Cogmed Working Memory Training

What claims does the company make / what does the programme target?

Cogmed focuses on improving working memory capacity as, according to its website, "[p]oor working memory is the source of many problems related to attention and is often linked to ADHD, and other learning disabilities." (Cogmed, n.d.-a, Question 5) Throughout its website are claims that Cogmed is "evidence-based" (Question 1) and "[b]ased on solid research" (Question 11), that it is "developed by leading neuroscientists" (Question 8), and that "Cogmed is dedicated to providing only products that are proven to be effective in rigorous research." (Question 8)

In their information document Cogmed Claims & Evidence (n.d.-b), Cogmed's developers do claim that their product can improve the inattentive and hyperactive symptoms of those with ADHD, but acknowledge that it does not constitute a cure. They also claim that Cogmed can lead to improved academic performance, but acknowledge that more research involving post- intervention reassessment is required.

Cogmed's developers claim that improvements in users' working memory and other behavioural outcomes are sustained over the long term. They are careful to point out, however, that they do not claim these gains will last forever, or that use of Cogmed will certainly result in a student getting better marks at school.

Evidence for efficacy:

There is undoubtedly a substantial volume of research investigating the efficacy of Cogmed, considerably larger than that investigating any of its competitors (Shipstead, Hicks, & Engle, 2012).

A large number of studies suggest that Cogmed training can indeed increase working memory capacity, at the very least in the short term (see generally the review of Rabipour & Raz, 2012 and (as examples) the experimental work of Brehmer, Westerberg and Bäckman, 2012; Holmes, Gathercole, & Dunning, 2009; Klingberg, Forssberg & Westerberg, 2002; Klingberg et al., 2005; Roughan & Hadwin, 2011). Further, some research suggests that such increases in working memory persist across time (Holmes, Gathercole, & Dunning, 2009; Klingberg et al., 2005; Roughan & Hadwin, 2011). However in a recent meta-analysis, Melby-Lervåg & Hulme (2013) suggested that it may be only improvements in visuospatial working memory which persist after training, with improvements in verbal working memory generally failing to persist.

A more contentious body of research suggests that Cogmed training can lead to improvement in other cognitive constructs, and that it may ameliorate the symptoms of ADHD and other learning disorders. A number of studies (Klingberg et al., 2002; Klingberg et al. 2005; Olesen, Westerberg, & Klingberg, 2004) suggest that Cogmed may improve reasoning ability as measured by Raven's Progressive Matrices, and attentional processes as measured by the Stroop Test. These results have not always been replicated in other newer studies, however (see e.g. Brehmer et al., 2012; Dahlin, 2011). Studies have also shown a reduction in the inattentive and hyperactive symptoms of those with ADHD undergoing Cogmed training (Beck, Hanson, Puffenberger, Benninger, & Benninger, 2010; Klingberg et al., 2002; Klingberg et al. 2005; Mezzacappa & Buckner, 2010), although significant reductions in symptoms tend to be based on the ratings of parents or teachers (see below for discussion about the lack of proper blinding in these studies). Klingberg et al. (2002) did find a reduction in hyperactive head- movements (an objective measure), although their results could not be replicated by Klingberg et al. (2005).

Few studies have directly examined Cogmed's impact on reading, or its efficacy as an intervention for dyslexia. One exception is the work of Dahlin (2011). She found that Cogmed training improved reading comprehension performance (although not word decoding or orthographic verification) in Swedish children with attentional deficits and other learning problems (NB: this was not a study limited to dyslexia). On the other hand, Holmes et al. (2009) found no increase in basic word reading after Cogmed training, but did find an improvement in mathematical ability at the 6-month follow-up point.

