RESEARCH ARTICLE

Dose response and working memory limit in an eye movement desensitisation and reprocessing prospective case series

[version 1; referees: awaiting peer review]

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Abstract

\textbf{Background:} Eye movement desensitization and reprocessing (EMDR) is a psychological therapy for post-traumatic stress disorder, or any disorder where the patient reports distressing imagery. We report here a prospective case series to test the prediction that the average number of distress images tends to seven.

\textbf{Methods:} Patients in a sexual health clinic were offered EMDR treatment. In total, 130 were entered and 50 completed treatment. All distressing images to all bad life events and anxieties reported were treated. Images that caused high distress or stopped progressing were usually decomposed until progress resumed.

\textbf{Results:} The median number of images per patient was seven. This required three treatment sessions in a total of five appointments, on average. This result was replicated twice in separate retrospective case series.

\textbf{Conclusion:} We propose that EMDR works by unloading an overloaded memory buffer. If this bandwidth is liberated by treatment, this permits the cognitive and emotional change observed in EMDR treatment. The tendency to seven may signal involvement of the working memory limit. This approach enables clinical decision making and gives common ground with other psychotherapy methods.

\textbf{Keywords:} Eye Movement Desensitization and Reprocessing, Dose dependency, Working memory, Clinical decisions, Seven
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Introduction

Eye movement desensitisation and reprocessing (EMDR) is a psychological therapy, originally for post traumatic distress disorder (PTSD), but generalizing to any patient who reports distressing imagery\(^1\). The image is specified with negative cognitions and distressing physical sensations. The patient is then taken through a procedure based on series of sets of 25 eye movements with the guidance of the therapist. The patient will report the image is fading or changing in some way, the negative cognitions improving and the distress reducing. The cognitions and distress improve without necessarily being addressed by direct verbal methods. Other methods of sensory stimulation have the same effect. There is no explanation of how this procedure works. An explanation is required to inform clinical judgements and to permit the design of more accurate trials.

On the basis of clinical experience, we hypothesize that EMDR is superior to cognitive behavioural therapy (CBT) because it is faster. If a treatment can be accelerated with equal benefit, then more patients could be treated within a given budget. One premise of a controlled trial is that both control and experimental group receive equivalent treatment, except for the variable being investigated. In psychological trials, this requires that both groups should receive an equal treatment time. The published trials do not always balance the number of sessions or treatment time. Consider a trial in which EMDR is compared to CBT over ten weekly appointments of one hour. CBT includes homework, such as listening to audio files of the trauma event, or real life exposure when practical. Assume this homework takes one hour per day, happens each of the six days the patient does not attend an appointment and is performed with perfect compliance. Therefore, EMDR clients are getting 10 hours of treatment, while CBT clients are getting 70 hours. If the result shows equal results for each therapy, then we should conclude that EMDR is seven times faster than CBT and avoids the problem of homework compliance. Homework compliance is associated with improvement in CBT for PTSD. Some trials address this problem\(^1\) and some do not (e.g 5). For a recent review see 6.

To prove EMDR is faster than CBT, patients in a controlled trial should receive an equal number of sessions. Since we could not do a trial in our circumstances, we investigated if the number of EMDR sessions required is limited by the number of distress images. In our clinic, eye movement therapy has been used since 1991 and was based on Shapiro’s original reports\(^1,2,7\). Clinical experience showed that EMDR treatment required treatment of around seven images. We hypothesised that the average number of distress images in an EMDR series would be attracted to seven, plus or minus two, images. A retrospective investigation of 400 case files discovered an average of 5.5 distress images\(^8\). To investigate this, we counted the distress images in a prospective series and collected demographic and evaluation data.

Methods

Participants

This study was approved by the Plymouth Local Ethics Committee (number, 1743). All patients gave written informed consent to enter the study. The original analysis plan, using non parametric, required 50 patients to complete. However, this plan was superseded by the analysis described below. The patients were recruited between September 2001 and March 2007.

