline, post-treatment and follow-up (6-8wk later). **Outcome Measures:** Goal-setting and recall, Goal achievement (Goal Attainment Scaling (GAS)).	treatment session; however, no statistical analyses were conducted. 4. Goal achievement significantly improved from pre-treatment to post-treatment as rated by the participant (p<0.001) and their communication partner (p<0.001). This improvement was maintained at follow-up. 5. Participants and communication partners agreed on GAS ratings, as no significant differences were observed between groups at any time point (p>0.05).
Douglas et al., (2019) Australia Pre-Post $N_{Initial}$=13, N_{Final}=13	**Population:** TBI=13; Mean Age=27.54±10.51yr; Gender: Male=Not Reported, Female=Not Reported; Mean Time Post Injury=7.62±5.16yr; Severity: Mild=0, Moderate=0, Severe=13. **Intervention:** Participants completed a communication-specific coping intervention (CommCope-1) program in two group sessions per wk for 6wk. The program focused on cognitive behavioural therapy, self-coaching and social communication therapy. Outcome measures were assessed at baseline, 6 and 12wk. **Outcome Measures:** Communication-Specific Coping Scale- Research Version (CommSPeCS), Discourse Coping Scale-Clinician Rating (DCS-CR), La Trobe Communication Questionnaire (LCQ), Stress Subscale of the Depression Anxiety Stress Scales-21(DASS-21).	1. A significant improvement in functional communication (LCQ, p=0.017), stress (DASS-21, p=0.026) as well as self, close other and clinician rated communication-specific coping strategies (CommSpeCS, p<0.05; DCS-CR; p<0.05) was observed at 12wk follow-up when compared to baseline.
Keegan et al., (2019) USA Pre-Post $N_{Initial}$=10, N_{Final}=6	**Population:** TBI=9; Age Range=28-58yr; Gender: Male=8, Female=2; Mean Time Post Injury= 18yr; Severity: Mild=0, Moderate=1, Severe=5. **Intervention:** Participants attended a group program (INSIGHT) that was focused on improving cognitive-communication skills 2h/wk for 35 sessions. Outcome measures were assessed at baseline, 2mo, 6mo and 1yr. **Outcome Measures:** Goal Attainment Scaling (GAS), Exchange Structure Analysis (Qualitative).	1. GAS significantly improved over time (p<0.05), indicating progress towards set goals. 2. Exchange structure analysis revealed improvement in interaction and communicative participation in all participants.
Parola et al. (2019) Italy Pre-Post N=10	**Population:** TBI; Mean Age=41.4±12.2yr; Gender: Male=10, Female=0; Mean Time Post Injury=129.1±97.1mo; Mean GCS=4.7±1.9. **Intervention:** Cognitive pragmatic treatment (CPT) that encompasses different communicative skills such as how to structure a discourse. CPT was run by 2 psychologists in groups of 5, 1.5hr/session, 2x/wk for 3mo. Assessments conducted at T0 (3mo before treatment), T1 (1wk before treatment), T2 (1wk after treatment) and T3 (3mo post treatment). **Outcome Measures:** Neuropsychological Tests: Naming task of the Aachener Aphasie test, Attentional Matrices, Disyllabic Word	1. No significant differences were found between T1 and T2 for any of the neuropsychological tests (p>0.05). 2. From T1 to T2, participants produced significantly higher percentage of lexical information units after treatment (p<0.05), an indicator of improvement in the quality of their informational skills. 3. A main effect of treatment on the Assessment Battery for Communication was found; participants made significant improvements post treatment (T2 and T3) compared to before (T0 and T1; p<0.001).

	Repetition test, Corsi's Block-Tapping test, Deferred Recall test, Tower of London test, Modified Card Sorting test, Trail Making task, Raven's Colored Progressive Matrices, Sally & Ann task, Strange Stories task. Narrative Abilities: Picture narrative description tasks. Assessment of communicative pragmatic abilities: Assessment Battery for Communication.	
Bosco et al. (2018) Italy Pre-post N=19	**Population:** *Severe TBI:* Mean age=38.5yr; Gender: Male=16, Female=3; Mean time post-injury=99.4 months; GCS<8. **Intervention:** Groups of 5-6 participants met twice a week for 12 weeks for a total of 24 Cognitive Pragmatic Treatment (CPT) sessions. Participants were assessed at four time points, 3-months pretreatment, immediately before treatment, immediately following treatment, and 3-months post-treatment. **Outcomes:** Assessment Battery for Communication (ABaCo), Communications Activities of Daily Living (CADL), Aachener Aphasie test, Attentional Matrices, Trail Making test, Verbal Span, Corsi's Block-Tapping test, immediate and deferred recall test, Tower of London test, Modified Card Sorting test, Raven Colored Progressive Matrices, Sally & Ann, Strange Stories.	1. There was a significant difference in scores on the ABaCO between pretreatment and posttreatment scores (p<0.001). There were no significant differences between the two initial time points or the two posttreatment timepoints. 2. Similar results were seen for the CADL, with individuals showing a significant improvement in their functional communication skills following treatment (p=0.024). Between immediate pretreatment scores and immediate posttreatment scores significant differences were only seen on the Verbal Span (p=0.045), and the Modified Card Sorting test (p=0.004).
Finch et al. (2017) Australia Pre-Post N=8	**Population:** TBI; Mean Age=36.25 yr; Gender: Male=4, Female=4; Mean Time Post Injury=24.6 mo; Mean GCS=8.25; Severity: moderate=1, severe=7. **Treatment:** Participants received one 1 hr group and one 1 hr individual therapy session per wk for 8 wk. Therapy sessions were led by a speech-language pathologist and focussed on remediating impaired social communication skills using metacognitive strategy instruction training and goal-based therapy. Outcomes were assessed at baseline (4 wk baseline prior to intervention, pre-intervention, post-intervention, and 4 wk follow-up. **Outcome Measure:** Profile of Pragmatic Impairment in Communication (PPIC), LaTrobe Communication Questionnaire (LCQ), Goal Attainment Scaling (GAS).	1. For PPIC, only the literal content (p=0.005), general participation (p=0.02), internal relation (p=0.008), clarity of expression (p=0.026), and aesthetics (p=0.016) subscales showed significant improvement from baseline to 4 wk follow-up. No significant differences were observed for the quantity, quality, external relation, social style, or subject style subscores. 2. For PPIC, only the aesthetics subscale was significantly improved (p=0.039) comparing post-intervention to pre-intervention. 3. No significant differences for LCQ were observed when comparing baseline to 4 wk follow-up or pre- to post-intervention. 4. During the intervention, participants identified between three and six goals each. Following the intervention, there was a significant increase in GAS goal T-scores (p=0.012).
Llorens et al. (2012) Spain Pre-Post N=10	**Population:** ABI=10; Mean Age=41.1yr; Gender: Male=7, Female=3; Mean Time Post Injury=402.2d. **Intervention:** Participants underwent sessions (1hr/wk for 8mo) using an interactive touch screen-based game asking questions related to knowledge, reasoning, action, and cohesion in	1. On the SADI, after treatment all participants perceived their deficits properly compared to only 4 participants at baseline; 2 participants had difficulty perceiving their disability post treatment compared to 7 participants at baseline and 5 participants had difficulty establishing realistic goals post treatment compared to 7 at baseline.