Evidence against efficacy:

There is considerable uncertainty about the neural correlates of any improvement in working memory capacity brought about by Cogmed working memory training. The two experiments detailed by Olesen et al. (2004) both showed an increase in activation in the prefrontal and parietal cortices of healthy adults, and a decrease in activation in their cingulate sulci (in their second experiment they also found increases in the thalamic and caudate nuclei and decreases in the inferior frontal sulcus and postcentral gyrus). Conversely Brehmer et al. (2011), who studied older (M = 63.7 years) healthy adults, found activity decreases in activity in the prefrontal, temporal and occipital cortices post-training and increases in activity in subcortical areas (thalamus and caudate). Crucially, they found that the magnitude of these neocortical decreases and subcortical increases correlated with the extent of the gain achieved during the intervention period. Indeed, if Cogmed training does work, it is not yet clear how it works. A similar conclusion — i.e., there is currently no clear pattern of neural change brought about by working memory training — was reached in a wider review incorporating studies using other working memory training programmes (Buschkuehl, Jaeggi, & Jonides, 2012).

Further, although there is a substantial *quantity* of research investigating Cogmed, various reviewers (e.g., Hulme & Melby-Lervåg, 2012; Melby-Lervåg & Hulme, 2013; Shipstead, Hicks, & Engle, 2012) have begun to question its *quality*. Together they identify a number of issues with studies cited supporting Cogmed's efficacy. These are:

- *Control group issues*: some studies wholly fail to include a control group (e.g., Holmes, Gathercole, Place, Dunning, Hilton & Elliott, 2010) meaning improvements between pre- and post-intervention testing may in fact be due to other changes within the time period (e.g., practice effects or regression to the mean). Of those which do include a control group, some fail to randomly assign participants to treatment and control conditions, meaning differences between the groups may be explained by pre-existing differences. Others use an inappropriate control procedure. If a study uses only an untreated control group (e.g., Roughan & Hadwin, 2011), then differences between the trained and control groups may be due to other, unforeseen effects of an intervention, such as those inducing expectancy effects or otherwise affecting motivation. To circumvent this, researchers (e.g. Holmes et al., 2009; Klingberg et al. 2002; Klingberg et al. 2005) have taken to using non-adaptive active control groups, where participants complete the same training except that the tasks do not become more difficult with repeated success. Nevertheless, Shipstead, Hicks, and Engle (2012) go further and criticise this approach also, arguing that participants in the two groups might still be differentially motivated to perform during post-intervention testing. Non-adaptive controls, they suggest, may not effectively convince participants they are in the process of cognitive training, and do not suggest to the user that his/her working memory is increasing. Arguably, their doubt is excessive, with

some evidence suggesting that there is no difference in motivation between the groups, at least for young children (Bergman Nutley et al., 2011). Indeed, Jaeggi, Buschkuehl, Jonides
& Shah (2012) suggest that the positive reinforcement control groups usually receive in terms of points earned is likely to be sufficient motivation.

- *Blinding and expectancy effects*: even if an active control is used, some studies fail to employ appropriate blinding, meaning their results may be confounded by expectancy effects. As one potent example, Cogmed's developers use the Beck et al. (2010) article to support their claim that Cogmed can reduce the inattentive and hyperactive symptoms of those with ADHD as measured by behavioural rating scales. In that study, the experimental group did indeed show a significant reduction in ADHD symptomatology based on a series of parent-report scales. But neither participants nor parents were blind to treatment. Moreover, teachers, who were blind to treatment, reported no improvement in either executive functioning or ADHD symptomatology. Shipstead, Hicks, and Engle (2012) argue there is a pattern such that improved ADHD symptomatology is generally reported only in situations where raters are not blinded, and not in situations where they are.

- *Small sample sizes*: some of the earlier research which presented promising results involved limited sample sizes. For example, the second experiment reported by Klingberg et al. (2002) involved a treatment group of only four, and the first experiment reported by Olesen et al. (2004) involved a treatment group of only three.