Patients in the Genitourinary Medicine clinic (GUM) were offered EMDR whenever distressing images were reported. No prior judgements of single trauma event, multiple events or complexity of case were made. Patients were recruited according to the following inclusion criteria:

1. They reported a defined traumatic event or history;
2. English was their first language;
3. They were not receiving any concurrent psychological therapy or counselling. If they were, they were willing to suspend this during EMDR treatment;
4. They were not suffering any concurrent bad life event or illness;

Patients were disqualified from the study under the following circumstances:

1. They suffered a bad life event during treatment. For example, a serious illness suffered by themselves or family member;
2. Any increase in medication. If medication levels were stable, or decreasing, they were retained;
3. They requested to leave.

A disqualifying event was any active event. For example, a patient with stable diabetes was entered, but a patient who was diagnosed with diabetes the week after entry was removed from the study. Removed patients continued with EMDR or other treatment or help as required. Most had a history of sexual health problems that bought them into GUM in the first place. Some patients were the marital or sexual partners of GUM patients, but without primary sexual health concerns. The following information was collected for each patient: sex, age, marital status, employment status, initially presented trauma, how long since that trauma, any significant mental health or addiction issues, presence of panics, total contact hours and number of EMDR treatment sessions.

Measures

EMDR treatment reduces clarity and perception of distress images and consequently the distress score reduces.

We recorded the number of distress images reduced to a low distress score that remained stable on retesting in subsequent treatment sessions (designated “F”). Distress was measured with the Subjective Units of Disturbance score from zero to ten and the end point was taken as zero, one or two. The Foa PTSD questionnaire was used to measure initial severity\(^9\).

Treatment progress was measured with three questionnaires: the Impact of Events Revised, (IOE-R), the General Health Questionnaire (GHQ-12), and the Posttraumatic Cognitions Inventory (PTCI). The Impact of Events revised version was used, which matches the later definition of PTSD\(^10,11\). A drawback of the IOE-R is that it only refers to one bad event. We intended to
deal with all reported events. Patients who reported more than one were asked to consider the initial event. The GHQ-12 is a psychiatric screen\(^2\). The PTCI measures cognitive symptoms and was chosen to exclude imagery or physiological arousal\(^3\).

**Therapeutic procedure**

All patients received EMDR from the clinical psychologist (AH). This psychologist had 10 years’ experience with EMDR before the study began and was level one and level two trained. EMDR, as used here, was based on the original protocol and resembles the “eye movement desensitization” protocol that can be found in Chapter 9 of the third edition of Shapiro’s manual\(^4\). However, it does not include all eight stages later described by Shapiro, elsewhere in this book.

Body scan, re-evaluation, debriefing and closure were employed when required. Three parts of the eight-phase EMDR procedure were omitted. The safe place procedure and the “cognitive interleave” were never required. If distress stopped progress, the image was reassessed or decomposed to smaller components. At a certain point, the treatment would start reducing distress again. If the patient was distressed at the end of the session, a brief relaxation was taught. The patients reported cognitive changes during the procedure and the PTCI was intended to measure this. The “positive cognitions” procedure was not used. Here, patients report what positive belief they would like concerning themselves and rate it on a one to seven validity scale. This is then used for “installation” of positive cognitions. The therapist dropped this because switching from discussing the bad event to discussing what the patient might think in an ideal world was confusing and distressing for the patient\(^5\). It became redundant since patients would report positive thoughts when treatment continued through the series of distress images.

Treatment sessions began by revisiting relevant issues. All distressing images collected or treated in previous sessions were reassessed. The EMDR was then started. The starting rule was expressed as follows: “We will start on the highest scoring image, because that probably makes the procedure shorter in the long run. If you are not ready to start there, please choose somewhere else to start”. The patient was asked to attend to the chosen image and nod when ready. He or she was then taken through sets of 25 eye movements. A stick 70 cm long, with a coin at one end as a visual target was used to guide the eye movements. If the patient reported a problem with eye movements another method of sensory stimulation was used. This was auditory or tactile stimulation using the (www.neurotekcorp.com). This change was judged as a clinical decision and no attempt made to balance it between patients. After each set, the patient was reassessed. When a new image was reported, it was treated or recorded for later treatment.

