Plasticity of memory in the etiology and treatment of Post Traumatic Stress Disorder.

SITCC
Marcel van den Hout
Computer memory vs. human memory

Plasticity of human memory: a) Memory inflation
Imagination inflation

- Recall PRE Imag
- Recall DURING Imag
- Recall POST Imag

Vividness
Imagination inflation

Vividness

Recall
PRE Imag
Recall
DURING Imag
Recall
POST Imag
Imagination inflation

<table>
<thead>
<tr>
<th></th>
<th>Recall PRE Imag</th>
<th>Recall DURING Imag</th>
<th>Recall POST Imag</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>80</td>
<td>0</td>
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</tbody>
</table>
Imagination inflation

![Graph showing vividness levels during different recall periods: PRE Imag, DURING Imag, POST Imag.](image)
Computer memory vs. human memory

Plasticity of human memory:  a) Memory *inflation*

b) Memory *deflation*
Imagination deflation

Recall
PRE Imag
Recall
DURING
Imag
Recall
POST
Imag

Vividness
Imagination deflation

Recall
PRE Imag
Recall
DURING Imag
Recall
POST Imag

Vividness
Imagination deflation

- Recall PRE Imag
- Recall DURING Imag
- Recall POST Imag

Vividness
Imagination deflation

Temporal ‘blurring’
Imagination deflation

Recall
PRE Imag
Recall
DURING Imag
Recall
POST Imag

Vividness

Recall PRE Imag
Recall DURING Imag
Recall POST Imag
Application to PTSD

Memory *inflation* in the *etiology* of PTSD:
- Dutch troops after Iraq

Memory *deflation* in the *treatment* of PTSD:
- the curious case of EMDR
1) Memory *inflation* in the *etiology* of PTSD:

Traumatic event → PTSD

- Duration; distance; number of combat events
- non-traumatic stressors (daily difficulties; e.g., King et al., 1995; Bolton et al., 2003)
- Often interpreted as “causal” impact
- But: retrospective reports (e.g., Schwarz, Kowalski, & McNally, 1993; Southwick et al., 1997)

→ Methodological limitations
Memory consistency study

Participants

• Infantry troops deployed in 2004

Measures

• PSS (Foa et al., 1993)
• 22 war zone stressors
  30 non-traumatic stressors
  → Experienced? Impact? (1-4 scale) (Maguen et al., 2004)

(Engelhard, van den Hout, & McNally, 2008)
Before Iraq
(N=214)

Iraq

5 months
(N=171; 80%)

15 months
(N=152; 71%)
<table>
<thead>
<tr>
<th>Traumatic stressor</th>
<th>YY</th>
<th>YN</th>
<th>NY</th>
<th>NN</th>
<th>Change N</th>
<th>%</th>
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<tbody>
<tr>
<td>Injured civilians due to own action</td>
<td>16</td>
<td>29</td>
<td>20</td>
<td>68</td>
<td>49</td>
<td>37</td>
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<td>Seeing dead/injured NATO (non-Dutch) soldiers</td>
<td>16</td>
<td>22</td>
<td>16</td>
<td>79</td>
<td>38</td>
<td>29</td>
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<td>Seeing human remains</td>
<td>21</td>
<td>16</td>
<td>18</td>
<td>78</td>
<td>34</td>
<td>26</td>
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<td>Seeing dead/injured civilians</td>
<td>48</td>
<td>7</td>
<td>25</td>
<td>53</td>
<td>32</td>
<td>24</td>
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<tr>
<td>Having to aid in removal of unexploded ordnance</td>
<td>10</td>
<td>16</td>
<td>16</td>
<td>91</td>
<td>32</td>
<td>24</td>
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<td>Needing to manage civilians in chaotic conditions</td>
<td>74</td>
<td>13</td>
<td>16</td>
<td>30</td>
<td>29</td>
<td>22</td>
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<tr>
<td>Traumatic stressor</td>
<td>YY</td>
<td>YN</td>
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<td>Change N</td>
<td>%</td>
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<td>Seeing dead/injured Dutch soldiers</td>
<td>52</td>
<td>13</td>
<td>13</td>
<td>55</td>
<td>26</td>
<td>20</td>
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<tr>
<td>Having to aid in removal of human remains</td>
<td>3</td>
<td>15</td>
<td>11</td>
<td>104</td>
<td>26</td>
<td>20</td>
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<td>Being shot at</td>
<td>75</td>
<td>6</td>
<td>19</td>
<td>33</td>
<td>25</td>
<td>19</td>
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<tr>
<td>Locating unexploded land mines</td>
<td>12</td>
<td>9</td>
<td>15</td>
<td>97</td>
<td>24</td>
<td>18</td>
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<tr>
<td>Witnessing an explosion</td>
<td>90</td>
<td>14</td>
<td>9</td>
<td>20</td>
<td>23</td>
<td>17</td>
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<tr>
<td>Being injured because of an assault/attack</td>
<td>5</td>
<td>14</td>
<td>5</td>
<td>109</td>
<td>19</td>
<td>14</td>
</tr>
</tbody>
</table>
**Fig 1:** nr. of potentially traumatic stressors recalled