	groups of ≤4. Testing of participants occurred at baseline and post intervention. **Outcome Measure:** Self-Awareness Deficits Interview (SADI), Social Skills Scale (SSS).	2. On the SSS at baseline, 6 participants showed altered levels in social skills, compared to 2 following treatment.
Braden et al. (2010) UK Cohort $N_{initial}$=30 N_{final}=17	**Population:** TBI; Mean Age=42.11 yr; Gender: Male=21, Female=9; Mean Time Post Injury=7.85 yr. **Treatment:** Participants received Group Interactive Structured Treatment (GIST) for social competence. This program was provided in a rehabilitation facility or in the community. A treatment workbook, developed specifically for GIST, was given to each participant. Each group member was asked to attend 13, 1.5 hr/wk sessions to discuss various topics related to effective communication. Patients were assessed at baseline, post-treatment, and at 3 and 6 mo. **Outcome Measure:** Profile of Pragmatic Impairment in Communication (PPIC), Social Communication Skills Questionnaire-Adapted (SCSQ-A), Goal Attainment Scale (GAS), Satisfaction with Life Scale (SWLS).	1. Social communication skills, as assessed by SCSQ-A, GAS and SWLS, improved significantly pre- to post-assessment (p<0.05). 2. For those in the TBI+ group (those with a substance disorder, a psychiatric disorder, or other neurological complications) significant improvement was noted on their SCSQ-A, GAS, SWLS scores (p<0.01, p<0.000 and p=0.01 respectively). The improvement on the PPIC was not significant (p=0.40). 3. There were no significant differences comparing the groups (TBI only to TBI+) at baseline, post-intervention or 6 mo post-intervention for the PPIC, person ratings on SCSQ-A, GAS and SWLS.

Discussion

An RCT by Westerhof-Evers et al. (2017) compared the use of a Social cognition and Emotion regulation treatment (T-ScEmo) to a treatment for general cognitive gains (Cogniplus) (control group), to evaluate how participants performed on emotion perception, social understanding, and social behavior. The T-ScEmo group had statistically significant improvements on emotion perception (facial affect recognition), theory of mind, proxy-rated empathic behavior, societal participation, and treatment goal attainment, when compared with the Cogniplus group (Westerhof-Evers et al., 2017). Participants in the T-ScEmo group also reported higher quality of life and their life partners rated relationship quality to be higher than those in the Cogniplus group. Similarly, in a pre-post study, Douglas et al. (2019) examined the effects of a communication-specific coping program and found a significant improvement in functional communication, stress, and communication-specific coping strategies.

In an RCT conducted by Dahlberg et al. (2007) it was found that subjects in the experimental group, when exposed to twelve, 1.5 hour communication sessions, significantly improved their scores on the general participation in conversation subscale on the Profile of Functional Impairment in Communication and the Social Communication Skills questionnaire-adapted (Dahlberg et al., 2007). These improvements were also noted at 6- and 9-month follow-up periods. It's worth noting that both Dahlberg et al. (2007) and Westerhof-Evers et al. (2017) interventions included components of emotional regulation.

Finch et al. (2017) conducted pre-post study in adults with brain injury aimed at improving and maintaining social communication skills, in particular, the study authors focused on improved perceived communication skills, and achievement of goals. The results from this study indicated that goal-driven and metacognitive strategy-based interventions may help individuals with TBI achieve social communication goals. Similarly, three studies examined the effects of a group social communication intervention, focused on achieving social communication goals, on improving social communication skills (Behn et al., 2019a, 2019b). The results from these studies support that of Finch et al. (2017), in that conservational interaction significantly improved with the achievement of social communication goals. In contrast, one study found that a goal orientated communication program did not significantly improve social communication skill; however, it is important to note that the population size of this study was only seven (Cizman Staba et al., 2020).

Braden et al. (2010) examined the efficacy of the Group Interactive Structured Treatment (GIST) for social competence in a cohort study examining 30 individuals greater than one year post ABI. The 13 week training reviewed the following topics: skills of the great communicator, self-assessment and goal setting, starting conversations, keeping conversations going and using feedback, assertiveness in solving problems, practice in the community, social confidence through positive self-talk, social boundaries, videotaping, video review, conflict resolution, closure and celebration (Braden et al., 2010). Overall, data gathered demonstrated significant positive effects of GIST on social communication. Further, the program seemed to be effective for individuals with TBI who also comorbidities had, as stratification revealed there were no significant differences between these groups in terms of outcome. Two other studies have examined the effects of group cognitive pragmatic therapy (Bosco et al., 2018; Parola et al., 2019). In both studies, individuals were seen to improve on measures of communication, communication in daily activities, and verbal span. Although these studies demonstrated significant improvements in social and functional communication, there was no control group to determine the effects of this therapy compared to no or alternative therapies.

