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INTRODUCTION

From 1990 to 2016 the prevalence of TBI increased by 8.4%, with 55.5 million people worldwide experiencing TBI in 2016.[1] Approximately 65% of patients who sustain a moderate-severe TBI report long-term problems with cognitive functioning, and as many as 15% of patients who experience a mild TBI have persistent problems, which often include problems with cognition.[2] The cognitive domains most often impacted by mild to moderate TBI include memory, attention, processing speed, and executive functioning.[2]

Deficits in executive functioning impact an individual's ability to engage in independent, goal-directed behavior, as planning, judgment, decision-making, motivation, memory, and attention are impaired.[2] Specifically, executive functioning is an integral skill for successful performance of many activities of daily living (ADLs), instrumental activities of daily living (IADLs), job tasks, and social participation.[2,3]

Cognitive rehabilitation (CR) is proposed as an effective intervention for individuals post TBI, by addressing cognitive function through remediating skills and practicing new compensatory skills. While there is considerable research, including systematic reviews that explore cognitive interventions post TBI, more research is needed in which occupational performance is the primary outcome of cognitive intervention.[4] This current systematic review aims to synthesize the current body of evidence available on how using CR techniques to address executive functioning impact occupational performance

Cognitive Rehabilitation: Therapeutic interventions designed to improve cognitive functioning and participation in activities that may be affected by difficulties in one or more cognitive domains.[5]

Executive Functioning: A person's coordinated ability to plan, initiate, organize, connect information, transition, shift mindsets, set goals, prioritize, remember, and self-monitor.[6]

Activities of Daily Living (ADLs): Activities oriented toward taking care of one's own body (dressing, bathing, eating, feeding, functional mobility, personal hygiene).[7]

Instrumental Activities of Daily Living (IADLs): Activities to support daily life within the home and community that often require more complex interaction than those used in ADLs (care of others, care of pets, child rearing, communication management, community mobility, financial management).[7]

in individuals who sustained a mild or moderate TBI.

METHODS

A systematic review was conducted using an *a priori* protocol to determine the efficacy of cognitive and metacognitive interventions in increasing occupational performance post traumatic brain injury (Table 1). Information found in the protocol includes each element of the PICO question being searched, the databases to be searched, search strategies for each database, the inclusion criteria, and the search methodology. Each of the six reviewers closely followed this protocol to search, identify, appraise, and synthesize articles for this systematic review.

Search Strategy

A systematic search of four databases was conducted in February 2020: CINAHL, PsycInfo, PubMed, and ProQuest Health and Medical Complete. Table 1 shows the search terms used to search each database.

Two reviewers were assigned to each database to complete the search. Following the protocol, each reviewer independently applied inclusion criteria to the retrieved articles' abstract and title (Table 2). If relevance could not be determined by the abstract or title, the full text was retrieved to determine eligibility. After each pair of reviewers independently identified relevant articles for the database, they compared the lists to come to a consensus on relevance. If a consensus could not be reached, a third reviewer was brought in to resolve any discrepancies.

Each pair produced one list per database. The lists of all reviewer pairs were compared and duplicate articles were removed. The six reviewers came to a consensus and a final list was developed that included articles across all four databases. The flowchart summarizes the results for each database, application of inclusion criteria, and the consensus process (Figure 1).

Inclusion Criteria

Articles were considered for review if they met the following inclusion criteria: (1) individuals were diagnosed with TBI of mild-moderate severity; (2) individuals were receiving a cognitive intervention that addressed executive functioning to enhance occupational performance; (3) individuals were between the ages of 15-64 years old; (4) study was peer-reviewed; (5) study was written in English; (6) study was quantitative in nature.

Review Process

Two reviewers were assigned one relevant article in which to appraise, determine level and quality of evidence, and complete the study description table with published results. Level of evidence was given based on the design of the study being appraised. The quality of evidence was determined using predetermined criteria relevant for the identified level of evidence. These three steps were completed independently first and after, partners reached consensus. These steps were repeated for each article appraised per two reviewers. Discrepancies were resolved by bringing in a third reviewer.

The final level and quality of evidence ratings for each of the included eight articles were compiled in Table 3.

RESULTS

A total of 706 articles were retrieved across all databases, eight of which met the pre-established inclusion criteria. The flowchart depicts the inclusion and exclusion process of all articles retrieved through group consensus (Figure 1). Of the eight included articles, five were of level I evidence (e.g., RCT), one was of level II evidence (e.g., pre/posttest study), and two were of level III evidence (e.g., one group non-randomized study) as shown in (Table 4). In terms of quality of evidence, the studies varied from low to moderate, with four studies being of low quality of evidence and four studies being of moderate quality of evidence (Table 3).

TBI severity is categorized as mild, moderate, and severe. All study participants in the included articles experienced a mild-moderate TBI. This level of severity resulted in an array of deficits demonstrated through outcome measures examining executive functioning, occupational performance, memory, adaptive functioning, quality of life, and cognitive symptom severity. Included studies were arranged into four categories of intervention, including; (1) Compensatory Cognitive Training (2) Virtual Reality (3) Tele-Analogy Based Problem Solving Training (4) Individualized Cognitive Strategies.

