How does Working Memory Training affect Anxiety?

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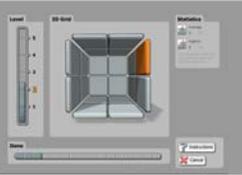**202-333-3210**
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Agenda

WM deficits & anxiety: Does one cause the other?

Negative emotion/Anxiety & WM functioning.

Affective updating, anxiety & depression.

Cogmed-specific studies related to anxiety.
- Children with Social Emotional Behavioural Disorder.
- Adults with acquired brain injury.
- Children with high anxiety
- War veterans with PTSD.

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Surprisingly working memory (WM) deficits are common among a number of mental health disorders.

What do patients with traumatic brain injury (TBI), stroke, schizophrenia, ADHD, anxiety, PTSD, depression, etc. have in common?

WM deficits?

Early Cogmed research focused upon patients identified with attention deficits (ADHD, TBI, stroke, etc.) or healthy clients, some more recent work has moved into disorders in which anxiety is the primary deficit.

It seems PUZZLING that Cogmed might be relevant to an anxiety disorder?

Is a WM deficit a 'symptom' of anxiety or do WM deficits contribute to anxiety?

Chicken or the egg?

…Or both. In other words is there a reciprocal interaction between the two?

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Does anxiety result in WM deficits?
Does a WM deficit result in anxiety?

Schweizer & Dalgleish (2016) appears to address both questions.

Impact of affective contexts on WM capacity (WMC) in healthy populations and in those with PTSD.

Experiment 1 & 2: Confirmed that WM capacity would be reduced in the context of emotional vs. neutral distractors in a student and community sample.

Experiment 3: Extended these findings to a clinical sample with PTSD. WMC in motor vehicle accident survivors with a history of post-traumatic stress disorder (PTSD) was selectively reduced in the presence of trauma-related emotional distractions (background images related to car accidents on the screen while engaging in complex WM tasks) compared with survivors of car accidents without a history of PTSD.

These findings merit closer consideration as to how were 'emotional' distractors and 'trauma-related emotional distractions operationalized'.

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Experiment 1:
Schweizer & Dalgleish (2016)

n=31, mean age=23 years, 19 women, 12 men. Students at the University of Cambridge graduate and undergraduate programs.

All over 18 years old, fluent in English, normal vision, no history of neurological disorders or head injuries.

Affective Picture Span Paradigm (ASPS) was with a neutral image or a negatively emotional background image. Storage component required recalling 4 to 7 words per block. Examples in the actual journal article were things like the butchering of an animal in a meat factory or the view of victims of famine and starvation – provocative images for experiment 1 & 2. The images were described by the study as "International Affective Picture System images."

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Experiment 1:
Schweizer & Dalgleish (2016)

APSP: Affective Picture Span Paradigm developed to test the hypotheses of the first 2 experiments.

Complex span task presented against different background images measure "**_affective WMC_**".

•**Task**: Sequential storage of words presented on a PC, while either a neutral or emotional full-screen background images. Interference shapes precede and follow the words.

  •7 shapes appeared during 6 s against a background image that was continually present.

  •First 4 shapes, then a 'to be remembered word', then 3 more shapes.

  •Screen clears & participants enter number of shapes counted.

  •At the end of the block (several trials) subjects recalled as many of the presented words as possible and it was stressed they should recall them in correct presentation order.

  •88 trials over 16 blocks.

  •To calculate complex span scores calculated the proportion of all words recalled in correct position.

Background image, neutral or provocative.

Blank background for recall.

word

Count the pink squares.
Remember the words in order.

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Experiment 1 & 2:
Schweizer & Dalgleish (2016)

Experiment 2. Replication study with same experiment but with a community sample.
n=59 subjects, average age=45 years, 45 women. 14 men.

Results:

Experiment 1: p=.007, d=.52. The **_negative background image or APSP resulted in poorer WMC performance in the student sample_**.

Experiment 2: p< .001, d=.55. Again the **_negative background image or APSP resulted in poorer performance in the community sample._**

Overall performance was lower in the community sample vs. student sample as expected.