One study used interactive touch screens to apply a game-based question activity, which included topics around knowledge, reasoning, action, and cohesion of thoughts (Llorens et al., 2012). Although formal statistical analysis was not performed, 6/10 participants initially showed altered levels of communication on the Social Skills Scale, compared to only 2/10 post-treatment.

Lastly, two cohort studies investigated the effects of in-person versus telehealth delivery of a social communication skills program (R. Rietdijk et al., 2020; Rachael Rietdijk et al., 2020). Both studies found no significant differences on communication skills outcomes, suggesting that telehealth delivery of social communication programs is equally effective as in-person programs.

Conclusions

There is level 1b evidence that the Social Cognition and Emotion Regulation protocol when administered by a neuropsychologist is more effective for the remediation of social communication skills than the Cogniplus protocol in individuals with an ABI.

There is level 1b evidence that a variety of communication skills training programs improve social communication skills in individuals with an ABI, as well as self-concept and self-confidence in social communications.

There is level 4 evidence suggesting that a goal-driven, metacognitive approach to intervention may be beneficial in assisting individuals with TBI to achieve social communication goals.

There is level 4 evidence that interactive touch screen games focused on areas of reasoning, knowledge and action may be effective for improving social skills following an ABI.

There is level 2 evidence that the Group Interactive Structured Treatment program (GIST) is effective for improving social communication skills in those with a TBI as well as other neuropsychological comorbidities.

There is level 2 evidence that telehealth social communication skills programs are equally effective as in-person programs for improving social communication skills in individuals with TBI.

KEY POINTS

- Training in social skills, social communication or pragmatics is effective in improving communication following brain injury.
- Goal-driven interventions may be effective in improving social communication skills and goals following TBI.
- Group Interactive Structured Treatment (GIST) is effective for improving social communication skills following an ABI.
- Computer-based game programs which deliver cognitive-communication skills training may be effective for improving social skills.

Training Communication Partners

The success of communication interventions often relies on the understanding, compliance and competence of communication partners. Training of communication partners has become a central component of communication interventions with many populations. This development is consistent with the World Health Organization (2001) emphasis on *context* (environmental and attitudinal) as a determinant in health and disability outcomes. Training of communication partners has been shown to have a positive effect on communication effectiveness and reacquisition of communication skills in children with language disorders and developmental disabilities (Girolametto et al., 1994), adults with aphasia (Kagan et al., 2001), adults with dementia (Ripich et al., 1999), and adults with ABI (Togher et al., 2004).

Following an ABI individuals may have difficulty engaging in meaningful conversation with others. Training communication partners is particularly helpful in successfully facilitating communication with those with moderate to severe ABI. The strategies that are most useful in ensuring success of treatment include speaking in short, simple sentences, making and maintaining eye contact, and asking the patient to repeat the messages being conveyed (Behn et al., 2013). Also, asking patients to clarify that they understand the information and repeating the information, when necessary, while allowing adequate time to receive an answer. Presenting the information in written form can also elicit a positive outcome from patients (Behn et al., 2013). Eliminating environmental distractions will be a tremendous aid to allow proper focus and attention for optimal results. Communication partners should present choices to patients and clarify the intent of the message being delivered. Using a variety of modes of communication (such as nonverbal) can also be a useful strategy (Behn et al., 2012, Togher et al., 2004, Togher et al., 2016, Sim et al., 2013, Togher et al. 2013).

TABLE 7 | Strategies for Training Communication Partners for those with ABI

Author, Year Country Study Design Sample Size	Methods	**Outcome**
Behn et al. (2012) Australia RCT PEDro=6 N=15	**Population:** Caregivers=10, TBI=5. *TBI*: Mean Age=29.2 yr; Gender: Male=3, Female=2; Mean Time Post Injury=6.8 yr. **Treatment:** Caregivers were randomly assigned to a program on how to facilitate better conversations with individuals who had a TBI. The treatment group (n=5) participated in in a range of collaboration and elaboration conversational strategies (17 hr across 8 wk). Collaborative strategies were designed to encourage those with a TBI to participate more actively in conversations. The control group (n=5) was not trained. **Outcome Measure:** Adapted Measure of Support in conversation (MSC), Adapted Measure of Participation in Conversation, La Trobe Communication Questionnaire, Modified Burden Scale.	1. The trained group improved significantly on the MSC-acknowledging competence (p<0.001) and MSC-revealing competence (p=0.002). 2. Study results found paid caregivers were able to benefit from training; all participants were able to improve their communication skills with those who had sustained a TBI. Trained caregivers also found they experienced greater levels of burden and described negative aspects of caring more often than those who were not in the paid group.
Togher et al. (2004) Australia RCT Crossover PEDro=5 N=40	**Population:** Police Officers=20, TBI=20**.** *TBI*: Gender: Male=20, Female=0; Mean Age=36.75 yr; Mean Time Post Injury=8.8 yr. **Treatment:** Patients were randomly assigned to interact with trained (treatment; n=10) or untrained (control; n=10) male police officers. Trained officers were provided with a 6 wk program targeting communication strategies using videos, theory, and transcripts **Outcome Measure:** Analyzed transcripts, Communication effectiveness.	1. Partner training resulted in more efficient and focused interactions, and fewer episodes of unrelated utterances by the people with ABI. 2. Trained communication partners were able to use strategies such as providing appropriate feedback and support during service encounter interactions, which enabled people with ABI to respond in an appropriate manner.
Togher et al. (2016) Australia	**Population:** TBI; Gender: Male=26, Female=18. *Control (n=15)*: Mean Age=38.1 yr; Mean Time	1. Post treatment, communication partners in JOINT reported greater overall improvements