- *Working memory assessment*: more varied testing is needed to provide robust evidence for increased working memory capacity after Cogmed training. Unfortunately, many studies reporting positive results use simple forward and backward span tasks to assess working memory, which are exactly what Cogmed uses for training (Shipstead, Hicks, & Engle, 2012). Their results may therefore (at least partially) represent the effect of task-specific practice. The results of studies which have used complex span tasks are mixed (Holmes et al., 2009; Holmes et al., 2010; cf Bergman Nutley et al., 2011; Shavelson et al., 2008). Further research using different types of working memory task is desirable. This, according to Shipstead, Hicks and Engle, could include not only complex span tasks but also visual arrays, running memory span, keeping track and free recall.

- *Generalizability*: reviewers have also doubted whether Cogmed generalises sufficiently to make it a worthwhile intervention. Again given the fact far-transfer effects have been found (as outlined above, e.g. improvements on the Stroop task and Raven's matrices) reviewers question the quality of those findings. As an example, a notable problem with studies finding transfer to the Stroop task is that they frequently use only incongruent trials (Klingberg, 2010). As Shipstead, Hicks and Engle point out, citing the work of Hutchison (2007) and Kane and Engle (2003), working memory capacity is in fact unrelated to performance on Stroop tasks involving only incongruent trials. Consequently, increased working memory capacity cannot readily explain increased performance on wholly incongruent Stroop tasks (although such increased performance could, as Jaeggi, Buschkuehl, Jonides & Shah, 2012 point out, result from other processes). Further, other studies have failed to replicate a transfer to the Stroop test (e.g. Brehmer et al., 2012, Dahlin, 2011; Westerberg et al., 2007) and to Raven's matrices (e.g. Dahlin, 2011).

- *A lack of theory*: finally, reviewers have questioned the sufficiency of theoretical basis behind Cogmed's claims. Even if we assume for this purpose that there are certain reliable generalizing effects, there is no solid theory to explain why these transfer effects occur (Jaeggi, Buschkuehl, Jonides & Shah, 2012; Hulme & Melby-Lervåg, 2012). More research is needed in particular to elucidate the relationship between attentional control and working memory capacity and training programmes.

In summary, despite the above, the overwhelming volume of research suggests that Cogmed certainly has the potential to improve performance on assessments of working memory. How far any improvements generalise is still not clear. For present purposes, it is important to note that there have been only isolated findings of transfer to reading (Dahlin, 2011) and mathematics (Holmes et al., 2009). As discussed above, detractors of working memory training suggest this is because working memory training does not affect any underlying neural substrate, but instead only stimulates the development of task-specific strategies which are not called on in everyday activities. A more optimistic interpretation is also possible, however. Such transfer failures may signal no more than a need to incorporate into Cogmed a wider, more-stimulating range of activities which explicitly allow users to practice transferring any newly-learned strategies to a range of other situations (Gathercole, Dunning, & Holmes, 2009).

Price:

According to The Parent Room (n.d.) website, $1475 privately and for schools, $3,600 for 10 students and 4 teachers.

A note about other working memory training programmes:

Cogmed — although the most researched — is not the only computerised working memory training programme for which there is support in the literature. Other working memory training programmes discovered during the audit are discussed briefly below.

<u>Jungle Memory:</u>

In contrast to Cogmed which uses simple span tasks for training, Jungle Memory (http://junglememory.com) uses three complex span tasks to train working memory. Users must recall visuo-spatial or verbal information which was presented as they performed word completion, mental rotation or mathematics tasks (Shipstead, Redick, & Engle, 2012; for a detailed description of each game see Alloway, 2012). Two studies support its efficacy. Both involve students with learning difficulties, and both use active control groups. They are:

<u>*Alloway (2012):*</u>

15 students (11.10 to 14.70 years old) with learning difficulties were randomly allocated to the treatment (n = 8) or control (n = 7) group. The treatment group trained on the three Jungle Memory exercises for 30 minutes three times per week for eight weeks. The control group received individualised targeted educational support for 30 minutes three times per week over the same eight-week period.

Pre- and post-intervention measures included the vocabulary test from the Wechsler Abbreviated Scales of Intelligence (WASI), the numerical operations test from the Wechsler Objective Numerical Dimensions, the spelling test from the Wechsler Objective Reading Dimensions and a self-developed computerised working memory assessment.