Due to larger number of females in this sample they repeated analysis including gender as a covariate and found no significant gender effect on valence with no significant interaction effect and the main effect intact at significance level of p=.009.

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Experiment 3: Both groups car accident trauma, 1 group with PTSD.
Schweizer & Dlgleish (2016)

Background:

"Research in cognitive neuroscience and the clinical sciences **_reliably shows that the capacity to direct attention and responses away from negative distractors is relatively impaired in individuals with emotional disorders_** (Etkin & Wager, 2007; Joormann, Levens, & Gotlib, 2011)."

One study found that compared to subjects who have never suffered PTSD, **_WMC in those with a lifetime history of PTSD was "relatively more impaired in the context of trauma-related sentences_**" (Schweizer & Dlgeish, 2016).

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Affective Picture Span Paradigm (APSP) for Experiment 3.

Schweizer & Dalgleish (2016)

APSP: Affective Picture Span Paradigm: "The APSP-**Neu** was populated with emotionally **neutral** images of traffic scenes and the **APSP-Neg** with images of **MVAs** (motor vehicle accidents)."

"The two sets of images were rated on valence, arousal, image complexity, and picture quality by seven independent raters."

"The two sets of images differed in valence and arousal, but were matched for image complexity and picture quality (Table S2)."

"MVA images, although somewhat affectively negative, were only rated as mildly evocative with an emotional impact that was significantly lower than that of the emotional images used in Experiments 1 and 2, difference in mean distress ratings: F(1, 114) 20.05, p .001, p .88."

Because of the milder MVA content investigators did not expect that the MVA content would affect WMC of either the PTSD or the non-PTSD patients.

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Experiment 3:

Schweizer & Dalgleish (2016)

n=37 subjects ALL survivors of life-threatening or fatal motor vehicle accidents (MVAs), mean age=46 years, 16 women, 21 men.

Assessed whether the subject developed PTSD at any point post MVA using structured Clinical interview for the DSM (SCID, First, Spitzer, Gibbon, & Williams, 1995).

PTSD n=12, 10 female, 5 currently suffering from PTSD, 7 remitted PTSD.
No PTSD (PTSD-) n=15, 6 female, 9 male.

Groups did not differ significantly on age, gender ratio, or verbal IQ as assessed by NART (Nelson, 1982).

PTSD group significantly higher on **depression** (Beck Depression Inventory-II) & **trend** for differences on **trait anxiety** on Spielberger State and Trait Anxiety Inventory (Speilberger, Gorsuch, & Lushene, 1970). *However, between groups there were no differences in current levels of state anxiety.*

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Experiment 3:

Schweizer & Dalgleish (2016)

Results: "A group (PTSD, PTSD–) by condition (APSP-Neg, APSPNeu) mixed-model analysis of variance (ANOVA) **revealed the predicted condition by group interaction**, *F(1, 26) 5.74, p*=.025, eta=.19."

The "*PTSD group being significantly more impaired by MVA versus traffic distractors*. *t(11)*=2.01, *p*=.03, *d* =.61, 95% CI [00, .18], compared with PTSD– participants who showed no significant effect of background context."

"This interaction qualified a weak trend for a main effect of APSP condition, *F(1, 25)*=2.93, p .099, *eta*=.11, with performance being more impaired by MVA scenes relative to traffic scenes."

Additionally, the "*lack of significant findings for those negative distractor material in trauma survivors without PTSD is noteworthy.*"

Finally, WMC performance was lower and there was greater variability for all participants in experiment 3 than in 1 or 2. This variability in clinical profile was described as common among clinical populations.

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Experiment 3:

Schweizer & Dalgleish (2016)

Discussion: Negative images may elicit greater cognitive processing (e.g. depth of processing, rumination, etc.) vs. neutral images and put greater demands on executive functioning underlying WMC.

Compellingly given our context of Cogmed working memory training, "*individuals with greater WMC show better emotion regulation capacity* (Schmeichel, Volokhohv, & Demaree, 2008)". Others have found that "the *neural network involved in successful WM performance has also been implicated in emotional regulation* (Buhle, et al., in press; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008).