Compensatory Cognitive Training

Three of the eight studies used forms of compensatory cognitive training including Cognitive Symptom Management and Rehabilitation Therapy (CogSMART)[8], Cognitive Strategy Training (CST)[9], and Group-Based Compensatory Cognitive Training.[10] Two studies presented low quality of evidence [9,10] and one study presented moderate quality of evidence.[8] Two of the three studies were of level I evidence [8,10], and one study was of level III evidence.[9]

Outcome measures examined within the three studies using compensatory cognitive training included executive function, memory, adaptive functioning, cognitive symptom severity, quality of life, and occupational performance. All outcomes had overall small effect sizes and therefore, were clinically insignificant other than quality of life and memory which had medium effect sizes.

Virtual Reality

Two studies utilized virtual reality-based interventions to examine outcomes related to executive functioning and cognitive symptom severity.[3,11] The interventions included were Artificial Intelligent Virtual Reality-Based Vocational Training System (AIVTS)[11] and a Virtual Reality Training Group (VRTG)[3]. Both studies were of level I evidence and presented moderate quality of evidence.

Statistically significant improvements in executive functioning and cognitive symptom severity were found following VRTG. AIVTS presented statistically insignificant results related to both outcomes. Clinical significance was not reported and could not be calculated for both studies.

Tele-Analogy Based Problem Solving

One study utilized a tele-analogy problem solving training to address executive functioning and IADL performance.[12] This study was level I evidence but presented low quality of evidence.

No statistically significant improvements were found in this study. Clinical significance was not given and could not be calculated.

Individualized Cognitive Strategies

Two studies used different forms of individualized cognitive strategies including internal memory strategies [13] and attention management strategies.[14] Both studies were level II evidence. One study was identified as low quality [14] and one as moderate quality.[13] No statistically significant improvements were found following the memory strategies intervention, but statistically significant improvements were found following attention management strategies. In terms of clinical significance, little effect size[14] and medium effect size[13] was reported.

Terminology

Level of Evidence: Levels are described for studies of interventions, diagnosis and prognosis, defined according to the strength of the design used. [15] Levels range from 1 (highest) to 5 (lowest).

Quality of Evidence: The confidence that the reported estimates of effect are adequate to support a specific recommendation. [16]

Effect Size: A statistical expression of the magnitude of the difference between two treatments or the magnitude of a relationship between two variables, based on the proportional relationship of the difference to the variance [15]

Statistical Significance: The term indicating that the results of an analysis are unlikely to be the result of chance at a specified probability level; rejection of the null hypothesis.[15]

PRACTICE RECOMMENDATIONS

All eight studies included in this systematic review were evaluated using a modified version of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) rating system.[17] The eight studies were grouped into four main cognitive intervention categories. The following are recommendations for each of the four categories of cognitive interventions with individuals post mild-moderate TBI to address executive functioning impairments and enhance occupational performance.

Compensatory Cognitive Training

Three of the eight published studies that met this systematic review's inclusion criteria examined compensatory cognitive training interventions. Two of the three studies were level I studies and the third was a level III study.[18] Two of the three studies were of low quality, while one was of moderate quality. Clinical significance for measures of executive functioning and occupational performance varied from low to moderate across the three studies. Due to the preponderance of low quality studies, the recommendation for using compensatory cognitive strategies with individuals post mild-moderate TBI to address executive functioning and improve occupational performance is weak. This means that further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. As such an occupational therapy practitioner may or may not choose to use this intervention in practice.

Virtual Reality

Two of the eight published studies examined virtual reality interventions. Both of the studies were level I studies[18] and had moderate quality of evidence. Clinical significance was not given and could not be calculated for these studies. Given the quality of evidence and lack of clinically significant results, the recommendation for using virtual reality to address executive functioning to improve occupational performance is weak. Further research is very likely to have an important impact on our confidence in the

estimate of effect and is likely to change the estimate.

Tele-Analogy Based Problem Solving

One of the eight published studies examined a tele-analogy based problem solving training intervention. This study was a level I study[18] and had low quality of evidence. Clinical significance was not given and could not be calculated. Due to the low quality of evidence and lack of results, a weak recommendation can be made for the use of this intervention. Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Individualized Cognitive Strategies

Two of the eight published studies examined individual cognitive strategies. Both of these were level II studies.[18] One study was of moderate quality while the other was of low quality. While one study demonstrated moderate clinical significance, the other demonstrated low clinical significance. Due to the limited number of studies employing this intervention there is not enough research to support the use of individualized cognitive interventions in individuals post mild-moderate TBI. As such, the evidence only supports a weak recommendation for this intervention. Further research is very likely to have an impact on our confidence of the effect of this category of intervention and is likely to change the estimate.

CLINICAL IMPLICATIONS

The current available evidence on cognitive interventions post mild-moderate TBI that address executive function provide little to no evidence to support the use of these forms of CR as a means for enhancing occupational performance. Two level I studies, and one level III study utilized compensatory cognitive training and reported a range of small to large effect sizes related to clinical significance, however these studies were of moderate to low quality. Additionally, the level three study which reported large effects only had 16 participants, making it unlikely that these results could be generalized to the larger population.

Two level I studies utilized virtual reality to address executive functioning and reported statistical significance, however clinical significance was not given and could not be calculated. A level I study that utilized an analogy-based problem-solving program was low quality, did not report any statistically significant results, and clinical significance was not reported and could not be calculated. Two level II studies that utilized individualized cognitive strategies were low and moderate quality. One of the studies was low quality and only included a total of eight participants, four in each group, making it unlikely any results could be generalized to the larger population. The other study reported both small and large effects but was of moderate quality of evidence.