The treatment group improved across all measures, while the control group improved only in the spelling test. Mann-Whitney analysis of the differences between pre- and post-intervention scores revealed significant differences between the treatment and control groups' gains in the vocabulary, numerical operations and working memory measures, but no significant difference between the groups' changes in spelling scores.

Limitations: this was a pilot study with a small sample size.

Alloway, Bibile, & Lau (2013):

94 students with learning difficulties were allocated to one of three groups for the eight weeks of the study. The first group (*n* = 39) was the nonactive control. The second group (*n* = 32) was the active control, who trained using Jungle Memory, but only once a week. The third group was the treatment group, who trained using Jungle Memory four times per week.

Measures administered to all groups include the vocabulary test from the WASI, the spelling test from the Wechsler Objective Reading Dimensions, a test of arithmetic and fractions from the Wechsler Objective Numerical Dimensions and an updated version of Alloway's computerised working memory assessment (Automated Working Memory Assessment-II; AWMA). Measures were taken pre-training, immediately post-training, and eight months after training ended.

The nonactive and active control groups did not show significant improvements on any of the cognitive tests. In contrast, the treatment group showed significant improvements from pre-intervention to post-intervention in the working memory, vocabulary, and spelling measures, although not in the mathematics measure. They also showed a maintenance effect for working memory, vocabulary, and spelling at the eight-month follow up period.

These results suggest that the regularity with which cognitive training is undertaken is of great importance.

Odd Yellow:

Van der Molen, Van Luit, Van der Molen, Klugkist, and Jongmans (2010) report improvements in working memory, arithmetic and story recall in adolescents with mild to borderline intellectual disabilities who trained using a package developed by the researchers called 'Odd Yellow'. This involves one exercise where the user is shown sequences of three similar shapes on a computer screen. Two are identical in shape, and one is different. The shapes are black except for one of the two that are identical in shape, which is yellow. The user must identify the location of both the differently shaped and yellow figures for each sequence. The adaptive mechanism varies the number of sequences presented in each trial between one and seven.

Unfortunately, while interesting, Odd Yellow does not seem to be available for purchase by the public.

Lumosity:

Lumosity — which has its own section in this report — also incorporates some working memory training tasks.

Other, 'in-house' solutions:

Finally, given the focus of this report on specific learning disabilities, it is worth noting two studies where researchers have devised their own working memory training programmes and noted improvements in reading performance.

Chein and Morrison (2010) developed a working memory training programme where users trained on two adaptive complex span tasks. The first was a verbal task where users had to remember a series of letters which were presented between four seconds of lexical decision-making. The second was a spatial task where users had to remember the locations of stimuli which were presented between symmetry decisions. They found that healthy adults who trained using this programme improved significantly more than untrained controls in performance on working memory tests, the Stroop test, and the Nelson–Denny test of reading comprehension. Transfer to the ETS reading battery or Raven's matricies was observed.

Limitations: used a no-contact as opposed to an active control group and so does not account for Hawthorne effects.

Loosli, Buschkuehl, Perrig and Jaeggi (2012) developed a complex span task where the users were shown a series (which adaptively varied in length) of animal pictures. They had to decide whether each picture in the series was correctly oriented (i.e., whether were they upside down or not). Immediately afterwards they had to recreate the series of animal pictures from memory. They found that typically developing children who trained using this task for 2 weeks improved more than an untrained control group in measures of text reading and single-word reading, but not pseudoword reading.

Limitations: only quasi-experimental — participants not randomly matched to groups; used a no-contact as opposed to an active control group and so does not account for Hawthorne effects.

For an in-depth review of working memory training programmes and paradigms, results, and relevant methodological concerns, see Shipstead, Redick, and Engle (2012).