The images in Experiment 3 did not have sufficient impact to affect the WMC for trauma survivors who had not suffered PTSD, but does impair WMC for those who have suffered PTSD.

__Again, of particular interest was the authors conclusion that "improving individuals' WMC in affective contexts may particularly benefit those suffering from affective psychopathology".__

__Also, intriguingly Schweizer, et al., 2013 reported that they did indeed improve WM for affective material in healthy controls.__

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High stress, WM, poor affective updating and depressive symptoms…

200 students assessed for affective updating ability, stress and depressive symptoms. 4 months later and then again 1 year later they assessed depressive symptoms.

"*__Under high stress poor affective updating ability was associated with an increase in depressive symptoms__* at both 4 months and 1 year."

Thus the authors conclude "*affective updating ability* is an important cognitive vulnerability factor that interacts with stressful events to accelerate the development of depressive symptoms".

Affective updating? Clearing the emotive cache? "…affective executive functions involve not only inhibiting irrelevant information from gaining access to working memory or switching mindsets, but *also processes that actively modify information in working memory to allow new information to become the focus of attention* (e.g., Denkova, Dolcos, & Dolcos, 2015); this process is handled by the executive process of affective updating (Miyake & Friedman, 2012)."

__In other words one might conceptualize "affective updating" as working memory employed as it relates to managing emotional information.__

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Affective updating a key cognitive vulnerability factor in depression?

Participants completed an affective two-back task to measure **updating affective information** (Pe, Koval, Kuppens, 2013; Pe Raes, et al., 2013). "…at each trial, participants must remove previously relevant affective information from working memory, which has now become irrelevant (trial n-3), encode and identify newer, more relevant affective information in working memory (trial n) and match the valence of this new information with relevant, but old affective information in working memory (trial n-2)."

47 positive and 49 negative words were selected from a **Affective Norms of English Words** list (Bradley & Lang,1999). Words are identified as negative and positive if their valence ranged from 1 to 4 and 6 to 9 respectively. Stimuli matched in "word length, number of syllables, and arousal levels (see Pe, Raes, et al., 2013)".

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Affective updating.

The task included "24 practice trials (not scored) and 96 actual trials separated into four blocks of 24 trials. The first two trials of every block were not scored, leaving a total of 88 relevant trials for analysis." Subjects were presented a single affective word followed by an interval. Then subjects had to identify whether the valence of the current word was the same or different than the word two trials back by pressing either the "1" or "2" key. 44 of the trials were matches and 44 were not. In the 44 match trials half were positive valence and the other half were negative valenced.

To calculate participants' ability to update affective information investigators calculated the mean accuracy across all trials.

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Stress & Depression Assessments

Stress 3 measures: Subjects completed the **Perceived Stress Scale** (PSS; Cohen, Kamarck, & Mermelstein, 1983), a 10-items self-report indicating stress in the last month. The mean PSS was used as a measure of stress.

They also completed the **Depression, anxiety, stress scale** (DASS) upon which subjects indicated the extent to which they have experienced each symptom over the past week. The **stress subscale** was used as a measure of stress.

Subjects also used **Experience sampling method** with a Smartphone which was programmed to beep 10 times a day between 10 am and 10 pm for 7 days at random intervals and subjects recorded who **stressed** they were at the moment using a 0 to 100 slider, but they also reported how **depressed** they were with a 0 to 100 scale.

Depression 3 measures: Center for Epidemiological Studies Depression Scale. Mean of **Depression subscale** of DASS & experience sampling above.

"***Under high stress poor affective updating ability was associated with an increase in depressive symptoms*** at both 4 months and 1 year."

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These 2 studies suggest that Cogmed may appear to have salience to anxiety.

1. Stress and/or anxiety can reduce WMC.
2. Those with PTSD show poorer WMC than both students and community samples.
3. Those with PTSD show poorer WMC when exposed to a mild MVA stressor than those without PTSD even when both groups experienced a motor vehicle accident.
4. Poorer affective updating and high stress is associated with greater risk for depression.