Based on the limited and low quality of evidence, these specific CR interventions (memory-aids, virtual reality, etc.) have shown little to no improvement when compared to standard therapist-assisted therapy, usual care, or no intervention at all. Therapists should only consider the use of these forms of interventions if standard therapy has shown to be ineffective for their client. Cost and burden are relatively low for engaging in these interventions; however, it may not be worthwhile due to there being no reported clinically significant difference of

outcomes when compared to standard therapist-assisted treatment or no treatment. Occupational therapists should consider the available evidence, their clinical experience, and client's preferences while planning an evidence-based intervention.

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Table 1. Search Strategy

PICO question			
P - Post Traumatic Brain Injury	**I -** Cognitive Intervention	**C -** No comparison	**O –** Occupational Performance

Databases Included in SR Search	**Planned the Search**		**Will conduct the Search**	
	Person 1	**Person 2**	**Person 1**	**Person 2**
PubMed	Amy	Alicia	Sarah	Maria
CINAHL	Sarah	Maria	Kelly	Colleen
Health and Medical Collection (ProQuest)	Sarah	Maria	Kelly	Colleen
PsycINFO	Kelly	Colleen	Amy	Alicia

	Construct 1		**Construct 2**		**Limits (if any)**
Database	**Subject Headings**	**Keywords**	**Subject Headings**	**Keywords**	
PubMed	Brain injuries, Traumatic	"Traumatic brain injury"	Cognitive remediation	-"Cognitive intervention" -" Cognitive rehabilitation" - "Cognitive training" -"Cognitive exercise"	Human

				-“Mental exercise” -” Cognitive remediation”	
CINAHL	Brain Injuries	“Traumatic brain injur*”	Rehabilitation, cognitive	- “Cognitive intervention*” - “Cognitive rehabilitation” - “Cognitive training” - “Cognitive exercise” - “Mental exercise”	Human, English, Peer review-ed Age groups: Adoles-cent 13-18 years, Adult 19-44 years, Middle Aged 45-64 years
Health and Medical Collec-tion ProQuest	Traumatic Brain Injury	“Traumatic brain injur*”		- “Cognitive intervention*” - “Cognitive rehabilitation” - “Cognitive training” - “Cognitive remediation” - “Mental exercise”	Peer review-ed, humans
PsycInfo	“Traumatic Brain Injury”	“Traumatic Brain Injur*”	- “Neuropsycho-logical Rehabilitation” - “Cognitive Techniques” - “Cognitive Rehabilitation” - “Brain Training”	- “Cognitive intervention*” - “Mental exercise” -“Cognitive exercise” - “Cognitive Rehabilitation” - “Brain Training” -“Cognitive training”	

Table 2. Article Inclusion and Exclusion Criteria

Inclusion Criteria			
Population: Post traumatic brain injury	Intervention: cognitive intervention	Outcome: Occupational performance	Other
Male and Female	-Cognitive remediation -cognitive training -cognitive rehabilitation -cognitive therapy -cognitive intervention -co-op -compensatory strategies -problem solving strategies -attention remediation training -cognitive behavioral therapy -encoding strategies -metacognitive interventions -Coaching -Coaching in Context **OR**	-IADLs -Work -Education -Social Participation -role and routine management -leisure -quality of life **OR**	Quantitative controlled studies
Mild and moderate TBI (define by LOC and Glasgow Scale-see below)	Executive function **AND**		Published in peer reviewed journal
Age: 15-64yo (highest incidence)			
Traumatic brain injury defined as: “a disruption in the			

normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury" (CDC, 2019).			
Exclusion Criteria			
Population	Intervention and Comparison	Outcome	Other
Adults with prior cognitive disability	Intervention may not be combined with another intervention unless outcome data can be extracted by each individual intervention		Studies in non-English language