If the patient became distressed, treatment was continued until the distress reduced. If the distress did not reduce after four sets of eye movements the image was changed in some way. The first move was to enquire if there was a more distressing image, negative thought, emotion or physical sensation or pain. Another option was to move to an alternative image that did reduce and return to the difficult image later. The best option was to decompose the target image in some way. One method was to reduce that part of the timeline the patient was focusing on. For example, the event would be divided up into smaller stages of the sequence. The second was to divide up into sensory modalities. For example, a sexual assault could be divided up into the physical pain images, the sound of the assailant’s voice and the feeling of the weight of their body. Each sensory image was treated individually and included in the “F” count. This course of action generally resulted in effective treatment.

All reported distress images were treated. This included any anxiety or distress trigger that could be elicited as an image and scored, not just the initial presented event. EMDR targets also included images of future events (“flashforwards”). Other images were imagined or symbolic representations of events where the patient had been absent or unconscious. Some images were general (semantic) memories, not episodic. For example, a repeated act of child abuse would be reported as one image, not individual episodes with time tags. Such semantic images might decompose to episodes with treatment, but could be treated without this happening. One strategy to use such semantic memories for desensitization was to ask the patient to imagine the face of the assailant or abuser, then describe and score bad emotions.

**Research procedure**

The patient was briefed on the procedure. Any problems or limitations of EMDR specific to that patient were discussed. The patient was informed of the seven image average to achieve informed consent, but it was emphasized that this was an average. The patient could report more or less than seven. It was made clear that treatment would continue until all reported distressing images, of whatever origin, were treated. The initial assessment explicitly included listing all trauma life events and distress triggers. The patient gave signed consent to the project as required by the local ethical committee.

Each patient received the IoE-R, GHQ12 and PTCI questionnaires on each treatment appointment. On the first treatment appointment, the Foa questionnaire was also given. Questionnaires were completed on arrival, before the appointment began.

In the first session, the EMDR procedure began at an agreed starting point. In the second and subsequent appointments, the patient was reassessed for each image collected in previous sessions. The patient visualised the image, reported if that was impossible, difficult or easy, reported the distress score and then anything else relevant. Treatment then continued, as described above. Treatment sessions continued until all images were desensitized to a distress score of zero, one or two. The number of images desensitized was recorded on each occasion (“F”). The value of F recorded in the first treatment session was zero.

It was not expected that EMDR treatment would be sufficient for all the needs of all the patients or that all patients would complete treatment. Patients in this clinic have a high drop-out rate from medical treatment. We investigated if there were any
systematic differences between completers and dropouts, using the data collected. A record was kept of all patient outcomes or destinations.

Postal follow-up
Six months after treatment ended, all 50 patients who completed treatment were contacted by mail. The letter contained a list of recorded distress images and the three questionnaires. The patient was requested to score all items and return by stamped addressed envelope. In total 31/50 scores were returned.

Two informal replications
Another retrospective count of distress images was included in an audit of appointment attendance. This was a “file drawer” sample, to replicate this result. In total 200 cases were audited from GUM, of which 167 (83%) were EMDR cases. These cases were collected between November 2010 and June 2012.

A second retrospective series was collected at GUM during a period when it appeared that some severe cases were showing high numbers of images. The idea was to test the resilience of the hypothesis that the average would tend to seven. These cases were collected between November 2015 and July 2017.

These two series were taken from routine audit databases for which ethical permission is not required by local rules. The three case series reported were all separate, with no overlap of cases.

Data analysis
Data was analysed using R version 3.4.1. R code used in the analysis can be found in Dataset 1.

Results
Patients
To acquire 50 patients who finished treatment, it was necessary to recruit 130 patients, giving a fail to complete number of 80 (62%). There were 104 females and 26 males. The average age was 33 years. A total of 85 (65%) were employed, 25 unemployed, 14 students and 6 retired; 67 (51%) were single, 54 (41%) were married or co-habiting, the 9 remaining were divorced. They were all white British, except one Irish female and one white South African male. These patients were entered into the study between September 2001 and March 2007.