**Fig 2:** nr. of negative traumatic stressors recalled

(Engelhard, van den Hout, & McNally, 2008)
• Accounts of trauma are plastic over time
• More severe current PTSD symptoms → increased reporting of (major and minor) stressor exposure
Memory *deflation* in the *treatment* of PTSD

The curious case of EMDR
Historical notes:

1) **EMDR: technique, theory and claims extraordinary and “extraordinary claims need extraordinary evidence”**
Historical notes:

1) **EMDR: technique, theory and claims extraordinary and “extraordinary claims need extraordinary evidence”**

2) **Scientific community sceptical**

3) **EMDR outcome studies and meta-analyses: EMDR as effective as CBT**


Typical preparation of lab studies on EMDR

1) Healthy volunteers retrieve aversive memories

2) Pre-test: memories scored in terms of vividness/adversity

3) Interventions: during recall a) Recall + Eye movements or b) Recall only

4) Post test: recall and scored in terms of vividness/adversity
Three theories on EMDR effects considered here.

EMDR works

1) Via exposure (recall only, EM’s irrelevant)

2) By promoting “interhemispheric communication” during recall

3) Both EM’s and recall need ‘resources’ of working memory. Recall ‘looses competition” with EM’s
**Exposure Theories:** Recall only = Recall + EM’s (EM’s irrelevant)

**Januari 2011:** at least 14 experiments

<table>
<thead>
<tr>
<th>Author</th>
<th>Outcome</th>
<th>Recall Only</th>
<th>Recall + EM’s</th>
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<tbody>
<tr>
<td>Atrande et al.,</td>
<td></td>
<td>0</td>
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<tr>
<td>Van den Hout et al.,</td>
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<td>Kavanagh et al.,</td>
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<tr>
<td>Kemps et al.,</td>
<td></td>
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<td>Maxfield et al.,</td>
<td></td>
<td>0</td>
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<tr>
<td>Gunter &amp; Bodner</td>
<td></td>
<td>0</td>
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<td>Lilley et al.</td>
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<tr>
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<td>Engelhard et al.</td>
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<td></td>
<td>0</td>
<td>+</td>
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</tbody>
</table>

Expt 1
Expt 2
Expt 3
Expt 4
Expt 5
Expt 6
Expt 7
Expt 8
Expt 9
Expt 10
Expt 11
Expt 12
Expt 13
Expt 14
Data:

Recall + EM’s > Recall only

Therefore:

Exposure theories fail to explain EMDR effects
Interhemispheric communication theories

EMDR effects depend on Left-Right alternation of EM’s.

Implication:

*Horizontal EM’s > Vertical EM’s*
From: Gunter & Bodner, 2008

Pre-to-post decreases

Vividness     Emotionality    Completeness

Horizontal

Vertical

Eyes stationary               Eye Movements
Data:

\[ \text{Recall + horizontal EM’s} = \text{Recall + vertical EM’s}. \]

Therefore:

“Interhemispheric communication” theory fails to explain EMDR effects.
Working Memory (WM) Theory: background.

1) WM: problem solving, planning, holding memory in mind etc.

2) WM acts on ‘limited resources’

3) EMDR: retrieval and EM’s ‘compete for WM resources’: less resources available for retrieval

4) Therefore: *during* recall less vivid/less emotional and reconsolidated as less vivid

5) Reconsolidation of memory affected by recall. Cf. Imagination inflation effect
Imagination deflation

Recall
PRE Imag
Recall
DURING Imag
Recall
POST Imag
Vividness

Recall
PRE Imag
Recall
DURING Imag
Recall
POST Imag
Critical tests WM explanation of EMDR effects

1) Any technique that makes memory compete for WM resources $\rightarrow$ reduction of emotionality
<table>
<thead>
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<th>Technique</th>
<th>Author</th>
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<th>Outcome</th>
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<tr>
<td>Vertical EM’s</td>
<td>(Gunter &amp; Bodner, 2008)</td>
<td>0</td>
<td>+</td>
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<tr>
<td>Drawing</td>
<td>(idem)</td>
<td>0</td>
<td>+</td>
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<tr>
<td>Shadowing</td>
<td>(idem)</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Tetris</td>
<td>(Engelhard et al, 2011)</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Counting</td>
<td>(van den Hout et al., 2010)</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>(Engelhard et al., 2010)</td>
<td>0</td>
<td>+</td>
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<tr>
<td>Articulatory suppresion</td>
<td>(Kemps et al., 2007)</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Attentional breathing</td>
<td>(van den Hout et al., 2010)</td>
<td>0</td>
<td>+</td>
</tr>
</tbody>
</table>
Critical tests WM explanation of EMDR effects