Figure 1. Flowchart

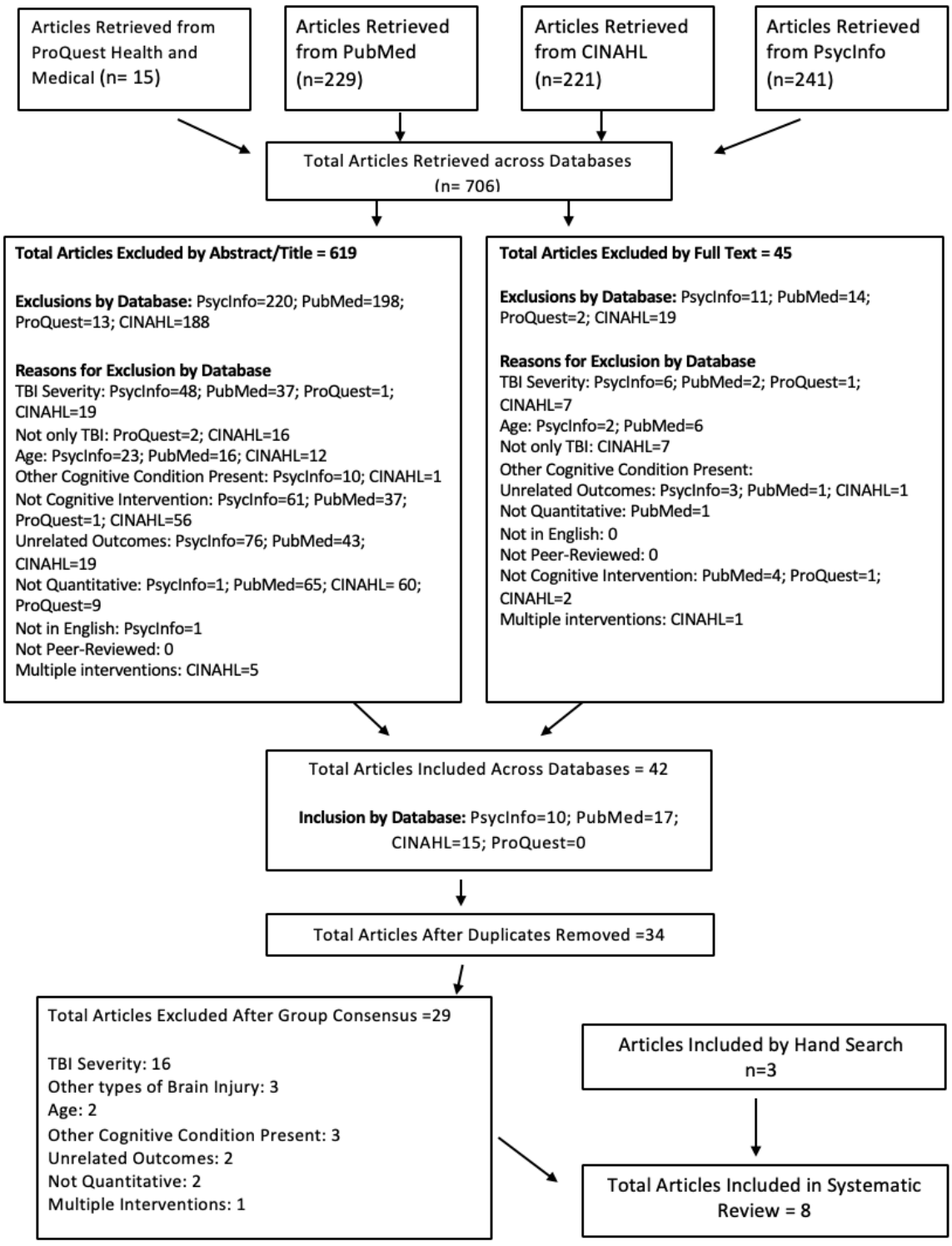

Table 3. Quality of Evidence

		Quality Criteria											
Citation	Type of design	1	2	3	4	5	6	7	8	9	10	Quality Level	Evidence Level
(Twamley et al., 2015)	3	0	0	1	1	0	0	1	1	0	1	Moderate	Level I
(DeLuca, 2019)	2	0	0	1	1	0	1	0	1	0	0	Moderate	Level I
(Storzbach et al., 2017)	2	0	0	1	1	0	0	0	0	0	1	Low	Level I
(Soong et al., 2005)	3	1	1	0	1	0	0	0	0	0	0	Low	Level I
(O'Neil-Pirozzi et al., 2010) article within (Radomski et al., 2016)	5	0	1	1	0	0	0	0	1	0	1	Moderate	Level II
(Huckans et al., 2010)	6	0	1	0	0	0	1	1	0	N/A	N/A	Low	Level III
(Cicerone, 2002) article within (Comper et al., 2005)	5	0	1	1	0	0	0	0	0	0	1	Low	Level III
(Man, et al. 2013) article within (Alashram, et al., 2019)	3	0	0	0	1	0	1	N/A	1	1	1	Moderate	Level I

Table 4. Study Description Table

Study	Design Type	Number of Criteria met and Quality Level	Population (including age)	Group (Intervention, Comparison, n)	Outcome(s)	Measurement Tools	Point estimate and direction of differences	Clinical Significance	Statistical significance
(De Luca et al., 2019)	RCT Level I	4/10 moder-ate	Age: 39.91 +/- 10.1 years Gender: 56% male 44% female Dx: Mild/mod TBI No additional psychiatric condition	<u>Intervention Group:</u> VRTG performed VRT using BTs-N. Semi-immersive therapy program 24 1-hour sessions (3x week for 8 weeks) <u>Comparison Group:</u> Individual Cognitive Rehabilitation Face-to-face interactions w/ paper and pencil activities 24 1-hour sessions (3x week for 8 weeks) N=50	1.General cognitive state	1. MOCA (0-30) Score>26=normal	Pre/post: median (first-third quartile) 1.MOCA TX— <u>Pre:</u> 23.0 (21.25-24.7) <u>Post:</u> 27.0 (26.0-28.0) Control— <u>Pre:</u> 23.0 (20.0-24.7) <u>Post:</u> 24.0 (22.0-25.7)	1.Not Given (N.G) Not Possible to Calculate (N.P.C)	1. MOCA TX— p-value <0.001 CG— p-value <0.001
					2.Frontal Abilities	2. FAB (0-18) Higher=better performance	2. FAB TX— <u>Pre:</u> 14.4 (11.1-15.9) <u>Post:</u> 17.2 (15.2-18.0) Control— <u>Pre:</u> 13.6 (13.0-16.3) <u>Post:</u> 14.9 (5.8-11.5)	2. N.G N.P.C	2. FAB TX— p-value <0.001 CG— p-value <0.001
					3a. Attention process and shifting, visual research	3a. WT (0-4) Higher=better cognitive function	3a. WT TX— <u>Pre:</u> 8.1 (6.3-9.2) <u>Post:</u> 12.1 (10.1-14.0) Control— <u>Pre:</u> 7.2 (4.7-10.7) <u>Post:</u> 8.2 (5.8-11.5)	3a. N.G N.P.C	3a. WT TX— p-value <0.001 CG— p-value <0.001
					3b. Attention process and	3b.VS Higher=better performance	3b. VS TX— <u>Pre:</u> 34.0	3b. N.G N.P.C	3b. VS TX—