The initially reported trauma event occurred at a mean of 12 years previously. Forty (30%) patients reported medical problems, including 3 stable diabetics. Thirty-nine (30%) reported another mental health or addiction problem, of which 32 reported depression and 12 reported panics; Twenty-four required medication for that problem. Initially presented trauma events, by sex, are shown in Table 1 for all 130 patients. Most patients were sexually assaulted females. No distinction was made between different types of childhood abuse. Sexual misadventure means any such trouble that was not sexual assault. See Dataset 2.

The 50 patients who completed treatment required a mean of 3.8 treatment sessions (mode = 3.0). A treatment session was one hour long. The mean number of contact hours required per patient was 5.04 (mode = 4.0). This includes assessment, treatment sessions, follow-up and time required for other matters.

Psychometric test scores
Convincing improvement in score results are required to validate the results below. 50 cases completed treatment, resulting in 49 complete before and after pairs. There were 31 complete follow-up scores, which were paired with the respective after scores. Good score decreases were observed for all three questionnaires, all of which had low probability values. All score changes and statistics are shown on Table 2–Table 4. Follow-up gave stable values for the IoE-R scale and PTCI. Note the PTCI decreased without any items concerning imagery. However, the GHQ-12 follow-up scores increased, with statistical significance. Raw data is available in Dataset 3 with analysis programmes in Dataset 1.

Table 1. Initially presented trauma of eye movement desensitisation and reprocessing patients distributed by sex (n=130).

<table>
<thead>
<tr>
<th>Event</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rape</td>
<td>7</td>
<td>46</td>
</tr>
<tr>
<td>Assault</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Child Abuse</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Bereavement</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Combat</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Sexual misadventure</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Marital abuse</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>School bullying</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Medical misadventure</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Occupational Hazard</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Accident</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>26</strong></td>
<td><strong>104</strong></td>
</tr>
</tbody>
</table>
Average value of F

The hypothesis was that the average number of distress images would approach seven. The frequency distribution of F is shown in Table 5 (Dataset 4\textsuperscript{20}). The mean value for the 50 patients is 7.6 images. The median was seven and the mode was seven. Figure 1 shows the case series of the 50 completed cases as a “law of large numbers” graph. This is a plot of progressively calculated running means on the Y axis, ascending the case series on the X axis. This shows that after about 20 cases, the mean number of distress images is between seven and eight, close to the hypothesised value. Since the data are not a random sample, we cannot assume a conventional statistical model to test this result. However, having shown the average tends to seven, we need a way of assessing and testing variation in this value.

We can investigate this with bootstrapping\textsuperscript{21}, which simulates repeating the study many times to give an empirical distribution for F. In this case, a sample of 50 cases was taken from the data, at random, with replacement of each value, so there is always 50 cases to sample from. The sampling was repeated 1000 times. Each sample of 50 generates a mean value and consequently confidence intervals can be found for true mean of F. An R program was written to achieve this\textsuperscript{16,22,23}. We used percentile confidence intervals, so the 95\% boundaries take the value of the 25\textsuperscript{th} lowest and highest means from the 1000 iterations. This program will give slightly different results each run, but example values are 6.68 and 8.90, which accommodate the hypothesised value and suggests that in groups of 50 patients we would expect the average number of distress images to be between six and nine. The bootstrap confidence interval is skewed right, reflecting that a small number of cases with a high number of distress images have a big influence on the mean in this relatively small group size. The bootstrap values and graphs are in Dataset 2\textsuperscript{21} (RunningMeans&PlotFig1to4.R). The intention to treat value of “F” was determined from the 99 cases who completed at least two sessions and recorded at least one F value. This includes the

### Table 2. Questionnaire score changes: Impact of Event Score-Revised.

<table>
<thead>
<tr>
<th>First</th>
<th>Last</th>
<th>FU</th>
<th>Z</th>
<th>W</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.5</td>
<td>6.0</td>
<td>7.0</td>
<td>5.9</td>
<td>1126</td>
<td>184</td>
<td>5.6 E 9</td>
</tr>
</tbody>
</table>

Scores summarized as medians, for First, Last and Follow-up (FU). There were 48 pairs First v. Last and 31 pairs for Last v. Follow-up. Z = Z score; number of standard deviations difference. W = Wilcoxon signed-rank test value. P = Probability median scores are different by chance; values are multiplied by 2, to adjust for multiple comparison, by Bonferroni correction. C = Common language effect size\textsuperscript{15}; this is the probability that any initial score will be different from any subsequent score\textsuperscript{15}.

