

## Reducing anger outbursts after a severe TBI: A single-case study

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Complete List of Authors:	Rochat, Lucien; University of Geneva, Cognitive Psychopathology and Neuropsychology Unit Manolov, Rumen; University of Barcelona, Behavioral Sciences Methods; ESADE, Operations Management and Innovation Abouafia Brakha, Tatiana; Geneva University Hospitals, Neurology; Geneva University Hospitals, Neurorehabilitation Berner-Burkard, Christina; University of Geneva, Cognitive Psychopathology and Neuropsychology Unit Van der Linden, Martial; University of Geneva, Cognitive Psychopathology and Neuropsychology Unit,
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**Reducing anger outbursts after a severe TBI: A single-case study**

Rochat Lucien<sup>1,2</sup>, Manolov Rumen<sup>3,4</sup>, Aboulafia-Brakha Tatiana<sup>5</sup>, Berner-Burkard  
Christina<sup>1,6</sup>, & Van der Linden Martial<sup>1,2,7</sup>

<sup>1</sup> Cognitive Psychopathology and Neuropsychology Unit, University of Geneva, Switzerland

<sup>2</sup> Swiss Centre for Affective Sciences, University of Geneva, Switzerland

<sup>3</sup> Department of Behavioural Sciences Methods, University of Barcelona, Spain

<sup>4</sup> Institute for Brain, Cognition and Behavior (IR3C), University of Barcelona, Spain

<sup>5</sup> Division of Neurorehabilitation, Department of Clinical Neurosciences, Geneva University Hospitals,  
Switzerland

<sup>6</sup> Neuropsychology and speech therapy Unit, Institution of Lavigny, Switzerland

<sup>7</sup> Cognitive Psychopathology Unit, University of Liège, Belgium

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Manolov Rumen, PhD: [rumanov13@ub.edu](mailto:rumanov13@ub.edu). Phone: 0034 934031137.

Tatiana Aboulafia-Brakha, PhD: [Tatiana.Aboulafia@hcuge.ch](mailto:Tatiana.Aboulafia@hcuge.ch). Phone: 0041 22 37 23640

Christina Berner-Burkard, PhD: [christina.berner@ilavigny.ch](mailto:christina.berner@ilavigny.ch). Phone: 0041 21 82 14685

Martial Van der Linden, PhD: [martial.vanderlinden@unige.ch](mailto:martial.vanderlinden@unige.ch). Phone: 0041 22 37 99341

Correspondence should be addressed to Lucien Rochat, PhD, Cognitive  
Psychopathology and Neuropsychology Unit, Faculty of Psychology and Educational  
Sciences, University of Geneva, Boulevard du Pont d'Arve 40, CH-1205 Geneva,  
Switzerland. E-mail: [Lucien.Rochat@unige.ch](mailto:Lucien.Rochat@unige.ch); Phone: 0041 37 99346.

**ABSTRACT**

Anger outbursts constitute a frequent behavioural issue after a traumatic brain injury (TBI) and have a strong negative impact on the social outcomes resulting from the TBI. However, few studies have examined the efficacy of specific intervention strategies to reduce the frequency and intensity of anger outbursts. We therefore performed a single-case study on this topic by administering two successive and complementary psychological interventions with an AB design with maintenance (first intervention) and an AC design with maintenance plus a 1-month follow-up (second intervention) to a patient with a severe TBI. Whereas the first intervention focused on improving the recognition and expression of basic emotions, the second consisted of a self-regulation programme, including various features such as psychoeducation about self-control strategies, relaxation and assertiveness training that aimed to establish adequate behaviours, which were further promoted by an implementation intentions strategy in the patient's daily life. The results indicated that all interventions resulted in a reduced frequency and intensity of anger outbursts, and the data upheld the specificity of these effects. In addition, a meta-analytic integration of the effects of both interventions on the outcomes indicated a medium effect size. Further research is needed on other patients who experience long-standing anger outbursts to examine whether the observed gains can be replicated, sustained on a longer-term basis and improved.