					shifting, visual search		(26.0-43.7) Post: 42.7 (36.8-47.2) Control— Pre: 33.6 (25.1-43.7) Post: 36.8 (27.1-46.2)		p-value <0.001 CG— p-value 0.002
					3c. Attention process and shifting, visual search	3c.TMT PART A: Average=29s Deficient=+78s	3c. TMT-A TX— Pre: 67.5 (55.25-100) Post: 57.0 (35.0-85.0) Control— Pre: 79.5 (57.25-168.0) Post: 74.5 (55.0-160.75)	3c.N.G	3c. TMT-A TX— p-value <0.001 CG— p-value <0.001
						PART B: Average= 75s Deficient= +273s	TMT-B TX— Pre: 201.5 (130.2-274.0) Post: 145.5 (92.0-200.0) Control— Pre: 179.0 (140.0-246.5) Post: 174.0 (140.0-237.5)		TMT-B TX— p-value <0.001 CG— p-value <0.001
						B-A	B-A TX— Pre: 95.5 (57.5-161.0) Post: 82.5 (40.0-115.5) Control— Pre: 82.0 (65.0-160.5) Post: 80.5 (62.5-155.0)		TMT B-A TX— p-value <0.001 CG— p-value 0.4

(Storzbach et al., 2017)	RCT Level I	3/10 Low	N=119 Combat Veterans from OEF/OIF/OND who experienced mild TBI Age: 27.4-43.8 94-96% male 64-68% Caucasian	<u>Intervention Group:</u> Compensatory Cognitive Training (CCT); n=50 <u>Comparison Group:</u> Usual care (UC); n=69				Partial n^2 Effect sizes: Small > 0.01 Med > 0.06 Large > 0.15	
					1. Memory	1. PRMQ (Higher scores indicate more problems)	1. PRMQ CCT Baseline 57.2 (8.0) Week 5 55.0 (7.5) Week 10 49.6 (10.0) Week 15 49.8 (8.5) UC Baseline 55.4 (10.5) Week 5 55.2 (11.03) Week 10 55.2 (11.98) Week 15 55.0 (12.3)	1. PRMQ Week 10: 0.142 Week 15: 0.122	1. PRMQ p = .001
					2. Attention and organization	2. MSNQ (Higher scores indicate more problems)	2. MSNQ CCT Baseline 37.8 (9.1) Week 5 37.3 (8.1) Week 10 33.6 (8.1) Week 15 34.4 (9.7) UC Baseline 37.0 (10.2) Week 5 36.4 (9.0) Week 10 36.3 (10.2) Week 15 37.7 (10.5)	2. MSNQ Week 10: 0.067 Week 15: 0.091	2. MSNQ p = .005
					3a. Compensatory Strategy Use	3a. MCQ (Higher scores = more frequent use)	3a. MCQ CCT Baseline 119.8 (23.5) Week 5	3a. MCQ Week 10: 0.003 Week 15: 0.001	3a. MCQ p = .068

							115.9 (20.8) Week 10 123.1 (26.2) Week 15 124.9 (25.8) UC Baseline 118.5 (25.7) Week 5 121.7 (23.9) Week 10 119.5 (28.3) Week 15 120.4 (29.7)		
					3b. Compensatory Strategy Use	3b. PCSS (Higher scores = more frequent use)	3b. PCSS CCT Baseline 38.6 (11.8) Week 5 46.2 (8.6) Week 10 50.4 (6.1) Week 15 51.4 (6.4) UC Baseline 40.1 (11.2) Week 5 42.3 (10.3) Week 10 43.0 (10.3) Week 15 44.6 (8.5)	3b. PCSS Week 10: 0.163 Week 15: 0.134	3b. PCSS p = < .001
					4. Postconcussive Symptom Severity	4. NSI (Higher rating = more severe symptoms)	4. NSI CCT Baseline 45.0 (16.3) Week 5 45.6 (17.4) Week 10 40.9 (17.9) Week 15 39.6 (17.6) UC Baseline 44.8 (14.5) Week 5 44.0 (15.9) Week 10	4. NSI Week 10: 0.018 Week 15: 0.025	4. NSI p = .078

							43.5 (17.7) Week 15 43.2 (17.6)		
					5. Verbal list learning	5. HVLT-R Total Recall (higher score = higher level of performance)	5. HVLT-R Total Recall CCT Baseline 43.0 (10) Week 10 50.6 (13) UC Baseline 42.6 (12) Week 10 44.7 (12)	5. HVLT-R Recall: Week 10: 0.054	5. HVLT-R Total Recall (learning) p = .029
					6. Delayed Recall	6. HVLT-R Retention (higher score = higher level of performance)	6. HVLT-R Retention CCT Baseline 42.6 (14) Week 10 48.5 (12) UC Baseline 46.6 (13) Week 10 47.2 (12)	6. HVLT-R Retention: Week 10: 0.034	6. HVLT-R Retention (memory) p = .095
					7. Attention & working memory	7. WAIS-IV Digit Span Subtest (higher score = higher level of performance)	7. WAIS-IV Digit Span CCT Baseline 8.7 (3) Week 10 10.16 (3) UC Baseline 9.96 (3) Week 10 10.3 (3)	7. WAIS-IV Digit Span: Week 10: 0.048	7. WAIS-IV Digit Span p = .041
					8. Processing Speed	8. Digit Symbol Subtest (higher score = higher level of performance)	8. WAIS-IV Digit Symbol Coding CCT Baseline 8.5 (3)	8. WAIS-IV Digit Symbol Coding: Week 10: 0.000	8. WAIS-IV Digit Symbol Coding p = .946