1) Any technique that makes memory compete
   for WM resources $\rightarrow$ reduction of emotionality

2) EM’s during recall: Negative memories $\rightarrow$ less negative.
   Positive memories $\rightarrow$ less positive.
Positive Memories: More Vivid
Negative Memories: More Vivid

- Positive Memories: Recall only
- Negative Memories: Recall only

- Positive Memories: Recall + tapping
- Negative Memories: Recall + EM

More Vivid: 0.6, 0.4, 0.2, 0, -0.2, -0.4, -0.6, -0.8, -1, -1.2, -1.4
Less Vivid: -1.4, -1.2, -1, -0.8, -0.6, -0.4, -0.2, 0, 0.2, 0.4, 0.6
Critical tests WM explanation of EMDR effects

1) Any technique that makes memory compete for WM resources $\implies$ reduction of emotionality

2) EM’s during recall: Neg. memories $\implies$ less neg.
   Pos. Memories $\implies$ less pos.

3) Treatment of ‘flash forwards’ rather than “flash backs” should work also
Change in “flash forwards” 1

Engelhard, van den Hout, Janssen & van der Beek, 2010 (Behav Res Ther)
Change in “flash forwards” 2

(Engelhard, van den Hout et al., 2011)
Critical tests WM explanation of EMDR effects

1) Any technique that makes memory compete for WM resources \(\rightarrow\) reduction of emotionality

2) EM’s during recall: Neg. memories \(\rightarrow\) less neg. Pos. Memories \(\rightarrow\) less pos.

3) Treatment ‘flash forwards’ rather than flash backs

4) Effective treatments *really* tax WM
Van den Hout, Engelhard et al., 2011, Behav Res Ther,
Critical tests WM explanation of EMDR effects

1) Any technique that makes memory compete for WM resources → reduction of emotionality

2) EM’s during recall: Neg. memories → less neg. Pos. Memories → less pos.

3) Treatment ‘flash forwards’ rather than flash backs

4) Effective treatments really tax WM

5) Bad at multi-tasking? Good effects EM’s!
Correlations between WM span on prior test and reductions of vividness and emotionality during EM’s etc.

<table>
<thead>
<tr>
<th>Task</th>
<th>Vividness</th>
<th>Emotionality</th>
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<tbody>
<tr>
<td>(Gunter &amp; Bodner, 2008)</td>
<td></td>
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<tr>
<td>EM’s</td>
<td>-0.44*</td>
<td>-0.43*</td>
</tr>
<tr>
<td>Shadowing</td>
<td>-0.69*</td>
<td>-0.59*</td>
</tr>
<tr>
<td>Drawing</td>
<td>-0.58*</td>
<td>-0.49*</td>
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<tr>
<td>Van den Hout et al., 2020, 2011 a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counting</td>
<td>-0.31*</td>
<td>-0.18*</td>
</tr>
<tr>
<td>EM’s</td>
<td>-0.30*</td>
<td>-0.29*</td>
</tr>
<tr>
<td>Attentional breathing</td>
<td>ns</td>
<td>ns</td>
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<tr>
<td>EM’s (Positive background)</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>EM’s (Neutral background)</td>
<td>-</td>
<td>ns</td>
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<tr>
<td>EM’s (Negative background)</td>
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<td>Engelhard et al, 2011</td>
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<tr>
<td>EM’s (Positive memories)</td>
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<td>-0.51*</td>
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<tr>
<td>Tetris</td>
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Critical tests WM explanation of EMDR effects

1) Any technique that makes memory compete for WM resources $\rightarrow$ reduction of emotionality

2) EM’s during recall: Neg. memories $\rightarrow$ less neg. Pos. Memories $\rightarrow$ less pos.

3) Treatment ‘flash forwards’ rather than flash backs

4) Effective treatments *really* tax WM

5) Bad at multi-tasking? Good effects EM’s!

6) Dual task should not be TOO taxing (memory should be activated): inverted U predicted (Gunter & Bodner, 2008)
Inverted U?