### Table 3. Questionnaire score changes: Post Traumatic Cognitions Inventory.

<table>
<thead>
<tr>
<th>First</th>
<th>Last</th>
<th>FU</th>
<th>Z</th>
<th>W</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>147</td>
<td>61</td>
<td>64</td>
<td>5.8</td>
<td>1078</td>
<td>197</td>
<td>8.8 E 9</td>
</tr>
</tbody>
</table>

Scores summarized as medians, for First, Last and Follow-up (FU). There were 48 pairs First v. Last and 31 pairs for Last v. Follow-up. Z = Z score; number of standard deviations difference. W = Wilcoxon signed-rank test value. P = Probability median scores are different by chance; values are multiplied by 2, to adjust for multiple comparison, by Bonferroni correction. C = Common language effect size\textsuperscript{15}; this is the probability that any initial score will be different from any subsequent score\textsuperscript{15}.

### Table 4. Questionnaire score changes: General Health Questionnaire-12.

<table>
<thead>
<tr>
<th>First</th>
<th>Last</th>
<th>FU</th>
<th>Z</th>
<th>W</th>
<th>P</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>5.0</td>
<td>10.0</td>
<td>5.7</td>
<td>988.5</td>
<td>59.5</td>
<td>1.7 E 8</td>
</tr>
</tbody>
</table>

Scores summarized as medians, for First, Last and Follow-up (FU). There were 48 pairs First v. Last and 31 pairs for Last v. Follow-up. Z = Z score; number of standard deviations difference. W = Wilcoxon signed-rank test value. P = Probability median scores are different by chance; values are multiplied by 2, to adjust for multiple comparison, by Bonferroni correction. C = Common language effect size\textsuperscript{15}; this is the probability that any initial score will be different from any subsequent score\textsuperscript{15}.

### Table 5. Distribution of final F values.

<table>
<thead>
<tr>
<th>F Value</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>4.0</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>18</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>22</td>
<td>62</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>10</td>
<td>72</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>8</td>
<td>88</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>8</td>
<td>88</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>4</td>
<td>92</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>4</td>
<td>96</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>2</td>
<td>98</td>
</tr>
<tr>
<td>23</td>
<td>1</td>
<td>2</td>
<td>100</td>
</tr>
</tbody>
</table>

F = number of distressing images, treated per patient. Mean = 7.62; Mode = 7; Median = 7.
50 cases discussed above. The mean was 6.5 and the mode and median both 6.0.

Two retrospective replications
The first retrospective series contained 167 cases (Figure 2). The sample mean is 7.17. Using the same R program, 95% percentile boundaries are 6.57 and 7.86. As we would expect with a larger group size, there is less variation in the mean and the bootstrap confidence interval is more symmetric about the sample mean (Dataset 4). The second retrospective series contained 106 cases (Figure 3). It was biased to start with high F values of 25, 20, 16, with a minimum value of 1. The mean was 8.5, with 95% percentile boundaries of 7.5 and 9.5. This shows increase of the mean with some severe cases in the series (Dataset 4). The two retrospective series included complete cases and those who did not complete, but were considered successful before they failed to attend. If all 323 cases reported here were combined, the mean was 7.68 inside boundaries of 7.20 and 8.20 (Figure 4). This estimates the long-term average of distress images for populations similar to that attending the clinic.

Discussion
The median number of distress images was seven. We defined and counted the unit “distress image” as that which reduces in distress when treated with eye movements. This definition is validated by the reduction in questionnaire scores. EMDR is considered as a titration of eye movements against distress. Distress memory images can be episodic or semantic. The “distress complex” is the collective noun for those distress images reported by one patient. Three qualifications are required.