							Week 10 9.89 (2) UC Baseline 8.49 (3) Week 10 9.96 (8)		
					9a. Verbal fluency, processing speed, and generativity	9a. D-KEFS Verbal Fluency Subtest (higher score = higher level of performance)	9a. D-KEFS Letter Fluency CCT Baseline 9.96 (3) Week 10 11.46 (3) UC Baseline 10.47 (4) Week 10 10.65 (3)	9a. D-KEFS Letter Fluency: Week 10: 0.076	9a. D-KEFS Letter Fluency p = .009
					9b. Verbal fluency, processing speed, and generativity	9b. D-KEFS Category Fluency (higher score = higher level of performance)	9b. D-KEFS Category Fluency CCT Baseline 11.20 (4) Week 10 11.83 (3) UC Baseline 10.11 (4) Week 10 10.53 (3)	9b. D-KEFS Category Fluency Week 10: 0.001	9b. D-KEFS Category Fluency p = .795
					10. Executive functioning and processing speed	10. D-KEFS Trails (higher score = higher level of performance)	10. D-KEFS Trails CCT Baseline 9.3 (3) Week 10 9.95 (3) UC Baseline 9.84 (2) Week 10 10.35 (2)	10. D-KEFS Trails: Week 10: 0.001	10. D-KEFS Trails p = .789

					11. Satisfaction with life	11. SLS (higher score = more satisfaction)	11. SLS CCT Baseline 16.3 (7.5) Week 5 15.8 (7.2) Week 10 17.4 (8.5) Week 15 16.6 (7.7) UC Baseline 16.7 (7.1) Week 5 14.5 (6.4) Week 10 17.7 (7.8) Week 15 15.6 (7.1)	11. SLS Week 10: 0.011 Week 15: 0.059	11. SLS p = .157
					12. Adaptive Functioning	12. USPA-Brief (higher score = higher level of performance)	12. USPA-Brief CCT Baseline 79.71 (1) Week 10 86.83 (8) UC Baseline 83.44 (10) Week 10 86.47 (9)	12. USPA-Brief Week 10: 0.038	12. UPSA-Brief p = .059
(Twamley et al., 2015)	RCT Level I	5/10 Moder-ate	Veterans with mild-mod TBI; average age = 32 years; 96% male;	<u>Intervention Group:</u> CogSMART and supported employment n= 25 <u>Comparison Group:</u> Enhanced supported employment (ESE) n = 25	1. Quality of life	1. Quality of Life Interview-Brief Version (ranging 1-7)	N.G. = Not Given 1. N.G.	m (months) minus baseline change score Cohen's d: 1. 3m: 0.48 6m: -0.19 12m: 1.00	1. N.G.
					2a. Memory	2a. MIST- 30 min summary probe	2a. N.G.	2a. 3m: -0.08 6m: 0.17 12m: 0.55	2a. N.G.

					2b. Memory	2b. MIST- 24-hour probe	2b. N.G.	2b. 3m: 0.74 6m: 0.75 12m: 0.41	2b. N.G.
					3. Attention and working memory	3. WAIS-III Digit Span	3. N.G.	3. 3m: -0.46 6m: 0.25 12m: 0.11	3. N.G.
					4a. Verbal learning and memory	4a. CVLT-II (trials 1-5 T-score)	4a. N.G.	4a. 3m: -0.07 6m: 0.02 12mo: -0.71	4a. N.G.
					4b. Verbal learning and memory	4b. CVLT-II (long delay free recall, uses Z scores to measure memory)	4b. N.G.	4b. 3m: 0.08 6m: 0.80 12m: 0.02	4b. N.G.
					5a. Executive functioning (verbal fluency)	5a. D-KEFS Letter Fluency	5a. N.G.	5a. 3m: 0.29 6m: 0.30 12m: 0.10	5a. N.G.
					5b. Executive functioning (verbal fluency)	5b. D-KEFS Category Fluency	5b. N.G.	5b. 3m: 0.33 6m: 0.17 12m: 0.06	5b. N.G.
					5c. Executive functioning (verbal fluency)	5c. D-KEFS Category Switching	5c. N.G.	5c. 3m: 0.17 6m: -0.14 12m: -0.46	5c. N.G.
					5d. Executive functioning (verbal fluency)	5d. WCST-64 Perseverative Errors	5d. N.G.	5d. 3m: -0.50 6m: -0.08 12m: -0.59	5d. N.G.
					6. Post concussive symptom severity	6. Neurobehavioral Symptom Inventory (ranging from 0-4, “none” to “severe”	6. N.G.	6. 3m: 0.98 6m: 0.69 12m: 0.64	6. N.G.