PCT $N_{Initial}$=44 N_{Final}=38	Post Injury=9.7 yr. *JOINT (n=14)*: Mean Age=30.3 yr; Mean Time Post Injury=8yr; *TBI SOLO (n=15)*: Mean Age=39.7 yr; Mean Time Post Injury=8.1 yr; **Treatment:** Participants were allocated to one of three groups: 1) control group, no training; 2) the JOINT group, attended all sessions together with their communication partner; or 3) the TBI SOLO group, attended sessions without their communication partner. The training was 2.5 hr/wk of group sessions and 1 hr/wk of individual sessions for 10 wk. Outcomes were assessed before and after treatment, and at 6 mo follow-up. **Outcome Measure:** La Trobe Communication Questionnaire (LCQ) - Self Report and Significant Other Report.	compared to TBI SOLO (p=0.05) and control (p<0.001). 2. Post treatment, individuals with TBI and their partners reported more positive change on LCQ in JOINT (p<0.001 for both) and TBI SOLO (p=.01; p=0.004) compared to controls, with only a significant difference on LCQ significant others reports between JOINT and TBI SOLO conditions (p=0.002). 3. At follow-up, individuals with TBI reported increase in positive change in communication skills in JOINT (p=0.01) and TBI SOLO (p=0.03) compared to controls, with no significant difference between JOINT and TBI SOLO. 4. At follow-up, more change was reported in communication partners in JOINT than TBI SOLO (p=0.01) and controls (p<0.001).
Sim et al. (2013) Australia PCT $N_{Initial}$=29 N_{Final}=27	**Population:** TBI; Gender: Male=24, Female=5. *JOINT Group (n=14)*: Mean Age=30.29 yr; Mean Time Post Injury=8.04 yr *Control Group (n=15)*: Mean Age=38.07 yr; Mean Time Post Injury=9.71 yr. **Intervention:** Participants and their everyday communication partners (ECPs) were allocated into either the JOINT training that received social communication training or a waitlist control group. The training was 2.5 hr/wk of group sessions and 1 hr/wk of individual sessions for 10 wk **Outcome Measure:** Exchange Structure Analysis (ESA), Productivity analysis, Information giving moves (K1), Information requesting or receiving moves (K2), Dynamic Moves (DM), Per Minute Speaking Time (PMST).	1. Those ECPs in the JOINT group, compared to controls, changed their use of questions more often (p=0.04) and their DM (information tracking/negotiation; p=0.07). 2. Participates with TBI in the JOINT group made greater improvements in PMST than controls (p=0.03). 3. No significant between group changes were identified for ECPS in K1 and K2. 4. No significant between group differences were determined for those with TBI in DM, K1, or K2.
Togher et al. (2013) Australia PCT $N_{Initial}$=44 N_{Final}=38	**Population:** TBI; Gender: Male=38, Female=6. *Control (n=15):* Mean Age=38.1 yr; Mean Time Post Injury=9.7 yr. *JOINT (n=14):* Mean Age=30.3 yr; Mean Time Post Injury=8 yr. *TBI SOLO (n=15):* Mean Age=39.7 yr; Mean Time Post Injury=8.1 yr. **Intervention:** Participants were allocated to one of three groups: 1) control group, no training; 2) the JOINT group, attended all sessions together with their communication partner; or 3) the TBI SOLO group, attended sessions without their communication partner. The training was 2.5 hr/wk of group sessions and 1 hr/wk of individual sessions for 10 wk. Training included role-play, listening to audio-recordings, practice interactions, and conversation strategies. Outcomes were assessed before and after treatment, and at 6 mo follow-up. **Outcome Measure:** Adapted Measure of Participation in Conversation (MPC), Adapted	1. On the MPC, the JOINT group had greater improvements than the control group for both casual conversations (CC) and purposeful conversations (PC) on the Interaction scale (CC: p=0.01, PC: p=0.03) and on the Transaction scale (CC: p=0.003, PC: p=0.008). 2. The JOINT group made greater gains compared to the TBI SOLO group for Transaction scores in both conditions (CC: p=0.02, PC: p=0.01), and the Interaction scale for PC (p=0.03). 3. There were no significant differences between the TBI SOLO group and the control group on the MPC. 4. There were no significant between group differences on the MSC. 5. At 6mo follow-up, there were no significant changes on outcome measures.

	Measure of Support in Conversation (MSC).	

Discussion

Studies examining communication partner training either focused on training individuals and their communication partners jointly (n=5), or independently (n=1). For the single study examining communication training interventions only for communication partners positive effects were still found (Togher et al., 2004). In a RCT conducted by Togher et al. (2004), the benefits of training individuals regarding how to effectively communicate with post ABI individuals was evident. Police officers were trained to respond to individuals with ABI, while the remaining officers who volunteered did not participate in the training. Overall, it was noted that trained officers significantly reduced the number of inquiries required to gain the necessary information from their callers, as well as spent less time establishing the nature of the service request and more time answering the questions being presented.

For studies using grouped training Behn et al. (2012) found that training allowed for caregivers to interact more easily with the individual with a TBI when strategies were used to encourage dialogue, this was compared to an untrained control group. The training in this study consisted of a number of didactic and performance-based approaches such as modeling, role-playing, feedback and rehearsal. As well, the strategies used were both elaborative and collaborative.

When examining training communication partners, the most efficacious way to improve interactions is to have both the individual with an ABI and their communication partner participate in training together. Two studies by Togher et al. (2013; 2016) found that those who completed social communication training together, made significantly greater gains in participation and overall communication compared to individuals with TBI who attended alone or those who received no training. In a similar study, providing training to communication partners allowed for their communication styles to be modified, which in turn allowed for the individual with TBI to improve their communication (Sim et al., 2013). This study highlighted the benefits of monitoring the two-way interaction using discourse analysis to ensure that information is given, received, and negotiated in an effective and appropriate way (Sim et al., 2013).