Relevance to Cogmed:

1. Those with an anxiety disorder diagnoses are likely to have lower WMC.
2. If you can improve WMC with Cogmed, you may be able to decrease anxiety and stress.
3. You may also reduce risk for depression if you increase WMC.

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Study of children with Social Emotional and Behavior disorders who did Cogmed.
(Roughan & Hadwin, 2011)

Pilot. n=7 Tx, n-8 control. x=12.94 years old, children with SEBD, social emotional and behavioral disorders.

Testing WM (VWM & VSWM), IQ, inhibition, self-report test and trait anxiety, teacher reported emotional and behavior difficulties and attention control. 3 month follow up.

Post training WM, IQ, Inhibition, self-reported test and trait anxiety and teacher reported improved attentional control and emotional symptoms.

Improvements were not maintained at 3 months, except for WM which was maintained. Post training significantly better on IQ (Ravens' progressive matrices & Mill Hill Vocab. scale).

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Adults with Acquired brain injury & WM deficits do Cogmed & improve on WM, but also anxiety and depression.
(Akerlund, Esbjornsson, Sunerhagen, Bjorkdahl, 2013)

Adults with acquired brain injury in the **sub-acute phase** after acquired brain injury average age= 47. 7 years, n = 47, range= 22-63.

Deficit in WM: Patients *included if below normal range* on **digits forward, digits reversed** on WAIS-III; **digit span** and/or **blocks forward** and/or **blocks reversed** on the WAIS-III NI **Span board**. Exclusion criteria aphasia/non-Swedish communicable or if contra-indicated by MD (i.e. pronounced fatigue, pain or depression).

No significant differences were found between the Intervention group (IG) and Control Group (CG) regarding gender, age, time since injury, RLS (reaction level scale), educational level, diagnosis

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Can computerized working memory training improve impaired WM, cognition and psychological health?
(Akerlund, et al., 2013)

Table III. Background data for the Intervention (IG) and Control (CG) groups.

	Gender, male/female	Age (years), Md/range	Time since injury (weeks), Md/range	RLS. Md/range	Educational level, n, years of studies	Diagnosis frequency, % (n)
IG, n = 25	13/12	51 22–63	32 12–135	1 1–6	3, 1–9 years 8, 9–12 years 14, 12+ years	68% stroke (17) 16% trauma (4) 16% other (4)
CG, n = 20	10/10	53 22–62	22.5 16–500	1 1–5	2, 1–9 years 11, 9–12 years 7, 12+ years	75% stroke (15) 15% trauma (3) 10% other (2)

NOTE: For ethical reasons at the conclusion of the 18 weeks those in the Control Group (CG) were offered Cogmed. Those who wanted to do Cogmed, did.

For this purpose the CG was divided into C1 and C2.

C1 were those that did Cogmed.   (n=11)
C2 were those that refused to do Cogmed.   (n=10)

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Can computerized working memory training improve impaired WM, cognition and psychological health?
(Akerlund, et al., 2013)

Measures: The WAIS-III NI, Digit span, Arithmetic, Letter-Number Sequences, (**Working Memory sub-scale- aggregate of digit span, arithmetic & Letter-Number sequences),** Spatial span

Barrow Neurological Institute Screen for Higher Cerebral Functions (**BNIS**): This cognitive screening tool includes seven subscales: **speech & language, orientation, attention/concentration, visuospatial & visual problem-solving, memory, affect and self-awareness vs performance.**

Self ratings administered baseline and at follow-ups at 6 and 18 weeks.

Self-rating scales DEX: **Dysexecutive Questionnaire of problems in emotion, personality, motivation, behavior and cognition to assess problems in goal-directed behavior.**

Self-rating: **HADS (Hospital Anxiety and Depression Scale): Self-assessment of emotional and psychological health.**

Both groups underwent integrated rehabilitation.

The IG also trained with the computerized WM training program, Cogmed QM, which was offered to the CG and followed up after the study completion (C1).