Soong et al. (2005)	RCT Level I	3/10-Low	15 subjects with TBI Age: 18-55	<u>Intervention Group:</u> Analogy problem-solving strategy Online interactive computer-assisted skill-training program (OCRG); n=5 Therapist-administer-ed training program (TCRG); n=5 Computer-assisted skill-training program (CCRG); n=5	1. IADL performance 2a. Problem solving 2b. Problem solving	1. LIADL Higher=better performance 2a. HRTB 0-50:no impairment 50+: impairment 2b. Self-Efficacy Higher=better performance	<u>Mean Differences</u> 1.LIADL L1 -2.20 L2 -1.40 L3 -.080 2a. Category test of HRTB L1 -3.40 L2 -6.40 L3 3.00 2b. Self-Efficacy L1 9.60 L2 -4.80 L3 14.40	1. N. G N.P.C 2a. N.G N.P.C 2b. N.G N.P.C	1. LIADL L1: p= 0.06 L2: p=0.20 L3: p=0.45 2a. Category Test of HRTB L1: p=0.59 L2: p=:0.32 L3: p=0.64 2b. Self-Efficacy L1: p=0.34 L2: p=0.63 L3: p=0.16

(O'Neil-Pirozzi et al., 2010)	Nonrandomized pretest-posttest group comparison Level II	4/10 Moderate	Individuals with TBI 18+ years of age at time of injury and at least 1-year post-injury with memory impairment; mild to severe (able to be extracted)	<u>Intervention Group:</u> Internal Memory Strategies (I-MEMS); n = 54 <u>Comparison Group:</u> No intervention; n = 40	1a. Memory Verbal Learning	1a. HVLT-R	1a. Pretest: E: 6.09 (3.55) C: 7.82 (3.40) Posttest 1: E: 8.13 (3.22) C: 7.52 (3.52) Posttest 2: E: 8.50 (3.01) C: 7.34 (3.54)	1a. Pretest: 0.49 Posttest 1: 0.18 Posttest 2: 0.35	1a. p = 0.02 Posttest 1: -0.99 (0.33) Posttest 2: -1.58 (0.12)
					1b. Memory (Behavioral)	1b. RBMT-II	1b. Pretest: E: 15.92 (4.89) C: 15.65 (4.76) Posttest 1: E: 18.25 (4.90) C: 14.90 (4.81) Posttest 2: E: 18.22 (4.28) C: 14.82 (5.14)	1b. Pretest: 0.05 Posttest 1: 0.69 Posttest 2: 0.71	1b. p = 0.78 Posttest 1: -1.25 (0.22) Posttest 2: -1.72 (0.09)
(Huckans et al., 2010)	Quasi-experimental (1 group pre/post design)	3/8 Low	Veterans of OEF/OIF with cognitive disorder and history of combat	<u>Intervention Group:</u> 6 or 8 sessions of group-based Cognitive Strategy Training (CST)				*ES measured using Cohen-d	

	Level III		related mild TBI All male Ages 25.4-42.2 81% Caucasian	Sessions occurred weekly for 2 hours total, with breaks <u>Comparison Group:</u> None n = 16	1a. Frequency of compensatory strategy use/aid use	1a. MCQ (higher scores = greater use)	1a. MCQ Pre: 116.56 (24.67) Post: 128.25 (20.07)	1a. MCQ ES: 0.54	1a. MCQ p = 0.021
					1b. Frequency of compensatory strategy use/aid use	1b. FCSUS (higher scores = more use)	1b. FCSUS Pre: 22.00 (12.60) Post: 41.04(8.19)	1b. FCSUS ES: 1.87	1b. FCSUS p = 0.000
					2. Usefulness of strategy use/aid use	2. UCSS (greater scores = greater usefulness)	2. UCSS Pre: 17.08 (7.56) Post: 28.58 (3.58)	2. UCSS ES: 2.03	2. UCSS p = 0.000
					3. Frequency and usefulness of strategy use/aid use	3. CSTCE (higher scores = more use or frequency)	3. CSTCE Usefulness of cognitive strategies Pre: 6.25(1.88) Post: 7.94(1.34)	3. CSTCE ES: 1.07	3. CSTCE p = 0.004
							Usefulness of external aids Pre: 7.27(1.98) Post: 9.00 (1.20)	ES: 1.10	p = 0.001
					4. Attention and organization	4. MSNQ (higher scores = greater impairment)	4. MSNQ Pre: 41.5(10.12) Post: 36.19(9.03)	4. MSNQ ES: 0.57	4. MSNQ p = 0.034
					5. Memory	5. PRMQ (higher scores = greater impairment)	5. PRMQ Pre: 57.31(10.92) Post:	5. PRMQ ES: 0.43	5. PRMQ p = 0.009

							52.56(11.71)		
					6. Participation in community and social activities	6. CIQ (higher scores = greater functional independence & community integration)	6. CIQ Pre: 13.67(3.42) Post: 14.41(3.02)	6. CIQ ES: 0.24	6. CIQ p = 0.227
					7. Satisfaction with life	7. SLS (higher scores=greater satisfaction)	7. SLS Pre: 16.75(6.70) Post: 19.00(7.29)	7. SLS ES: 0.33	7. SLS p = 0.040
					8. Managing symptoms	8 TBI-SES (higher scores = greater sense of self-efficacy)	8. TBI-SES Pre: 23.56(12.44) Post: 29.38(15.97)	8. TBI-SES ES: 0.11	8. TBI-SES p = 0.085
(Man et al., 2013)	RCT Level I	5/10 Moder-ate	Dx: mild-moderate TBI Age: 18-55	<u>Intervention Group:</u> 12 sessions of 20–25 min. Artificial intelligent virtual reality based vocational training system (AIVTS) <u>Comparison Group:</u> 10 sessions of occupational therapy cognitive retraining n=20	1. Executive Function	1. WCST (<=better)	1. Tx: WCST-% errors Pre 47.28 ± 18.0 Post 40.08 ± 21.44 WCST-% perseverative errors Pre 31.32 ± 17.54 Post 21.88 ± 16.41 WCST-% conceptual level response Pre 38.04 ± 21.34 Post	1.N.G N.P.C	1. No significant difference between groups