Only data from one EMDR therapist is reported. This result requires replication with other therapists, following the same procedure. The two retrospective replications gives some mitigation for this issue. We cannot show replication with other therapists,
**Figure 2.** First retrospective replication of 167 cases. Final mean = 7.17.

**Figure 3.** Second retrospective replication of 106 cases, starting with high values. Final mean = 8.50.
because only one was available, but we can replicate within one therapist, across time. Second, the patients were informed of the expected seven image average. This raises the possibility that the seven is an artefact. We considered it necessary, and ethical, to inform them of this to achieve informed consent. It was emphasized that seven was an average and the patient should report all images, to all bad life events or distress triggers. The good before and after scores support the position that all images were reported and treated. Third, this was an uncontrolled case series, designed to observe the natural history of treatment to test a hypothesis. These limitations are dictated by the circumstances of an acute sexual medicine clinic, where a fast turnover of patients is required and where there is only one psychologist. Legal and practical difficulties limit communication to patients.

Subject to these issues, we can assert that for the typical population attending the clinic, the distress complex tends to contain seven, plus or minus two, distress images. This is demonstrated by the prospective case series that had a median of seven images. The two retrospective series also stabilised in this zone. These results are similar to those in a previous report\(^1\). The largest retrospective series (of 167) had a mean of 7.17 (with near-symmetric bootstrap 95% interval of 6.67–7.86). In the second retrospective series starting with more severe cases, the mean rises to 8.5. Combining all 323 cases moves the mean back towards seven, which we can consider a stable value in the long term. This observation may be sensitive to variation in patients and method. This demonstrates that the EMDR system is dose dependant, because sufficient EMDR is required to desensitize the whole distress complex. Any trial that compares eye movement or sensory stimulation methods with CBT must ensure that the amount of treatment time is equal across groups and is sufficient to desensitize the distress complex. Commonly, such patients have collected more than one trauma event. This issue is rarely addressed in published trials. If only the worst reported life event is treated, then other distress triggers may be missed. This might limit longer term results. This conclusion may apply to all psychological therapies.

Similar numbers are reported from similar patients. Such similarities are worth noting, but should be considered with due caution since there are differences of definition and method.

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**Table 6. Destinations of patients that underwent EMDR therapy.** EMDR, eye movement desensitisation and reprocessing.

<table>
<thead>
<tr>
<th>Destination</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Another traumatic event</td>
<td>9</td>
<td>6.9</td>
</tr>
<tr>
<td>Cognitive therapy</td>
<td>6</td>
<td>4.6</td>
</tr>
<tr>
<td>Did not attend treatment</td>
<td>12</td>
<td>9.2</td>
</tr>
<tr>
<td>Drop-out after 2 sessions</td>
<td>28</td>
<td>21.5</td>
</tr>
<tr>
<td>Drop-out after 1 session</td>
<td>18</td>
<td>13.8</td>
</tr>
<tr>
<td>EMDR finishers</td>
<td>50</td>
<td>38.5</td>
</tr>
<tr>
<td>Medication increase</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>To another therapist</td>
<td>6</td>
<td>4.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>130</td>
<td>100</td>
</tr>
</tbody>
</table>

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**Figure 4.** All 323 cases (50 + 167 + 106 = 323). Final mean = 7.68.
in each report. First, the Rothbaum et al. study treated one distressing memory, but reported discovering an average of six others in both patient groups. This is a total of seven. Second, a trial of EMDR treatment reported that patients were treated until they no longer had PTSD. This required treatment of six trauma memories. Third, Holmes et al. counted the number of “hotspots” in a sample of patients in treatment and discovered an average of six, in the context of an average of four intrusive images of different contents.