**Keywords:** traumatic brain injury, anger, single-case, emotion recognition, implementation intentions.

## INTRODUCTION

Anger outbursts constitute a frequent behavioural issue after a traumatic brain injury (TBI). Indeed, between 12% and 76% of persons with TBI experience symptoms ranging from irritability to aggressive outbursts (e.g., Baguley, Cooper, & Felmingham, 2006; Kim, Manes, Kosier, Baruah, & Robinson, 1999; Tateno, Jorge, & Robinson, 2003). In addition, these problematic behaviours are related to negative social outcomes such as family problems, social isolation and/or loss of employment (e.g., Kim et al., 2007).

Many studies have suggested the possibility of improving anger management and associated problems in persons with brain injury. In particular, cognitive behaviour therapy (CBT) has been shown to successfully decrease irritability and aggression in persons with TBI (e.g., Aboulaflia-Brakha, Greber Buschbeck, Rochat, & Annoni, 2013; Alderman, 2003; Medd & Tate, 2000; Walker et al., 2010). However, besides focusing on the identification and modification of cognitive distortions that contribute to the maintenance of these problems, as well as developing adapted coping strategies as in a CBT approach (Giles & Manchester, 2006), interventions should also focus on complementary variables that may contribute to the development and/or maintenance of maladapted behaviours, such as emotion expression and recognition. Indeed, the ability to decode and respond to emotions expressed by persons we are interacting with is a critical component for developing and maintaining harmonious social interactions (e.g., Driscoll, Dal Monte, & Grafman, 2011). A meta-analysis performed on 296 adults with moderate to severe TBI indicated that patients significantly differ from matched controls in their ability to decode static facial expressions, the results showing a large effect size ( $d = 1.1$ ; Babbage et al., 2011). Of note is that these deficits in emotion perception in patients with TBI have been associated with behavioural problems, lack of

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3 self-awareness, poor social competence and poorer social outcomes (Knox & Douglas,  
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5 2009; Milders, Ietswaart, Crawford, & Currie, 2008; Spikman et al., 2013; Watts &  
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7 Douglas, 2006). In addition, group-controlled randomised studies showed that  
8  
9 intervention programmes designed to improve emotion recognition (by using errorless  
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11 learning, imitation, vanishing cues) are successful, although the transfer of these effects  
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13 into patients' daily lives has not been systematically established (Bornhofen &  
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15 McDonald, 2008b; Neumann, Babbage, Zupan, & Willer, 2015; Radice-Neumann,  
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17 Zupan, Tomita, & Willer, 2009). One explanation for these poor transfer effects may  
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19 first lie in the fact that emotion recognition impairments are associated with many  
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21 variables (e.g., slowed processing speed, poor flexibility, or reduced selective or  
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23 sustained attention; Ietswaart, Milders, Crawford, Currie, & Scott, 2008; Mancuso et al.,  
24  
25 2015; McDonald & Saunders, 2005). **Second, problematic behaviours may be underlain**  
26  
27 **by a host of deficits or variables that these programmes do not act on (Bornhofen &**  
28  
29 **McDonald, 2008a). Consequently, a complementary approach to the improvement of**  
30  
31 **emotion recognition and expression is to provide patients with psychoeducation about**  
32  
33 **self-regulation strategies, relaxation with deep breathing, and assertiveness training that**  
34  
35 **will help them to decrease emotional overreactions and to develop more appropriate**  
36  
37 **behaviours (see Demark & Gemeinhardt, 2002). In this context, a specific self-**  
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39 **regulation strategy called "implementation intentions" might be used to promote or**  
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41 **facilitate the transfer of learning in the patient's daily life, especially in at-risk**  
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43 **situations.**  
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50 Numerous studies have shown that the execution of goal-directed behaviours can  
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52 be enhanced by the use of implementation intentions (Gollwitzer, 2014).  
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54 Implementation intentions are defined as a planning strategy that consists of specifying  
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56 with as much detail as possible when, where and how one will perform a specific action  
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3 (Gollwitzer, 1993). Such a plan is formulated as an if–then contingency by using the  
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5 following structure: “If situation X arises, then I will perform behaviour Y” (e.g., “If I  
6  
7 do not agree with my colleagues, then I will express my disagreement in a calm voice”).  
8  
9 In such a plan, the “if” component specifies a suitable occasion for the implementation,  
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11 whereas the “then” component identifies an adequate response to these target stimuli, a  
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13 behaviour that allows one to reach one’s goal (e.g., to behave in a socially adapted  
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15 manner). Implementation intentions can also include a visual component, consisting of  
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17 visualising oneself performing the intended action in the targeted situation. The imagery  
18  
19 component may help to strengthen the encoding of the implementation intention (Cohen  
20  
21 & Gollwitzer, 2008).  
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26  
27 This self-regulatory planning strategy has been shown to be effective in  
28  
29 improving a wide range of cognitive functions and goal-directed behaviours. Indeed, in  
30  
31 a meta-analysis examining the efficacy of implementation intentions, Gollwitzer and  
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33 Sheeran (2006) showed a moderate to strong effect size ( $d = 0.65$ ) for participants from  
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35 the community and a large effect size in clinical samples ( $d = 1.10$ ). According to  
36  
37 Gollwitzer (1999), implementation intentions promote high activation of the specified  
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39 situational cue (by perceptual, attentional and mnemonic processes) and create a link  
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41 between the situation and the behaviour, so that when the situation occurs, the  
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43 behaviour is automatically initiated (see also Brandstätter, Lengfelder, & Gollwitzer,  
44  
45 2001; Lengfelder & Gollwitzer, 2001; Wieber, Thürmer, & Gollwitzer, 2015). Because  
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47 several pieces of empirical evidence uphold the automaticity of implementation  
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49 intentions, participants with a TBI who frequently present difficulties with controlled  
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51 processes could benefit from this strategy. To the best of our knowledge, no studies to  
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53 date have used implementation intentions (within a broader self-regulation programme  
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55 that includes other features such as psychoeducation about self-regulation strategies,  
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relaxation and assertive training) to reduce the frequency and intensity of behavioural problems such as anger outbursts after a TBI.