Conclusions

There is level 2 evidence to support the effectiveness of interventions that focus on training communication partners in the community, compared to no training, for improving interactions between responders and those with an ABI.

There is level 2 evidence that providing training to both the communication partner and the individual with a TBI together is more effective than only training the individual with TBI alone or no training at all.

KEY POINT

- Providing communication training to individuals who interact with people with TBI is effective and encourages two-way dialogue.
- Providing training to the communication partner and the individual with TBI together is more effective than training the individual with TBI alone.

Non-Verbal Communication

Goals of treatment regarding non-verbal communication post ABI include initiating conversation with others, learning to understand the emotion presented in verbal language, the ability to respond appropriately, and to maintain conversation. In order to achieve these goals, the necessary strategies to be employed consist of environmental and behavioural modification, counselling and support, pragmatic skills trailing, and targeted speech and language therapy. Patients will require positive reinforcement of the appropriate responses, as well as auditory/visual feedback by others.

Studies have shown that the conversations of individuals with ABI, compared to individuals without injury, have been rated as significantly less interesting, less appropriate, less rewarding, more effortful, and more reliant on conversation partners to maintain the flow of the conversation (Bond & Godfrey, 1997; Coelho et al., 1996). Since it is through conversation that we form and maintain relationships, impaired communication can have a significant negative impact on social competence, vocational competence and academic competence. Social communication deficits in ABI can result in social isolation, frustration, and a sense of helplessness (Kilov et al., 2009; Sarno et al., 1986).

TABLE 8 | Effectiveness of Pragmatic and Emotional Intelligence Interventions

Author, Year Country Study Design Sample Size	Methods	Outcome
Westerhof-Evers et al. (2017) Netherlands RCT PEDro=7 $N_{Initial}$=61 N_{Final}=56	**Population:** TBI; Mean Age=43.2 yr; Gender: Male=83, Female=17; Severity: Moderate to severe. **Treatment:** Participants were randomly assigned to receive Treatment for Impairments in Social Cognition and Emotion Regulation (T-ScEmo, n=30) protocol or Cogniplus (n=29) training. The TScEmo protocol is aimed at enhancing emotion perception, perspective taking, theory of mind, goal-directed social behaviour through 20 individual treatment sessions offered 1-2x/wk by neuropsychologists. Cogniplus is an individually administered computerized attention training aimed at improving general cognition. Outcomes were assessed baseline (T0), post-intervention (T1), and 3-5 mo follow-up (T2). **Outcome Measure:** The Awareness of Social Inferences Test (TASIT-short), Sixty faces test (FEEST), Cartoon test, Faux Pas test (FP), Wechsler Adult Intelligence	1. For the primary outcome of TASIT-short, there was no significant improvements over time in either group or no significant differences between groups. 2. Significant Time x Group interactions from T0 to T1 were observed for FEEST (p=0.01), CT (p=0.02), RRL (p<0.01), and TGA (p<0.01). No significant interactions from T0 to T1 were observed for FP, DEX-Soc-self, DEX-Soc-proxy, BAFQ-SM-self, BAFQ-SM-proxy, BAFQ-Emp-self, BAFQ-Emp-proxy, QOLIBRI satisfaction, QOLIBRI burden, RQS-self, RQS-life partner, WAIS-III digit span, TMT A, TMT B/A, or TEA lottery. 3. Significant Time x Group interactions from T0 to T2 were observed for FEEST (p<0.01), CT (p=0.02), BAFQ-Emp-proxy (p=0.02), RRL

Author, Year Country Study Design Sample Size	Methods	Outcome
	Scale (WAIS-III digit span), Trail Making Test (TMT A and B/A), Test of Everyday Attention Lottery (TEA lottery), Dysexecutive Questionnaire-Social scales (DEX-Soc-self, DEX-Soc-proxy), Brock's Adaptive Functioning Questionnaire-Social monitoring scale (BAFQ-SM-self, BAFQ-SM-proxy), BAFQ empathy scale (BAFQ-Emp-self, BAFQ-Emp-proxy), Role Resumption List (RRL), Quality of Life after Brain Injury (QOLIBRI satisfaction, QOLIBRI burden), Treatment Goal Attainment (TGA), Relationship Quality Scale (RQS-self, RQS-life partner).	(p<0.01), QOLIBRI burden (p=0.04), RQS-life partner (p=0.02), and TGA (p<0.01). No significant interactions from T0 to T2 were observed for FP, DEX-Soc-self, DEX-Soc-proxy, BAFQ-SM-self, BAFQ-SM-proxy, BAFQ-Emp-self, QOLIBRI satisfaction, RQS-self, WAIS-III digit span, TMT A, TMT B/A, or TEA lottery.
Neumann et al. (2015) USA RCT PEDro=9 $N_{Initial}$=71 N_{Final}=60	**Population:** TBI; *Faces (n=24)*: Mean Age=41 yr; Gender: Male=23, Female=1; Mean Time Post Injury=10.5yr; Mean GCS=6.9; *Stories (n=23)*: Mean Age=41.5 yr; Gender: Male=18, Female=5; Mean Time Post Injury=10.9 yr; Mean GCS=4.4; *Control (n=24)*: Mean Age=39.5 yr; Gender: Male=16, Female=8; Mean Time Post Injury=9.8yr; Mean GCS=5.3. **Treatment:** Participants randomly assigned to one of three interventions for 1 hr sessions 3 days/wk for 3 wk. Faces intervention taught individuals to recognize emotions in facial expressions, whereas stories intervention taught individuals to recognize emotion within stories. Control group underwent cognitive training. Participants assessed at pre-treatment and post-treatment within 4 days, at 3 mo and 6 mo. **Outcome Measure:** Diagnostic Assessment of Nonverbal Accuracy 2-Adult Faces (DANVA 2-AF), Emotional Inference from Stories Test (EIST), Interpersonal Reactivity Index (IRI), Neuropsychiatric Inventory (NPI) Irritability and Aggression domain.	1. According to DANVA 2-AF, participants trained in the face's intervention had a significant improvement across all follow-up time points compared to controls (p=0.031). 2. No significant improvement for the story's intervention on DANVA 2-AF compared to controls (p=0.239). 3. No significant improvement on EIST for the story's intervention (p=0.167) and faces (p=0.349) compared to controls. 4. Across all post-treatment assessments, there was a main effect of time as performance decreased for the story's intervention on EIST compared to controls (p=0.001). 5. NPI irritability and aggression and IRI empathy were not significant for faces or story interventions compared to controls.
McDonald et al. (2013) Australia RCT PEDro=6 N=20	**Population:** Severe TBI=16, CVA=3, Other=1; Mean Age=45.62 yr; Gender: Male=15, Female=5; Mean Time Post Injury=9.41 yr. **Treatment:** Patients were assigned to either a treatment group (n=10) or a control group (n=10). Patients receiving treatment attended 2hr/wk treatment sessions for 3 wk. Sessions consisted of a therapist and two participants. The program was tailored to focus on prosodic cues that may be seen in expressions of emotions. **Outcome Measure:** Awareness of Social Interference Test Form B-Part 1 (audio presentation), Prosodic Emotion Labelling Task, Communication Questionnaires.	1. No significant treatment effects were found for the TASIT B, while accuracy on the prosody task (p=0.074) and rating of intensity of emotions (p=0.076) approached significance. 2. The treatment group showed a significant change on the self-report communication questionnaire (p=0.013).