Observing this attraction towards seven raises the possibility of involvement of the working memory. Seven is identified as the approximate number of information chunks that can be held in the working memory. If it is assumed that a distress image is a chunk, then perhaps this is a signal from the working memory limit. Working memory capacity is a complex subject, which we cannot simplify here. For reviews see Cowan, Jonides et al., and Richardson. It might be a safer initial claim that EMDR therapy works by unloading a limited capacity memory buffer, without specifying further. PTSD and similar disorder is caused by overloading this buffer.

A possible model to explain the unloading is “reverse learning”, originally postulated by Crick & Mitcheson. The speed of the EMDR effect implies a physiological explanation. The idea of unloading memory buffers enables several points to be made. Firstly, this is a good explanation for the patient, since such over-load is what chronic distress disorder feels like. Second, this enables clinical decisions in the treatment session. For example, on occasion, the patient becomes so distressed, or affected in some other way, that the treatment process stalls. This might mean the memory buffer capacity is saturated. Therefore, the EMDR target image should be progressively decomposed into smaller images, as described above, until distress starts to reduce again. At this point both the EMDR responsive image and the available memory processing bandwidth are defined. An analogy is threading a needle. A thread will not go through the eye of the needle if it is too big, so the size of the thread is reduced until it passes through. This liberated bandwidth enables further synergistic progress. We can now explain the cognitive and emotional change caused by the EMDR procedure. As memory bandwidth is liberated, the patient becomes progressively more able to think rationally. Distress is reduced to zero, or that level permitted by circumstances.

Can anything be said about this memory buffer? First, there must be two limited capacity systems involved. The first contains the whole distress complex and averages seven images. However, when treating each image, we presumably have placed that image into a second buffer, which only holds one. These might be working memory and focus of attention, respectively. It is established that eye movements affect working memory. If EMDR affects working memory capacity, then this is common ground with other therapeutic methods, such as mindfulness training, and counting during recall, where similar claims have been made.

The observation of a limit gives an approach to dealing with serious, or complex, cases. Using the distribution in Table 5, 96% of cases report up to 13 distress images. Therefore, only 4% of EMDR cases go to 14, or above. Such cases are either serious, or the therapist should consider if the limits of EMDR treatment have been reached and for what reason. Reaching image number 14 requires diagnosing between, for example, a child sexual abuse case with panics, in which case continue EMDR, or another issue which may require reconsidering EMDR. When a history of childhood abuse is reported, the fact that seven is average and fourteen is rare, enables patient and therapist to define the task. Patients may ask if they will require other psychotherapeutic help after EMDR. The answer can be given that, if this is required, they will benefit more from other methods once EMDR has unloaded the working memory up to this limit.

Conclusions
Both the observation of the seven images and the speed of treatment are achieved by this minimalist protocol, with decomposition of obstinate flashbacks. This probably accelerates treatment. Only an average of three treatment sessions and five in total were required per patient. It is likely that this version of the EMDR procedure permits the observation of the distress image horizon. With EMDR using the eight stage sequence, difficulties are solved by methods borrowed from cognitive therapy, or evaded by a retreat to the imagined safe place. In our version of eye movement or sensory stimulation therapy, difficulties are usually solved by decomposing the image into smaller elements that can be individually treated. Reducing an unresponsive distress image into smaller units permits us to continue treatment and define the units by their response to treatment. CBT does not permit this, especially if the distress complex is committed to audio or video file for self-exposure. The theory that it is necessary to match the image with some limit of memory processing bandwidth, which shows one sign of working memory, enables an account that facilitates clinical decisions and may improve trials.

Data availability
F1000Research: Dataset 1. : R program files, requiring R.app or RStudio.app (on Mac) or equivalent to run (cran.r-project.org), 10.5256/f1000research.15648.d217183

F1000Research: Dataset 2. Demographic data for participants., 10.5256/f1000research.15648.d217186

F1000Research: Dataset 3. The before, after and follow-up scores for the General Health Questionnaire (GHQ-12), the Impact of Events scale (IoE-R) and the Post Traumatic Cognitions Inventory (PTCI)., 10.5256/f1000research.15648.d217184

F1000Research: Dataset 4. “F” values for the initial prospective 50 cases and then the two retrospective series of 167 and 106 cases., 10.5256/f1000research.15648.d217185

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