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Can computerized working memory training improve impaired WM, cognition and psychological health?
(Akerlund, et al., 2013)

A1= baseline:
A2 = 6 week post training
A3 = 18 weeks post training
A4= 24 weeks post training

Intervention group (IG) n=25, control group (CG), n=20,

After initial phase control group offered Cogmed:
C1 were those that did Cogmed.   (n=11)
C2 were those that refused to do Cogmed.   (n=10)

HADS D: Hospital Anxiety and Depression Scale (Depression)

HADS A: Hospital Anxiety and Depression Scale (Anxiety)

Original treatment improved on depression at 18 weeks. post

After 24 weeks:
Control group that then did Cogmed improved on anxiety & depression.

(*Working Memory sub-scale-aggregate of digit span, arithmetic & Letter-Number sequences*)

BNIS= Barrow Neurological Inst. Screen for higher cerebral functions

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Can computerized working memory training improve impaired WM, cognition and psychological health in adults with acquired brain injury?
(Akerlund, et al., 2013)

Results: Both groups improved after their WM training in Working Memory, BNIS and in Digit span, particularly the reversed section.

Both the BNIS and the Digit span differed significantly between the IG and CG due to the greater improvement in the IG after their WM training.

Psychological health improved as both groups reported less depressive symptoms and the CG also less anxiety, after the training.

Conclusion: *Results indicated that computerized WM training can improve working memory, cognition and psychological health.*

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Cogmed study with adults with acquired brain injury shows improvement on anxiety & depression & other areas.
(Hellgren, Samuelsson, Lundqvist, Borsbo, 2015)

N=48 patients. (30 men 18 women); mean age= 43.7 years. Mean time since injury: 51.2 months (median 29 months) Whole Group Analysis, Sex Differences & a particularly unique & new analysis): Differences Related to Time since Injury: n=13 Injury >18 month ago, n=34 ≤ 18 months ago. **Those with less than 18 months since injury fared better.** There were no significant differences concerning age, gender or education between the 2 groups.

Design: test/retest, and comparison between groups.

Cause of brain injury: 21% TBI, 23% Cerebral infarction (stroke caused by blockage of a blood vessel in the brain), 19% infection, 13% intra cerebral hemorrhage (bleed), 10% subarachnoid hemorrhage (bleed), 8% brain tumor, 6% other.

Patients with non-progressive acquired brain injury who participated in a computerized WM training program (Cogmed QM) [31] at a Rehabilitation Medicine department in Sweden between 2009 and 2012.

Cogmed with Acquired Brain Injury Differentiating time since Injury
(Hellgren, Samuelsson, Lundqvist, Borsbo, 2015)

Participants did not have any co-morbidity that could have any significant effect on working memory.

Inclusion criteria: Age 20 - 65 years.
SUBJECTIVE WM IMPAIRMENT & OBJECTIVE WM IMPAIRMENT: Significantly impaired WAIS WM index (**VERBAL WM INDEX**) compared with index of verbal comprehension measured and/or index of perceptual organization or a WAIS WM index < 80 as measured by the WAIS-III, and motivated for training.

Exclusion criteria: IQ ≤ 70 as measured with WAIS-III/WAIS-IV, depression according to DSM-IV, and perceptual or motor difficulties that make the computerized WM training impossible.

Cogmed with Acquired Brain Injury Differentiating time since Injury
(Hellgren, Samuelsson, Lundqvist, Borsbo, 2015)

Training Intensity Varied: WM training performed on a computer (PC), and each session was 45 - 60 minutes of intense exercise including one break.

INTENSITY VARIATION: The exercise intensity varied. Some trained 5 days a week for 5 weeks another group trained 4 days a week for 7 weeks.

TRAINING IN PAIRS OR GROUPS of 3: All subjects trained in pairs or in groups of three in a quiet, private room at the Department of Rehabilitation Medicine.

COACHES PRESENT IN ROOM DURING TRAINING: Weekly coaching sessions were provided.

No other therapies were applied during the examination period.