The objectives of the current study were to examine the efficacy of two successive psychological interventions that aimed to decrease both the frequency and the intensity of anger outbursts in a patient with a severe TBI. The first intervention focused on improving the recognition and expression of basic emotions, as this ability constitutes a central component for developing and maintaining harmonious social interactions.

However, this intervention does not provide the patient with a specific self-regulation strategy that could be used in at-risk situations. Therefore, the second and complementary intervention consisted of a self-regulation programme, including various features such as discussion about emotion regulation strategies, relaxation and assertiveness training that aimed to establish adequate behaviours, which were further promoted by an implementation intentions strategy in the patient's daily life.

This study illustrates an attempt to separate out and evaluate some of the components (emotion recognition vs. self-regulation) of a combination treatment for anger management after a TBI. This multicomponential approach to anger management after a TBI fits well with recommendations by authorities in the field (see Demark & Gemeinhardt, 2002).

## CASE STUDY

### Background and clinical history

MD is a 47-year-old right-handed male who sustained a severe TBI after a 4-m fall in 2011. Magnetic resonance imaging revealed several haematomas (right frontal epidural and subdural, left frontal), a left anterior subarachnoid haemorrhage, bilateral fronto-basal haemorrhagic contusions and several fractures of the skull.

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3 Three months after the accident, MD was transferred to a neurological  
4 rehabilitation centre, where he benefited from several neuropsychological,  
5 ergotherapeutic and physiotherapeutic treatments. One year after the TBI, he also  
6 received a group intervention based on a CBT approach to decrease aggression and  
7 anger outbursts (focusing on anger awareness, self-monitoring, management of  
8 emotions in emergency situations, cognitive restructuring and prevention strategies; see  
9 Aboulaflia-Brakha et al., 2013). The patient and his spouse stated that he benefited from  
10 this intervention in that he acquired more introspection into his difficulties. However, 1  
11 year after the intervention, issues with anger outbursts remained, and MD was  
12 motivated to further improve his control of anger. Medical records showed that MD had  
13 no history of mental health or neurological difficulties before the TBI. At the time of  
14 assessment, a suspicion of obstructive sleep apnoea was mentioned and further  
15 diagnosed. A positive airway pressure device was thus introduced 2 weeks after the end  
16 of the first intervention and 8 weeks before starting the second intervention (see below).  
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34 MD spontaneously described frequent irritability and difficulty in managing anger  
35 since his brain injury. He pointed out that he had frequent anger outbursts when he was  
36 upset. He expressed his anger by yelling loudly, especially at home during interactions  
37 with his children when he felt that they lacked respect toward him, when they did not  
38 listen to him, or more generally when he did not agree with their behaviours or wishes.  
39 He also tended to ruminate on these angry episodes, wondering whether it was his fault  
40 or why he was so angry at the moment, which frequently prevented him from falling  
41 asleep at night. He reported symptoms of fatigue, low self-esteem and anxiety (e.g., he  
42 worried about his future and whether he might or might not improve at the cognitive  
43 and behavioural levels).  
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3 According to his wife, the number of anger outbursts at home was on average four  
4 to five episodes weekly. During a prototypical anger outburst, MD shouted loudly,  
5 became agitated and did not let the interlocutor speak. She also reported that her  
6 husband became impulsive after the TBI, whereas she evoked an image of him having a  
7 reserved personality before the accident. When more specifically questioned, however,  
8 she mentioned that even before the TBI, her husband could become intent upon doing  
9 things his own way in order to ensure that his high standards were met, which could  
10 lead to some irritability, but anger outbursts were rare. She also reported that the  
11 relationship between MD and his children had become conflictual since the injury and  