What it involves:

Cogmed comprises three distinct online software programmes designed to increase users' working memory capacity. These are Cogmed JM for pre-school children, Cogmed RM for school age children and Cogmed QM for adolescents and adults. All three programmes consist of approximately 25 sessions. They are designed to generally be used 5 days per week and thus completed in a five week period.

Cogmed JM

Sessions last 15-20 minutes each. Activities include:

- *Rollercoaster, Hotel Pool* and *Twister*, which are essentially variations on the same task. A number of 'furzies' are shown in a fixed arrangement. One or more then jump(s) up and down in a particular order, and the user must click on the furzies in the same order in which they jumped. The tasks primarily differ in the number of furzies displayed. *Rollercoaster* and *Hotel* each display 9 furzies, *Pool* displays 12, and *Twister* displays 16.
- *Bumper Cars*: 5 'furzies' are shown sitting in bumper cars that are continuously moving in a rink. One or more furzies then jump(s) up and down in a particular order. The user must click on the furzies in the same order in which they jumped.
- *Ferris Wheel*: 8 'furzies' are shown sitting in a continuously rotating Ferris wheel. One or more furzies then jump(s) up and down in a particular order. The user must click on the furzies in the same order in which they jumped.
- *Animals*: 8 pictures of animals bordered by light bulbs are presented arranged in a circle. A number of animal pictures are then highlighted in a particular order by the bulbs bordering them lighting up. The user must then click on the animal pictures in the same order in which they were highlighted.

Cogmed RM (also known as "RoboMemo")

Sessions last 30-45 minutes each. Activities include:

- *Space Whack*: a number of craters under which monsters live are shown to the user, who is told that before a monster appears there will be a puff of smoke emitted from its crater. Puffs of smoke are then emitted from certain craters. To kill the monsters and complete the task, the user must position his/her mouse over the craters in the same order as the puffs of smoke were emitted.
- *Data Room*: the user is shown a number of lamps arranged in a 3-D grid (as if looking into a room without a ceiling). A number of lamps then light up in a particular order. The user must click on the lamps in the same order in which they lit up.
- *Decoder*: a sequence of letters is read to the user, with separate lamps lighting up each time a letter is read. Then, under each lamp, three different letters are presented. The user must click on the letter which corresponds to the one read out when that lamp was lit up.
- *Asteroids*: floating asteroids are shown to the user. A number flash in a particular order. The user must then click on the asteroids in the same order in which they flashed.
- *Space Cube*: a floating cube with 3 faces and 12 individual panels visible is shown. A number of these panels light up, with the cube rotating a small amount each time a panel lights up. The user must then click on the panels in the same order in which they lit up.
- *Numbered Grid*: a grid with 16 latches (4 x 4) is shown. Some of these open to reveal numbers, presented out of order (e.g., a 2, then a 1, then a 3 is revealed). The user must click on the latches in numerical order (i.e., 1, then 2, then 3), not simply in the order in which they were first opened.
- *Input Module*: a sequence of numbers is read out, corresponding to keys that light up on a keypad. The user is required to input the numbers into the keypad in reverse order.
- *Input Module w/ Lid*: this is the same as the *Input Module* task except that the user cannot see the keys light up when the numbers are read out.
- *Rotating Dots*: 10 lamps are shown in a continuously rotating wheel. A number of the lamps then light up in a particular order. The user must click on the lamps (now in a new position) in the same order in which they lit up.
- *Visual Data Link*: a grid with 16 lamps (4 x 4) is shown, with a number of them then lighting up in a particular order. The user must reproduce the sequence by clicking on the in the same order in which they lit up.
- *Rotating Data Link*: this is the same as the *Visual Data Link* task, except that after the lamps light up, the grid is then rotated 90°. This means that when the user is required to reproduce the sequence, the lamps are in a new position.

Cogmed QM

- *Cube*: essentially the same as the *Space Cube* task in Cogmed RM.
- *Sort*: essentially the same as the *Numbered Grid* task in Cogmed RM.
- *Assembly*: essentially the same as the *Decoder* task in Cogmed RM.
- *Rotating*: essentially the same as the *Rotating Dots* task in Cogmed RM.