Cogmed with Acquired Brain Injury Differentiating time since Injury
(Hellgren, et al., 2015)

A neuropsychologist performed all neuropsychological tests, which were conducted before and 20 weeks after WM training.

Assessments:
PASAT: Paced Auditory Serial Attention Test, measures WM, info processing speed and ability to sustain and divide attention.

Forward and backward block repetition.

Listening Span task.

Canadian Occupational Performance Measure (**COPM**) – on WM-related activity *performance* and *satisfaction*.

EQ-5D Index (**European Quality of Life Instrument-Five Dimensions**): self-assessment on a person's perceived state of health on 5 dimensions: mobility, self-care, usual activities, pain/discomfort and **anxiety/depression**.

EQ-5D VAS European Quality of Life Instrument-100 Points Health Scale. Perceived health on a scale of 0 to 100.

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Results of Whole Group test/re-test from before training to 20 weeks post training.
(Hellgren, et al., 2015) Table 1 referenced in the paper.

	Before M (SD)	20 Wk. Aft. M(SD)	P value
PASAT	38.9 (11.1)	44.0 (11.0)	<.001
Listening Span	24.3 (6.1)	27.3 (5.3)	<.001
Forward Block repetition	7.5 (1.9)	8.9 (1.7)	<.001
Backward block repetition	7.0 (1.7)	8.4 (1.7)	<.001
COPM performance	3.8 (1.2)	5.5 (1.7)	<.001
COPM satisfaction	3.2 (1.8)	5.4 (1.8)	<.001
EQ-5D index	.62 (0.26)	.81 (0.25)	<.009
EQ-VAS	56.6 (21.0)	63.8 (17.7)	<.001

All improved significantly on all measures. However, there was individual variability.

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Cogmed with Acquired Brain Injury Differentiating time since Injury
(Hellgren, et al., 2015)

Health-related quality of life as measured by EQ-5D Index showed a significant positive change (p = 0.009) from before training versus 20 weeks after training. This included: mobility, self-care, usual activities, pain/discomfort and **anxiety/depression**.

In addition, a positive change in **perceived health** (as measured by EQ-VAS) from before versus 20 weeks after training was found (p < 0.001) (**Table 1).**

Yet, there was individual variability: *A significant positive correlation was found between the difference in WM index and the and the difference in patients' estimated activity performance* (COPM), from before training and 20 weeks after WM training. (r$_s$=0.536, p< .001).

The correlation found between the difference in WM index and the and the difference in patient's estimated satisfaction with activity performance before 20 weeks and after WM training. (r$_s$=0.226, p< .127) was *not significant.*

No sex differences were found.

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Results of Whole Group test/re-test from before training to 20 weeks post training.
(Hellgren, et al., 2015) Table 3 referenced in the paper.

	≤ 18 months –change before and after training M (SD) (less time since injury)	> 18 months –change before and after training M (SD)	P value
PASAT	2.8 (5.1)	5.2 (7.5)	<.193
Listening Span	2.0 (3.6)	2.9 (4.1)	<.347
Forward Block repetition	1.0(1.8)	1.5 (1.7)	<.537
Backward block repetition	.7 (2.4)	1.56 (1.9)	<.108
COPM performance	**2.5 (1.3)**	**1.4 (1.5)**	**<.05**
COPM satisfaction	**3.1 (1.9)**	**1.8 (1.3)**	**<.05**
EQ-5Dindex	.09 (0.11)	.10 (0.23)	<.298
EQ-VAS	5.7 (10.9)	9.1 (15.3)	<.572

Differences Related to Time since Injury: n=13 Injury >18 month ago, n=34 ≤ 18 months ago.
Those with less than 18 months since injury fared better.
There were no significant differences concerning age, gender or education between the 2 groups.

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Cogmed with Acquired Brain Injury Differentiating time since Injury
(Hellgren, et al., 2015)

Differences Related to Time since Injury: n=13 Injury >18 month ago, n=34 ≤ 18 months ago.

Both groups showed significant differences on WM index (p≤ 0.001).

However, the improvement in WM was greater with those injured less than 18 months ago at the (p<.05) level.