12 that they had lost respect for their father. She also described symptoms of fatigue,  
13 especially when he returns home after work, low self-esteem, and worries about the  
14 future. In addition, she spoke of increased sadness because MD did not meet his parents  
15 as frequently as he used to do.  
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### 34 **Neuropsychological assessment**

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36 A neuropsychological assessment performed 18 months after the TBI showed  
37 moderate impairments in executive functions (problem resolution integrating several  
38 constraints, inhibition), light to moderate deficits in long-term memory and slowing of  
39 reaction times. In a second assessment performed 3 years after the TBI in March 2014  
40 before the intervention began, the deficits were globally identical (see Table 1).  
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50 **--INSERT TABLE 1 ABOUT HERE --**

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52 The assessment emphasised cognitive impairments in executive functions (mental  
53 flexibility, divided attention, updating in working memory, planning and problem  
54 resolution), attention (slowing down of processing speed) and non-verbal episodic  
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3 memory, which are compatible with the TBI (Table 1). In addition, difficulties in  
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5 recognising emotions from static faces were stressed, in particular fear, and to a lesser  
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7 extent anger and sadness, in the absence of general perceptive or semantic impairments.  
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### 10 11 12 **Rationale for the intervention**

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15 Anger outbursts following MD's TBI could be associated with several variables,  
16  
17 such as (1) impairments in emotion recognition and expression; (2) poor  
18  
19 executive/attentional functioning; and (3) fatigue, which has also been associated with  
20  
21 decreased self-regulation abilities (e.g., Belmont, Agar, & Azouvi, 2009).  
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23 Consequently, complementary succeeding interventions that specifically target or  
24  
25 bypass these impairments were implemented in MD.  
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29 To decrease both the frequency and the intensity of anger outbursts, rehabilitation  
30  
31 efforts first focused on improving emotion expression and recognition by means of  
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33 several strategies, such as vanishing cues that enabled MD to direct his attention on  
34  
35 relevant features of faces. This strategy was used because eye-tracking data during the  
36  
37 baseline phase (see Table 5) revealed that MD's gaze focused much more on the mouth  
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39 than on the area of the eyes when determining the emotion expressed by a face. The  
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41 intervention then focused on physiological reactions related to each basic emotion and  
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43 on imitation in a mirror, which provided MD with internal signals that could help him  
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45 not only to better understand his own emotional reactions, but also to better recognise  
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47 others' emotions.  
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51 The second intervention contains various features that aimed to stop the rise in  
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53 anger and replace his habitual response (i.e., anger outbursts) with an assertive, socially  
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55 adapted behaviour. For this purpose, various emotion regulation strategies were  
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57 discussed, and relaxation training and assertiveness learning were performed in order to  
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3 formulate an alternative behaviour that could be used by MD in stressful situations.  
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5 Implementation intentions were then selected to promote the use of this alternative  
6  
7 adapted behaviour in MD's everyday life, as they rely principally on automatic  
8  
9 processes rather than on controlled mechanisms, which are impaired in MD.  
10