Author, Year Country Study Design Sample Size	Methods	Outcome
Radice-Neumann et al. (2009) USA RCT PEDro=5 N_{intial}=21 N_{final}=19	**Population:** TBI=19, ABI=2; Mean Age=43 yr; Gender: Male=12, Female=8; Mean Time Post Injury=12 yr; Mean GCS=4.08. **Treatment:** Patients were randomly assigned to receive either the facial affect recognition (FAR; n=10) training or the stories of emotional inference training (SEI; n=9). In the FAR training, individuals practiced identifying and discriminating emotions from facial expressions and focused on processing their internal emotions. SEI involved reading stories and answering questions. Sessions were 1:1 for 1 hr, 3 x/wk for 2-3 wk. **Outcome Measure:** Levels of Emotional Awareness Scale (LEAS), Diagnostic Assessment of Nonverbal Affect – adult faces/adult paralanguage (DANVA2-AF and DANVA2-AP), Brock Adaptive Functioning Questionnaire (BAFQ).	1. The FAR group improved on the DANVA2-AF over time (p<0.001), with changes being seen from pre-post (p<0.001) but not post to follow-up (p=0.244). 2. The SEI group also improved on the DANVA2-AF (p=0.006). The change occurred between the two pre-tests (p=0.004). 3. No significant changes were found for either group on the DANVA2-AP or the ability to infer emotions on video. 4. Both groups improved on their ability to infer emotions from contextual situations (LEAS; both p=0.019). 5. On the BAFQ, caregivers, indicated those in the FAR group showed improvement in the behaviour of patients (p=0.042); out of 4 emotional behaviours, only aggression changed significantly (p=0.047); SEI did not improve in perceived behaviour.
Gabbatore et al. (2015) Italy Pre-Post $N_{Initial}$=20 N_{Final}=15	**Population:** TBI; Mean Age=36.7 yr; Gender: Male=10, Female=5; Mean Time Post Injury=76.13 mo; Mean GSC=4.5. **Treatment:** Participants received a control procedure with non-communication activities for 3 mo. This was followed by a 3-mo cognitive pragmatic training program (2 sessions/wk) consisting of 5-patient groups focussed on improving pragmatic abilities, self awareness, and executive function. **Outcome Measure:** Assessment Battery for Communication (ABaCo-comprehension, production, linguistic, extralinguistic, paralinguistic, and context), Attentive Matrices, Trail Making test, Verbal Span, Spatial Span, Immediate and Deferred Recall test, Tower of London test, Wisconsin Card Sorting test (WCST), Coloured Progressive Matrices Raven, Aachener Aphasie test-denomination scale (AAT), Sally and Ann Task, Strange Stories Task.	1. No significant improvements in ABaCo (production and comprehension) were observed during the nonspecific control period. 2. Participants showed significant improvements from pre-training to post-training for ABaCo comprehension (p<0.001), production (p<0.001), linguistic (p=0.005), extralinguistic (p=0.008), paralinguistic (p=0.02), and context (p=0.01). 3. At 3 mo follow-up post-treatment, AbaCo scores did not show significant differences from post-treatment. 4. From pre-training to post-training, no significant differences were observed for Verbal Span, Spatial Span, Attentive Matrices test, Trial Making test, Tower of London test, Raven's Colored Progressive Matrices, AAT, Sally and Ann task, or the Strange Stories task. Improvements were observed for the Immediate and Deferred Recall task (p=0.01) and Wisconsin Card Sorting test (p=0.003).

Discussion

Westerhof-Evers et al. (2017) conducted an RCT describing social communication training. Not only did this study evaluate social understanding and social behaviour, it also examined emotional regulation and perception. On the emotional intelligence components of the study, the experimental group improved significantly on the facial affect recognition (Westerhof-Evers et al. 2017). Participants in the experimental group also reported higher quality of life and their life partners rated relationship quality to be higher than those in the control group (Westerhof-Evers et al. 2017).

A short treatment aimed at improving the ability to recognize emotional prosody was overall found to be ineffective (McDonald et al., 2013). Activities consisted of mostly games designed to focus on prosodic cues but found no change related to communication competence. Significance was approached for the treatment group in terms of improvements in the accuracy on the prosody task and ratings of intensity of emotions. However, participants in the treatment group self-reported that their ability to comprehend daily conversations had improved (McDonald et al., 2013).