Retrieval of memories about Queensday disaster (the Netherlands, 30 April 2009) under 4 conditions:

1) no-dual task (exposure only)

2) Simple counting

3) Intermediate complex counting

4) Complex counting

Support for WM explanation of EMDR:

1) Other WM taxing dual tasks effective (counting, drawing etc)

2) Positive memories after EM less positive

3) Flash forwards also affected

4) WM taxing is evident from RT tasks

5) Bad at multi-tasking → Good response to EM, counting etc

6) Dose response relationship: inverted U
Clinical Issues

1) WM taxing during positive imagery/thoughts?
“Resource Development and Installation” (RDI) according to EMDR protocol

Activation of “positive, functional and resourceful memories” and simultaneous EM’s

Experiment: RDI (positive memories!!) under three conditions:

a) Traditional (with horizontal EM’s)
b) Alternative (with vertical EM’s)
c) Crucial Alternative (without EM’s)
Vividness

Mean Difference scores (in VAS Rating)

Pleasantness

Mean Difference scores (in VAS Rating)

Hornsveld et al, 2011
Implication: WM taxing during positive ideation, counterproductive.
Clinical Issues (theoretically not irrelevant)

1) WM taxing during positive imagery/thoughts?

2) Memories for future events and treatment indication
Cf. earlier data:

EM’s positive effects on vividness/emotionality of flash forwards
Implication: theoretical and empirical basis for treating “flash forwards”
Clinical Issues

1) WM taxing during positive imagery/thoughts?

2) Memories for future events and indication

3) Using beeps instead of EM’s?
Replacing EM’s by bilateral beeps

1) > 50% of actual EMDR sessions presently with beeps instead of EM’s (Cf. interhemisphere theory of EMDR)

2) No studies on clinical effects of beeps

3) Do bilateral beeps tax WM?

4) Beeps effective in blurring memory?
Reaction times (Msec)

Reaction times (Msec)

- 150
- 200
- 250
- 300
- 350
- 400

Eye Movements

- Binaural stimulation
- No dual task
Reaction times (Msec)

Van den Hout, Engelhard et al., 2011, Behav Res Ther
Do beeps blur memory like EM’s do?
Theory and data suggest:

Beeps inferior to EM’s
Objection: Experimental model $\neq$ clinical reality

1) Students had no PTSD

2) “Unpleasant memory” $\neq$ trauma

Question: How do real PTSD patients respond to beeps and EM’s?
Clinical study; n= 12 PTSD
(van den Hout et al., 2012. Behav Res Ther)

(Rape (5 X), war + rape, years of sexual/physical abuse etc)

6 recalls during session 1: 2 X EM’s
2 X Beeps
2 X Recall only

Order of interventions: Balanced

Dependant variables : Vividness
Emotionality (SUDS)
Drop in scores

EM's Beeps Recall only

Emotionality Vividness

Drop in scores

EM's Beeps Recall only

Emotionality Vividness
Drop in scores

EM's
Beeps
Recall only

Emotionality
Vividness

Drop in scores?

-0.5
0
0.5
1
1.5
2
2.5
Drop in scores

- EM's
- Beeps
- Recall only

Drop in scores

- Emotionality
- Vividness

Bar chart showing the drop in scores for Emotionality and Vividness with different conditions.
What about patient’s *opinions* about
1) Recall only?
2) Recall+ beeps?
3) Recall+ EM’s?

“How would you prefer to continue?”
Patients preference

- EM's
- Beeps
- Recall only
Patients preference

- EM’s
- Beeps
- Recall only
Patients preference
Patients preference

- EM's
- Beeps
- Recall only
EM’s superior,
But patients preferred beeps.

Clinicians may infer effectivity from patients’ preference.
Clinical Issues

1) WM taxing during positive imagery/thoughts?

   Implication: WM taxing during positive ideation is counterproductive.

2) Memories for future events and indication

   Implication: theoretical and empirical basis for treating “flash forwards”

3) Using beeps instead of EM’s?

   Implication: beeps inferior to EM’s
Summary

1) General. Trauma memory is plastic:
   a) Emergence of trauma memories after PTSD (inflation)
   b) Blurring of trauma memories in EMDR (deflation) in EMDR

2) Regarding EMDR:
   a) Effects can be ‘modelled’ in lab.
   b) Explanation: Not merely exposure.
      Not interhemispheric communication.
   c) Robust evidence: deflation due to WM taxing.
      during retrieval.
   d) Rational basis for EMDR with clinical implications:
      a) Dual tasking during positive imagery unfortunate
      b) Flash forwards rational indication
      c) Replacing EM’s by beeps bad idea
Thank you!
Experience

1. Emotional arousal
2. Activation of noradrenaline release
3. Amygdala (basolateral)
4. Hippocampus
5. Cortex
6. Other brain regions

Modulation of memory consolidation

WM span

WM load of dual task

WM load provided by memory

TRENDS in Cognitive Sciences