11 In both interventions, repeated exercises, constant feedback and role playing were  
12  
13 used to promote their transfer to daily life. Finally, independently of our interventions, a  
14  
15 positive airway pressure device was successfully introduced to treat the obstructive  
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17 sleep apnoea between the two interventions to decrease symptoms of fatigue.  
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### 20 21 22 23 **Measures of anger outbursts and other behaviours**

24  
25 Anger outbursts were assessed daily with a home-made diary in which the spouse  
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27 and the patient were instructed to place a check mark each time MD presented a target  
28  
29 behaviour and to assess its intensity on a 10-point Likert scale from 1 (*irritability*) to 10  
30  
31 (*strong outburst with physical contacts*). Scores of frequency and intensity were  
32  
33 averaged for each week. The target behaviours included various emotional reactions or  
34  
35 behaviours such as exaggerated irritability, shouting, yelling, sudden movements, and  
36  
37 verbal or physical aggression toward another person. Internalized anger (e.g., self-  
38  
39 directed bitterness and resentment) was not considered a target behaviour. In addition,  
40  
41 in the same diary, both the patient and his spouse indicated the intensity of perceived  
42  
43 physical fatigue on a 10-point Likert scale from 1 (*slight fatigue*) to 10 (*strong fatigue*),  
44  
45 a control variable for which we did not expect any changes that resulted from our  
46  
47 interventions (i.e., emotion recognition and expression and self-regulation). Note that  
48  
49 the patient and the spouse each had their own diary. These behaviours were  
50  
51 continuously assessed throughout both interventions. However, only the spouse's diary  
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53 was taken into account in the analysis, as MD reported only one or two anger outbursts  
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3 per week (generally the most intense episodes) or sometimes forgot to complete the  
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5 schedule or to bring it back to the sessions.  
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8 In addition, the Neuropsychiatric Inventory (NPI; Cummings et al., 1994) and two  
9  
10 questionnaires, the Dysexecutive Questionnaire (DEX; Wilson, Alderman, Burgess,  
11  
12 Emslie, & Evans, 1996) and the short version of the UPPS Impulsive Behavior Scale  
13  
14 (Rochat et al., 2010), completed by MD's spouse, were used to assess whether the effect  
15  
16 of the interventions generalised to other behaviours. These questionnaires were  
17  
18 administered twice during the baseline and once during the post-test of each  
19  
20 intervention.  
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23  
24 The NPI consists of screening questions to determine whether behaviour changed  
25  
26 after the TBI and whether the altered behaviour was present at the time of the interview  
27  
28 ("in the current week"). It contains 12 subscales assessing delusions, hallucinations,  
29  
30 agitation/aggression, dysphoria/depressed mood, anxiety, euphoria, apathy,  
31  
32 disinhibition/impulsivity, irritability/lability, aberrant motor behaviour, nighttime  
33  
34 disturbances and appetite/eating disturbances. If the relative responds positively to a  
35  
36 screening question, the symptom is explored by means of several sub-questions focused  
37  
38 on specific features of each disturbance. Questions about the symptom's *severity*,  
39  
40 ranging from 1 (*mild*) to 3 (*severe*), and *frequency*, from 1 (*rarely*) to 4 (*very*  
41  
42 *frequently*), are then completed by the relative. The score for each behavioural domain  
43  
44 is the product of the frequency and severity subscore for that particular behaviour  
45  
46 (maximum 12), with higher scores indicating greater emotional or behavioural  
47  
48 difficulties.  
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51  
52 The DEX contains 20 items measuring difficulties in everyday life as a result of  
53  
54 executive dysfunction at a cognitive, emotional and behavioural level, with higher  
55  
56 scores indicating greater difficulties.  
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3 The short version of the UPPS Impulsive Behavior Scale (Rochat et al., 2010)  
4 assesses the multidimensional aspects of impulsivity after a TBI. The informants'  
5 version of this scale contains 16 items evaluating the four components of impulsivity,  
6 namely, urgency (e.g., "In the heat of an argument, he will say things that he later  
7 regrets"); (lack of) premeditation (e.g., "Before making up his mind, he considers all the  
8 advantages and disadvantages"); (lack of) perseverance (e.g., "Once he starts a project,  
9 he finishes it"); and sensation seeking (e.g., "He quite enjoys taking risks"). A current  
10 score for each dimension is computed, ranging from 4 to 16. Higher scores indicate  
11 greater impulsivity.  
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### 22 **Measures of emotion recognition**