Radice-Neumann et al. (2009) and Neumann et al. (2015) demonstrated that training focused on emotional processing (either by face affect recognition or by emotional inference training) can be effective when introduced to a group of individuals who had sustained an ABI. They assert that individuals with ABI can re-learn affective recognition skills. Two interventions to enhance emotion processing were utilized in both studies. The first intervention (Facial Affect Recognition), focused on attention to important visual information and attention to the participant’s own emotional experience. The second intervention (Stories of Emotional Inference) taught patients to read emotions from contextual cues presented in stories and then relate these stories to personal events. Participants who received Facial Affect Recognition training had more positive outcomes (Neumann et al., 2015). Participants were better at reading faces (emotions) and were more descriptive in relating how they or others would feel in a similar situation. Decreased level of aggression was an additional finding.

The Stories of Emotional Inference group produced fewer improvements; however, they were able to make more emotional inferences about how they would feel in a given context. Individuals were still unable to make improvements in their ability to infer how others would feel in a given situation. The authors hypothesized that this might be related to self-centeredness, a trait often attributed to post ABI individuals(Radice-Neumann et al., 2009). However, Neumann et al. (2015) noted that the ability to identify one’s own emotions is an important precursor to recognizing the emotions of others and therefore, should not be dismissed prematurely. The previous Radice-Neumann et al. (2009) RCT found slightly depressed effects compared to its 2015 follow-up. In 2009, groups were not significantly different from each other on the Diagnostic Assessment of Nonverbal Affect. However, both groups still significantly improved in their ability to infer emotions from contextual situations on the Levels of Emotional Awareness Scale (Radice-Neumann et al., 2009).

Gabbatore et al. (2015) evaluated a cognitive pragmatic rehabilitation program aimed at improving communicative-pragmatic abilities, in particular self-awareness and executive functioning. Study authors aimed at improving comprehension and production of a communication act. No improvements in comprehension were found from baseline to pre-training (p=0.41); however, significant improvements were demonstrated at post-training and follow-up (Gabbatore et al., 2015).

Conclusions

There is level 1b evidence that facial affect recognition training and emotional inference training is beneficial at improving the emotional perception of individuals with ABI.

There is level 1a evidence that the Treatment for Impairments in Social Cognition and Emotion Regulation and Cogniplus protocols are effective for improving emotional processing and emotional intelligence in individuals with an ABI.

There is level 1b evidence that short intervention designed to improve the ability to recognize emotional prosody was minimally effective in individuals with ABI.

There is level 4 evidence that a Cognitive Pragmatic Treatment (CPT) program is effective in improving communicative-pragmatic abilities in individuals with ABI.

KEY POINTS

- Facial affect recognition and emotional interference training improves emotional perception post ABI.
- Short intervention designed to improve emotional prosody is not effective post ABI.
- Cognitive Pragmatic Treatment (CPT) program is effective at improving comprehension and production of a communication act.
- The Treatment for Impairments in Social Cognition and Emotion Regulation and Cogniplus protocols are effective for improving emotional processing and emotional intelligence in individuals with an ABI.

Alternative and Augmentative Communication

Following severe ABI, patients present with significant communication challenges that interfere with daily communication needs. Whereas those who sustain a mild or moderate ABI may be more readily able to communicate using natural speech with minor difficulties, those with severe ABI may not be able to meet communication needs through speech alone and may benefit from an augmentative or alternative communication (AAC) strategy (M. S. Bourgeois et al., 2001; Burke et al., 2004; de Joode et al., 2012; Fager et al., 2006; Johannsen-Horbach et al., 1985). Many individuals eventually recover their speech abilities post ABI, but there are still many who remain unable to speak for extended periods of time (Fager et al., 2006). For this specific group, assessments and AAC interventions may be a continual process, ensuring that the individual's level of function is matched appropriately with new systems as needed (Fager et al., 2006).

In the AAC domain, there are divisions of complexity that include simple, low-tech options (e.g., alphabet boards, picture-based communication boards, memory books, conversation books, day planners) and high-tech options that include Voice Output Communication Aids (i.e., Dynavox, McCaw, Message Mate, Big Mack, Voice Pal and Boardmaker) (Fager et al., 2006). Notably, both low-tech and high-tech solutions to communication difficulties may have access that is either direct (i.e., touching/ pointing) or indirect (i.e., switch access or partner-assisted scanning).

Clinicians working in the area of AAC or Assistive/Enabling Technology are well acquainted with the recent explosion of technology options available. Presently, clinicians and patients have access to an extensive set of devices and peripherals including but not limited to iPad, Android, and Windows based tablets as well as a wide variety of associated applications and software (e.g., Proloquo2go, Talking Tiles). Changes in cost, improved ease of access/availability in mainstream retail, and rapid changes in the technology itself and associated applications have resulted in AAC clinical practice that is both invigorating and exhausting. Given that we are in the midst of unprecedented technology growth, the research in this area is lagging and limited.

In this particular area, difficulties sustained post ABI include verbal expression and severe dysarthria, with the primary goal of treatment being to allow individuals with severe ABI to efficiently access and communicate effectively via AAC. Particular treatment strategies for ACC may be to complete an initial assessment of the individuals needs from access and communication perspectives. From there, clinicians are able to determine the best device and method of access for individuals on a one-to-one basis (taking into account age and gender), and to allow time for training and teaching of both patient and communication partners (i.e., facilitator).

While there is a great deal of discussion around the importance of AAC, there is limited literature supporting the effectiveness of the strategies currently available for ABI populations. Further research is required in order to understand how these communication approaches or alternatives work to benefit individuals with an ABI and their care giving team.

Organizational Word Retrieval Strategies

Burke et al. (2004) studied the use of three organizational word retrieval strategies for adults with ABI who use AAC. These organizational strategies included semantic topic, geographic place, and first letter of alphabet. While the subjects retrieved words more accurately when using the alphabet organization strategy, they expressed the preference for use of the semantic topic strategy. Clinicians may consider providing these three strategies for clients using AAC and assisting with identification of the most beneficial and preferred strategy for the individual client.