- *Numbers*: essentially the same as the *Input Module* task in Cogmed RM.
- *Hidden*: essentially the same as the *Input Module w/ Lid* task in Cogmed RM.
- *Grid*: essentially the same as the *Visual Data Link* task in Cogmed RM.
- Twist: essentially the same as the *Rotating Data Link* task in Cogmed RM.
- *3D Grid*: very similar to the *Data Room* task in Cogmed RM. A number of panels in a 3-D grid (as if looking into a room without a ceiling) light up in a particular order. The user must click on the panels in the same order in which they lit up.
- *Chaos*: similar to the *Asteroids* task in Cogmed RM. Floating, continuously moving shapes are shown to the user, with a number flashing in a particular order. The user must then click on the shapes in the same order in which they flashed.

All three programmes feature an algorithm which continually adjusts the difficulty of the working memory task presented in order to ensure that the user is always performing at the limit of his or her (present) working memory capacity. When the user repeatedly gives correct responses, the task is modified to make it more difficult. Similarly if the user repeatedly gives incorrect responses, the task is modified to make it easier. The ostensible logic behind this is that cognitive resources can — much like muscles — be trained by repeated use near or at their full capacity (Melby-Lervåg & Hulme, 2013). There is at least some evidence that this may be the case (Diamond & Lee, 2011; Holmes, Gathercole, & Dunning, 2009; Klingberg et al., 2005).

References:

Alloway, T. (2012). Can interactive working memory training improving learning? *Journal of Interactive Learning Research, 23*(3), 197-207.

Alloway, T. P., Bibile, V., & Lau, G. (2013). Computerized working memory training: Can it lead to gains in cognitive skills in students? *Computers in Human Behavior, 29*(3), 632- 638.

Beck, S. J., Hanson, C. A., Puffenberger, S. S., Benninger, K. L., & Benninger, W. B. (2010). A controlled trial of working memory training for children and adolescents with ADHD. *Journal of Clinical Child & Adolescent Psychology, 39*(6), 825-836.

Bergman Nutley, S., Söderqvist, S., Bryde, S., Thorell, L. B., Humphreys, K., & Klingberg, T. (2011). Gains in fluid intelligence after training non!verbal reasoning in 4!year!old children: a controlled, randomized study. *Developmental Science, 14*(3), 591-601.

Brehmer, Y., Westerberg, H., & Bäckman, L. (2012). Working-memory training in younger and older adults: training gains, transfer, and maintenance. *Frontiers in Human Neuroscience, 6*:63.

Brehmer, Y., Rieckmann, A., Bellander, M., Westerberg, H., Fischer, H., & Bäckman, L. (2011). Neural correlates of training-related working-memory gains in old age. *Neuroimage, 58*(4), 1110-1120.

Buschkuehl, M., Jaeggi, S. M., & Jonides, J. (2012). Neuronal effects following working memory training. *Developmental Cognitive Neuroscience, 2*, S167-S179.

Chein, J. M., & Morrison, A. B. (2010). Expanding the mind's workspace: Training and transfer effects with a complex working memory span task. *Psychonomic Bulletin & Review, 17*(2), 193-199.

Cogmed. (n.d.-a). *Frequently Asked Questions*. Retrieved from http://www.cogmed.com/faq.

Cogmed. (n.d.-b). *Cogmed Claims & Evidence*. Prepared by Kathryn Ralph, Research Relationship Manager. Retrieved from http://www2.cogmed.com/l/6032/2012-03- 27/7st5w/ 6032/48666/Cogmed Research_Claims_and_Evidence.pdf.

Dahlin, K. I. (2011). Effects of working memory training on reading in children with special needs. *Reading and Writing, 24*(4), 479-491.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*(6045), 959-964.

Gathercole, S. E., Dunning, D. L., & Holmes, J. (2012). Cogmed training: Let's be realistic about intervention research. *Journal of Applied Research in Memory and Cognition, 1*(3), 201-203.