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24 During the baseline phase, the Ekman 60 Emotional Faces Test (Ekman &  
25 Friesen, 1976) was administered on three occasions to ensure stability of responses.  
26  
27 This test was also administered once at the post-test. As MD's impairments in emotion  
28 recognition could have been secondary to his limited attentional and executive abilities  
29 (e.g., difficulties in selecting specific face areas that are relevant for emotion  
30 recognition or continuously maintaining attention in these areas to gather relevant  
31 information to determine the emotion expressed by the face), the test was also repeated  
32 on the third assessment with an eye-tracker device. A Tobii T120 Eye Tracker with a  
33 17-inch thin-film transistor monitor (Tobii, Stockholm, Sweden; [www.tobii.com](http://www.tobii.com)) was  
34 used to assess visual exploration of the stimuli. The percentage of fixations in two  
35 relevant areas of the faces (around the mouth and around the eyes, including the  
36 eyebrows) was recorded. Indeed, the eyes and mouth constitute relevant facial features  
37 by which one can recognise emotions expressed by an interlocutor. In addition, the  
38 influence of practice effects from multiple pre-assessments was addressed by using  
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3 another battery of emotional faces at the post-test: the Karolinska Directed Emotional  
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5 Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998).  
6

7 To explore any transference of learning from one modality (visual) to another  
8  
9 modality (auditory) that MD had not been specifically trained for in the programme, we  
10  
11 assessed vocal emotion recognition by using the vocal stimuli of the Emotion  
12  
13 Recognition Index (Scherer & Scherer, 2011). In this task, vocal portrayals of  
14  
15 joy/happiness, sadness, fear, anger and neutral were played by four professional actors.  
16  
17 Actors were asked to produce two “standard utterances” for their portrayals – “Hat  
18  
19 sundig pron you ventsy” and “Fee gott laish jonkill gosterr” – to avoid any confounding  
20  
21 effect due to semantics. The task includes 30 stimuli (anger: seven; fear: five;  
22  
23 joy/happiness: six; sadness: eight; neutral: four). This task was administered on three  
24  
25 occasions to ensure stability of responses during the baseline, as well as once in the  
26  
27 post-test.  
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### 31 32 **Design**

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34 The study took place over a 1-year period. After MD completed the first  
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36 intervention, there was a 3-month interval, after which he completed the second  
37  
38 intervention. For the first intervention, an AB design with maintenance was used, while  
39  
40 for the second intervention, an AC design with maintenance plus a 1-month follow-up  
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42 was applied. Two main outcomes (target behaviours) were assessed per intervention: the  
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44 frequency and the intensity of anger outbursts (Figure 1).  
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--INSERT FIGURE 1 ABOUT HERE--

As it constitutes an important issue for MD, subjective physical fatigue was also measured. However, because fatigue was likely due to obstructive sleep apnoea, we

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2  
3 expected no changes or only minor changes for this variable after the two interventions.