Non-Electronic Communication Board

Assistive devices for AAC range in their properties and capabilities. Non-electronic communication boards, along with electronic counterparts, can aid post ABI individuals with messages and symbols depicted on the display. However, the number of messages they can display are limited, and they do not have the capacity for speech output (Iacono et al., 2011). This option would be ideal for people with complex communication needs, as they are easy to access, less expensive, and generally easier to use by patients, caregivers and clinicians.

Eye-Gaze Communication Board

Assistive technologies aim to improve outcomes in individuals with physical and cognitive impairments. Gaze-based communication boards use computers controlled by the individual’s eyes. This device replaces keyboard and mouse with eye gaze for those who have physical impairments that prevents the use of upper limb motor function (Borgestig et al., 2016). By using their eyes, individuals can control the computer and gain access to communication and activities, including playing games, music, and perform a range of activities that they would not otherwise be physically able to do (Borgestig et al., 2016). The limitation of this technology is that is not as cost effective as other AAC devices, and novice users may experience fatigue quickly, as there is a substantial learning curve with the type of specific eye movements needed to operate the communication board (it does not mimic natural/intuitive eye movements required for daily activities) (Borgestig et al., 2016).

Bliss Symbols

Bliss symbols or boards have been available and utilized for several years. The use of these symbols has been found to be very effective with those who have been diagnosed with aphasia or Broca’s aphasia (Rajaram et al., 2012). However, there is little in the literature specifically pertaining to individuals with an ABI.

Pictograms

Pictograms allow individuals to express their thoughts, emotions, wants and needs with pictures, as there is not a verbal explanation of all words. Pictogram-based ACC has been used for over 30 years and has been shown to help learn new linguistic skills(Pahisa-Solé & Herrera-Joancomartí, 2017).

Picture/Symbol Based Boards

Despite the surge in technology, picture and symbol-based boards remain in high use today (e.g. pictograms, Boardmaker). These symbols or pictures may represent a concept, object, activity, place or event. Symbols, pictures, and boards in general may be used with minimal training and software may be individualized (Bhatnagar SC & F, 1999). The selection of symbols should be appropriate to the individual's communicative needs. Picture/symbol software is also available for computers, iPads, and iPhones.

Alphabet Boards

Individuals with dysarthria or who are non-verbal may benefit from an alphabet board. These boards are helpful for spelling single word or short phrase messages. Board sizes may vary depending on the person's abilities, necessity, or access (Bhatnagar SC & F, 1999). A lexical communication board is another type of AAC that uses common words such as nouns, pronouns, verbs and adjectives to improve sentence formation in patients, however this is not supported by academic sources and therefore requires further research.

Memory Aids

The use of memory aids as an AAC tool has been studied extensively in patients with dementia and Alzheimer's, however their use in individuals with an ABI are not well documented. There are a number of different aids that can be used to compensate for memory loss and decline of cognitive and linguistic skills. Memory books are amongst the most popular and capitalize on procedural memory skills (page turning and reading aloud), they also promote transfer of information and increase social closeness (M. Bourgeois et al., 2001). Memory aids help compensate for memory loss by helping to access stored information and memories, therefore they can be an extremely effective tool that are easily accessible and straightforward to use from a patient's perspective (M. Bourgeois et al., 2001).

Synthetic Voice

Synthetic voice, or synthesized speech uses computer-generated text-to-speech synthesis to extract speech and sound components from words and then combine them to form a natural sounding voice (JL Flaubert, 2017)This differs from digitized speech, which uses human voices stored as segments of sounds waves. Synthesized speech is ideal because it allows greater message flexibility and accuracy of what the individual is trying to convey (JL Flaubert, 2017).

Sign Language

All the above AAC treatments are considered to be "aided" forms of communication, meaning they require external support by way of auxiliary materials (communication board, printed words, etc.) (Sigafoos & Drasgow, 2001). In contrast, natural gestures and sign language are forms of "unaided" AAC (Sigafoos & Drasgow, 2001)American Sign Language is the most commonly used, however there are other systems including Pidgin Signed English (PSE), and Signed Exact English (SEE). The advantages of sign language as an AAC are that it is portable (it does not require materials or devices), and it can be easier to teach than speech; communication partners, and clinicians can help individuals with hand formations (Sigafoos & Drasgow, 2001). There is no literature to support use of sign language in brain injured populations specifically, therefore more research in this field is required to make conclusions about its efficacy as a potential therapy.

KEY POINT

- Augmentative and alternative communication interventions designed to assist with organization, access, and efficiency of communication may be beneficial for individuals with severe ABI.

CONCLUSION

Cognitive interventions target a large variety of cognitive-communication functions and deficits. The rehabilitation of these functions is complicated by cross-study variability in treatment duration (e.g., from 30 minutes once a day for 5 days to 5 hours, every day for 6 weeks). Severity of injury and time since injury may also fluctuate from study to study.

Communication impairments among this group are generally described as non-aphasic in nature (Ylvisaker M & SF, 1994). This is a different type of communication impairment than that seen following stroke, and this distinction is an important one. Communication deficits in individuals with ABI may also include aphasic-like symptoms such as naming errors and word-finding problems, impaired self-monitoring, and auditory recognition impairments. These constraints may also be coupled with other cognitive-communication impairments, such as attention and perception difficulties, impaired memory, impulsivity, and severe impairment of the individual’s overall communicative proficiency within functional situations. These constraints can prevent individuals with ABI from exhibiting even simple communication skills (Lennox & Brune, 1993). (Amos, 2002)

Technology has increased the availability of external aids, although some seem more feasible to use than others (e.g., cell phones or hand-held recorders). Unfortunately, the studies reviewed did not specify the length of time subjects required to master compensatory strategies or the nature of the long-term effects. Generally, if these electronic appliances are used before the injury, they are more likely to be used post-injury as well. It was unclear from the studies if any of the participants had previous knowledge of these tools.

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