Those with less than 18 months since injury fared better on COPM performance and satisfaction.

There were no significant differences concerning age, gender or education between the 2 groups.

There were no significant differences on neuropsychological tests.

There were no significant differences on the quality of life measures.

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Cogmed with Acquired Brain Injury Differentiating time since Injury
(Hellgren, et al., 2015)

Limitations: *No Control group.* However, previous research with the same design and method has shown that *spontaneous recovery during the study period seems to be negligible and that the test-retest effect cannot explain the improvement between test sessions (Lundqvist, et al., 2010).*

Strengths: A strength of our study is its **large sample size**: previous studies relied on fewer participants [23]-[30].

Another strength **evaluated the effects of WM training using several methods—e.g.**, reflecting both trained (WM index) and untrained (neuropsychological tests) WM tasks.

The evaluation also included an investigation of the **outcome in patients' everyday life**, in terms of individually identified occupations of importance (COPM).

The fact that **data collection was done before and 20 weeks after training**, rather than directly after training, can also be seen as strength.

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Cogmed with Acquired Brain Injury Differentiating time since Injury
(Hellgren, et al., 2015)

Clinical Implications: "Computerized WM training is effective for patients with acquired brain injury. Despite the change in training intensity compared to other studies [23] [25] [29] [30], our study produces good results. *The change in training intensity makes the demanding training less so and therefore more patients might be able to cope with the training."*

"This study shows that some patients whose injuries occur more than 18 months before WM training improve more; *however, this improvement may have been even greater if the training has occurred even earlier. "*

"As it may be valuable for patients to receive this training soon after their injury, rehabilitation teams should make an early assessment of need. "

"At the same time, it is important to keep in mind that training can have an effect even a long time after injury, so WM training can be beneficial for a lot of patients with working memory dysfunction after a brain injury despite time since injury. However, the expectations associated with later stage training should be somewhat lower."

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Cogmed & CBT reduce anxiety and attentional bias to threat: A preliminary study.
(Hadwin & Richards, 2016)

N=40. **Ages 11 to 14**. Reporting high anxiety and poor attentional control. Randomly assigned: Cogmed or Cognitive Behavioral Therapy (CBT).

Impact of working memory training in compared to cognitive behavioral therapy in treating state and trait anxiety.

Cogmed associated with improved in trained WM tasks and attentional control. Both groups:
1. Reported fewer anxiety symptoms
2. Showed increased inhibitory control.
3. Showed a reduction in attentional biases to threat post intervention.
4. Gains maintained at follow up.
Only the Cogmed group improved WM.

"The study provides indicative evidence which suggests that WM training has similar benefits to a more traditional CBT intervention on reduced anxiety and attentional biases for threat."

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Cogmed & CBT reduce anxiety and attentional bias to threat: A preliminary study.
(Hadwin & Richards, 2016)

Attentional biases to threat: "Attention bias modification (ABM) techniques were developed to reduce attentional biases to threat in anxiety using experimental paradigms that direct attention away from threatening stimuli or toward positive stimuli and where the overall aim is to reduce symptoms of anxious affect. Recent studies have found that ABM leads to reductions in attentional biases for threat and anxiety symptoms in children and adolescents (e.g., Rozenman et al., 2011; Eldar et al., 2012). "

However, *Cogmed helps one improve attentional control more broadly.* These investigators posed the idea that *improved overall attentional control may improve anxiety*.

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Cogmed & CBT reduce anxiety: A preliminary study.
(Hadwin & Richards, 2016)

Will interventions to increase attentional control through improving WM reduce anxiety symptoms and "attentional processes associated with negative affect (poor attentional control and attentional capture or avoidance of threat stimuli; Legerstee et al., 2010; Waters et al., 2012)."

Cogmed was compared with cognitive behavioural therapy (CBT). CBT is well-regarded as an effective treatment for treating anxiety (review by Cowart and Ollendick, 2010).

Investigators "expected that the WM intervention should increase performance in WM tasks and that it would have a broader positive impact on key measures of attention (i.e., inhibitory control and attentional bias to threat), as well as feelings of anxious affect. "

It did.