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5 Rather, we expected symptoms of fatigue to decrease with the introduction of the  
6  
7 continuous positive airway pressure (CPAP) device.  
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10 After a 1-month baseline measurement for each intervention (A), the intervention  
11 began (B or C). One 60- to 90-minute session per week was delivered face to face for 2  
12  
13 months, followed by a 1-month post-test. After the second intervention, a 1-month  
14  
15 follow-up was also done. Finally, we met MD and his spouse 8 months after the end of  
16  
17 the second intervention for a follow-up interview.  
18  
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### 20 21 22 23 **First intervention: Emotion recognition and expression training**

24  
25 The main objectives of the first intervention were to train MD to focus on relevant  
26  
27 facial features and to associate these features with basic emotions (anger, joy, surprise,  
28  
29 sadness, disgust, fear), as well as to increase awareness of his own emotions through  
30  
31 imitation and introspection so that his own emotional experience could help him to  
32  
33 identify others' feelings (Radice-Neumann et al., 2009; Neumann et al., 2015). Four  
34  
35 main learning strategies were used: vanishing cues (i.e., cues that guide MD's attention  
36  
37 toward relevant features of the faces), repetition, imitation and feedback. Modelling was  
38  
39 also used in that, before each exercise, the therapist demonstrated how to do it.  
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42  
43 This programme, adapted from "Faces Intervention" (Radice-Neumann et al.,  
44  
45 2009; Neumann et al., 2015), is a computer-based programme of emotional faces  
46  
47 (NimStim Faces; Tottenham et al., 2009) that vary in gender and race and express the  
48  
49 six basic emotions. The programme contains six modules: (1) psychoeducation, (2)  
50  
51 emotion identification training with vanishing cues and mirror use for imitation, (3)  
52  
53 similarity/discrimination exercises, (4) expression and recognition of internal signals  
54  
55 (body reactions) related to each basic emotion and deep understanding of emotions, (5)  
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3 emotion attribution exercises and role playing, and (6) recapitulation (see Appendix A  
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5 for a description of each module).

### 7 **Second intervention: the self-regulation programme**

10 The main objective of the second intervention was to provide MD with an  
11  
12 alternative adapted behaviour in at-risk situations. This intervention contained four  
13  
14 modules: (1) psychoeducation and identification of self-control strategies (e.g.,  
15  
16 behaviour interruption, putting in perspective, suppression, distraction, relaxation),  
17  
18 assertiveness training (Nezu et al., 1991) and brief relaxation training with deep  
19  
20 breathing (Sessions 1-2); (2) development of an alternative assertive behaviour to anger  
21  
22 outbursts derived from the first module: the “PREP” acronym, representing four steps  
23  
24 (stop, breath, assess anger, share emotion or disagreement peacefully with others)  
25  
26 toward an adequate and assertive behaviour that could be easily encoded and  
27  
28 remembered by using spaced retrieval (Sessions 2-3); (3) implementation intentions:  
29  
30 general definition, training the “if-then” contingency through fictive scenario  
31  
32 analysis and imagery training (adapted from Burkard, RoCHAT, Blum, et al., 2014)  
33  
34 (Sessions 3-4); and (4) application of the “PREP” acronym in daily life by using  
35  
36 implementation intentions (Sessions 5-8) (see Appendix B for a description of each  
37  
38 module).  
39  
40  
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42

43 As a classic “stop-think-do strategy”, the implementation intentions used in the  
44  
45 current study included a “stop” component that aims to prevent the person from acting  
46  
47 impulsively. However, the stop-think-do strategy and the implementation intentions  
48  
49 strategy differ inasmuch as the latter constitutes a self-regulation strategy that  
50  
51 automatically triggers the initiation of a specific action in a specific targeted situation  
52  
53 (as defined in the “If..., then...” contingency), without the person deliberating on when  
54  
55 to act, whether or not to act, or how to act. More specifically, implementation intentions  
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3 were used in the current study to automatically initiate the previously established  
4  
5 assertive behaviours in specific targeted situations of the patient's daily life. By  
6  
7 contrast, the stop-think-do strategy refers to a self-regulation strategy used as a content-  
8  
9 free 'meta-prompt' to alert the person to engage in a problem resolution process (e.g.,  
10  
11 Nott et al., 2008).  
12