							49.28 ± 28.10 Control: WCST-% errors Pre 56.04 ± 15.81 Post 53.12 ± 14.75 WCST-% perseverative errors Pre 31.60 ± 18.86 Post 24.92 ± 10.82 WCST-% conceptual level response Pre 26.28 ± 19.9 Post 30.16 ± 18.23		
					2. Cognitive function	2. VCRS (>=better)	2. TX: VCRS (16–80) Pre 56.56 ± 7.24 Post 63.2 ± 5.52 Control: VCRS (16–80) Pre 56.36 ± 10.53 Post 62.36 ± 10.44	2. N.G N.P.C	2. No significant difference between groups

					3. Planning and problem solving	3. TOL (>=better)	3. Tx: Pre 25.0 ± 3.39 Post 26.92 ± 3.39 Control: Pre 24.04 ± 4.91 Post 26.48 ± 4.09	3. N.G. N.P.C	3. No significant difference between groups
(Cicerone, 2002)	Quasi-experi-mental pre/ post test group design Level II	3/10 Low	Adults with MTBI	<u>Intervention Group:</u> Development of individualized strategies to manage one's attention n= 4 <u>Comparison Group:</u> No comparison n= 4	1a. Attention 1b. Attention 1c. Attention	1a. Trailmaking A 1b. Trailmaking B 1c. PASAT	1a. Trailmaking A <u>Treatment</u> E3 Pre - 33 Post - 45 <u>Control</u> C2 Pre - 24 Post - 41 1b. Trailmaking B <u>Treatment</u> E1 Pre - 46 Post - 59 <u>Control</u> C2 Pre - 36 Post - 49 1c. PASAT <u>Treatment</u> E1 Pre - 42 Post - 57 <u>Treatment</u> E2 Pre - 37	Clinically meaningful if pre-post t score > 10 E=TX participant C=comparison 1a. Trailmaking A E3, C2 1b. Trailmaking B E1, C2 1c. PASAT E1, E2, E3, C3	Treatment group showed statistically significant change of measures of attention as compared to comparison group p = 0.0025

							Post - 50 Treatment E3 Pre - 43 Post - 57 Control C3 Pre - 44 Post - 55		
					1d. Attention	1d. CPTA	1d. CPTA Treatment E2 Pre -20 Post - 48 Treatment E3 Pre - 20 Post - 52 Treatment E4 Pre - 34 Post - 57	1d. CPTA E2, E3, E4	
					1e. Attention	1e. The 2 & 7 Test	1e. The 2 & 7 Test Treatment Automatic E2 Pre - 41 Post - 52 Automatic E3 Pre - 42 Post - 63 Automatic E4 Pre - 49 Post - 66 Treatment Controlled E2 Pre - 46 Post - 57 Controlled E3 Pre - 51 Post - 69 Controlled E4 Pre - 35 Post - 75	1e. The 2 & 7 Test E2, E3, E4	

					1f. Attention	1f. ARMS	1f. ARMS Treatment Pre - 59.3 Post - 42.5 Scores were only reported if pre-post score difference >10	1f. ARMS Not reported	1f. ARMS p = 0.021

Key. ARMS = Attention Rating and Monitoring Scale; CIQ = Community Integration Questionnaire; CPTA = The Continuous Performance Test of Attention; CSTCE = Cognitive Strategies Training Class Evaluation; CVLT-II = California Verbal Learning Test 2nd Edition; D-KEFS = Delis-Kaplan Executive Function System; FAB = Frontal Assessment Battery; FCSUS = Frequency of Cognitive Strategy Usage Scale; HRTB = Halstead-Reitan Test Battery; HVLT-R = Hopkins Verbal Learning Test- Revised; Lawton IADL = Lawton Instrumental Activities of Daily Living; MCQ = Memory Compensation Questionnaire; MIST = Memory for Intentions Screening Test; MOCA = Montreal Cognitive Assessment; MSNQ = Multiple Sclerosis Neuropsychological Screening Questionnaire-Patient Version; NSI = The Neurobehavioral Symptom Inventory; PASAT = The Paced Auditory Serial Addition Test; PCSS = Portland Cognitive Strategies Scale 2.0; PRMQ = Prospective-Retrospective Memory Questionnaire; RBMT-II = Rivermead Behavioral Memory Test II; SLS = Satisfaction with Life Scale; TBI-SES = TBI Self-Efficacy Scale; TMT = Trail Making Test; TOL = Tower of London Test; UCSS = Usefulness of Cognitive Strategies Scale; UPSA-Brief = University of California San Diego (UCSD) Performance-Based Skills Assessment, Brief Version; VCRS = The Vocational Cognitive Rating Scale; VS = Visual Search; WAIS-III = Wechsler Adult Intelligence Scale - 3rd Edition; WAIS-IV = Wechsler Adult Intelligence Scale - 4th Edition; WCST-64 = Wisconsin Card Sorting Test; WT = Weigl's Test