This alternative could be effective for individuals not responsive to traditional approaches to treat anxiety.

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Cogmed & War veterans with PTSD Pilot study.
(Saunders, et al, 2016)

N=4. Post-traumatic stress disorder (PTSD) among 4 war veterans ages 55 to 65 who also had poor working memory (WM).

Cogmed & transcranial direct current stimulation (tDCS) in a combined treatment.

All patients showed clinically significant improvement on a "range of cognitive and emotional performance measures".

Also, "theoretically significant neurophysiological changes between pre/post-treatment electroencephalographic (EEG) results. Specifically P3a, theorized to underline impaired cognitive processing abilities, also increased in both frequency and amplitude as a result of treatment.

Nerida Suanders, Russell Downham, Bulent Turman, Juri Kropotov, Richard Clark, Rustam Yumash & Arielle Szatmary (2014): Working memory training with tDCS improves behavioral and neuropsychological symptoms in pilot group with post-traumatic stress disorder (PTSD) and with poor working memory, Neurocase: The Neural Basis of Cognition, DOI: 10.1080/13554794.2014.890727.

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Cogmed & War veterans with PTSD Pilot study.
(Saunders, et al, 2016)

Treatment: 5 transcranial direct current stimulation (tDCS) treatments for 20 minutes each, once a week. Administered in the clinic after "working memory enhancement protocols (Fregni, et al., 2005). At the end of this period, clients did Cogmed for 5 weeks at home with weekly coach calls.

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Cogmed & War veterans with PTSD Pilot study.
(Saunders, et al, 2016)

N=4. Post-traumatic stress disorder (PTSD) among 4 war veterans ages 55 to 65 who also had poor working memory (WM).

These 4 subjects improved in several areas of functioning as measured by the Integneuro and the Brain Resources Inventory of Emotional intelligence Factors.

The areas in which more than one improved included the following: Working memory, switching attention (2), visual memory span (2), Mazes (3), empathy/intuition (2), continuous performance (2), visual memory span (3) & long delay recall (2).

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Cogmed & War veterans with PTSD Pilot study.
(Saunders, et al, 2016)

Review of the actual study would be necessary to get a better grasp of the change in the P3a area. However the image below will give you a general idea of where P3 is.
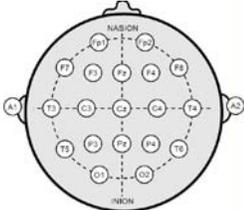
In all 4 subjects P3a shifted "significantly toward normality. Existing research shows that this component is involved in staying focused and not being distracted by novel situations, and so its normalization is consonant with the observed reduction in hypervigilance." Also, the

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Summary
1. Stress and/or anxiety can reduce WMC.
2. Those with PTSD show poorer WMC than both students and community samples.
3. Those with PTSD show poorer WMC than those without PTSD when exposed to a mild MVA stressor even when both groups had experienced a motor vehicle accident or trauma.
4. Poorer affective updating and high stress is associated with greater risk for depression.
5. Those with an anxiety disorder diagnoses do appear to at lest to tend toward lower WMC.

Cogmed has been found in research to have the following effects:
1. Improves WMC in those with anxiety.
2. Reduced state and trait anxiety in children and improved social and behavioral control as rated by teachers.
3. Reduced anxiety similarly to what many consider to be the gold standard of anxiety treatment: CBT and, additionally, improved WMC.
4. Cogmed reduced anxiety & depression in adults with acquired brain injury in 3 studies. Hence one might reduce risk for depression if you increase WMC.
5. Preliminary uncontrolled pilot data found that after Cogmed and transcranial direct current stimulation (tDCS) there was a reduction in anxiety and brain normalization with adult veterans with PTSD. This will need to be replicated.

The mechanism for reduced anxiety is somewhat unclear but may be improved emotional updating or better general attentional control that generalizes to reduced attentional biases to threat. There does appear to be a relationship between WMC and anxiety and both can be improved by Cogmed.

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