Holmes, J., Gathercole, S. E., & Dunning, D. L. (2009). Adaptive training leads to sustained enhancement of poor working memory in children. *Developmental Science, 12*(4), F9- F15.
Holmes, J., Gathercole, S. E., Place, M., Dunning, D. L., Hilton, K. A., & Elliott, J. G. (2010). Working memory deficits can be overcome: Impacts of training and medication on working memory in children with ADHD. *Applied Cognitive Psychology, 24*(6), 827-836.
Hulme, C., & Melby-Lervåg, M. (2012). Current evidence does not support the claims made for CogMed working memory training. *Journal of Applied Research in Memory and Cognition, 1*(3), 197-200.
Hutchison, K. A. (2007). Attentional control and the relatedness proportion effect in semantic priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*(4), 645–662.
Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Shah, P. (2012). Cogmed and working memory training —Current challenges and the search for underlying mechanisms. *Journal of Applied Research in Memory and Cognition, 1*(3), 211-213.
Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: the contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132*(1), 47-70.
Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences, 14*(7), 317-324.
Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlström, K., ... & Westerberg, H. (2005). Computerized training of working memory in children with ADHD-a randomized, controlled trial. *Journal of the American Academy of Child & Adolescent Psychiatry, 44*(2), 177-186.
Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology, 24*(6), 781-791.
Loosli, S. V., Buschkuehl, M., Perrig, W. J., & Jaeggi, S. M. (2012). Working memory training improves reading processes in typically developing children. *Child Neuropsychology, 18*(1), 62-78.
Melby-Lervåg, M., & Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Developmental Psychology, 49*(2), 270-291.
Mezzacappa, E., & Buckner, J. C. (2010). Working memory training for children with attention problems or hyperactivity: A school-based pilot study. *School Mental Health, 2*(4), 202-208.
Olesen, P. J., Westerberg, H., & Klingberg, T. (2004). Increased prefrontal and parietal activity after training of working memory. *Nature Neuroscience, 7*(1), 75-79.
Rabipour, S., & Raz, A. (2012). Training the brain: Fact and fad in cognitive and behavioral remediation. *Brain and Cognition, 79*(2), 159-179.
Roughan, L., & Hadwin, J. A. (2011). The impact of working memory training in young people with social, emotional and behavioural difficulties. *Learning and Individual Differences, 21*(6), 759-764.
Shavelson, R. J., Yuan, K., Alonzo, A. (2008). On the impact of computer training on working memory and fluid intelligence. In D. C. Berliner & H. Kuermintz (Eds). Fostering Change in Institutions, Environments, and People: A Festschrift in Honor of Gavriel (pp. 35-48). Routeledge, New York.
Shipstead, Z., Hicks, K. L., & Engle, R. W. (2012). Cogmed working memory training: Does the evidence support the claims? *Journal of Applied Research in Memory and Cognition, 1*(3), 185-193.
Shipstead, Z., Redick, T. S., & Engle, R. W. (2012). Is working memory training effective?. *Psychological Bulletin, 138*(4), 628.
The Parent Room. (n.d.). *Cogmed*. Retrieved from http://www.theparentroom.org/whats-out- there/ cogmed/.
Van der Molen, M., Van Luit, J. E. H., Van der Molen, M. W., Klugkist, I., & Jongmans, M. J. (2010). Effectiveness of a computerised working memory training in adolescents with mild to borderline intellectual disabilities. *Journal of Intellectual Disability Research, 54*(5), 433-447.
Westerberg, H., Jacobaeus, H., Hirvikoski, T., Clevberger, P., Östensson, M. L., Bartfai, A., & Klingberg, T. (2007). Computerized working memory training after stroke — A pilot study. *Brain Injury, 21*(1), 21-29.

Website / for more information see:

http://www.cogmed.com/
http://www.pearsonclinical.co.uk/Cogmed/Cogmed-Working-Memory-Training.aspx