### 13 14 15 **Statistical analyses**

16  
17  
18 The analysis of single-case data is still a controversial topic and no consensus has  
19  
20 been reached (Kratochwill et al., 2010; Smith, 2012). Thus, we decided to follow the  
21  
22 indications of Item 13 of the RoBiNT methodological quality scale (Tate et al., 2013),  
23  
24 which promotes using visual analysis, aided by quasi-statistical techniques and well-  
25  
26 justified statistical procedures. As a quasi-statistical procedure, the non-overlap of all  
27  
28 pairs (NAP; Parker & Vannest, 2009) focuses on data overlap (i.e., what proportion of  
29  
30 data points improves the measurements from the previous phase), with values between 0  
31  
32 and 0.66 indicating a small effect size, and those between 0.93 and 1.00 indicating a  
33  
34 large effect size. The slope and level change (SLC; Solanas, Manolov, & Onghena,  
35  
36 2010) quantifies progressive change (if present) and average change in level (useful  
37  
38 when the effect is abrupt and sustained). Unlike NAP, which yields a proportion, the  
39  
40 SLC quantifications are provided in the same measurement units as the dependent  
41  
42 variable (in this case, the number and intensity of anger outbursts). Finally, statistical  
43  
44 analysis was performed by using a variant of Cohen's  $d$  specifically adapted for single-  
45  
46 case designs to provide a broader quantitative summary of the results considering both  
47  
48 interventions jointly. Specifically, we used the multiple-baseline version of the  $d$ -  
49  
50 statistic (Hedges, Pustejovsky, & Shadish, 2013), comparing the initial baseline phase  
51  
52 (A) to the intervention phases (B or C). The  $d$ -statistic was obtained by using the R code  
53  
54 (R Core Team, 2013) from Shadish, Hedges and Pustejovsky (2014).  
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## RESULTS

### *Intervention 1: Emotion recognition and expression programme*

Figure 2 (upper panels) represents the measurements of frequency and median intensity of anger outbursts in the context of studying the effect of Intervention 1. The visual analysis indicates that the initial baselines are stable, allowing comparisons with the subsequent intervention condition. In addition, the introduction of the intervention is associated with a delayed change in level for frequency and a clearer change in level for intensity. At the post-test, an increase in the frequency of anger outbursts can be observed, whereas the data for intensity suggest maintenance of the effect with respect to the intervention phase.

Regarding data overlap (Table 2), the NAP indicates that a greater reduction took place for anger intensity: 93% of the intervention phase values are smaller than the pre-intervention values, which corresponds to a large effect. For frequency, the value of NAP is indicative of a lack of effect (Vannest & Ninci, 2015). The SLC quantifications provided in Table 2 show that when the intervention was introduced, there was an average decrease of 1.5 anger outbursts per measurement occasion (i.e., per week), although the net level change is close to 0 after this progressive change is taken into account. The evidence about median intensity is mixed, as the changes in level and in slope are in opposite directions. However, the results of SLC for intensity need to be validated by visual analysis (see Parker, Cryer, & Byrns, 2006). More specifically, the decrease in level is visually clear, but there are no visually clear trends in either the A or the B phase and thus the slope change estimate for this comparison seems less relevant. For the post-tests (i.e., the BM comparisons; see Table 2), an increase in outburst frequency was observed (i.e., a change in level of 6.98), but the slope change

(-0.48) implies a progressive reduction. For intensity, the low value of NAP reflects the fact that the post-test values are never higher than the intervention phase values. The effect is thus maintained.

--INSERT FIGURE 2 ABOUT HERE--

--INSERT TABLE 2 ABOUT HERE--

### ***Intervention 2: Self-regulation programme***

Figure 2 (lower panels) represents the measurements of frequency and median intensity of anger outbursts in the context of studying the effect of Intervention 2. First, baseline data for frequency and intensity are stable, allowing comparisons with the subsequent intervention condition. The introduction of the self-regulation intervention is associated with a progressive reduction of frequency and a more immediate improvement in intensity, which is, however, not maintained until the end of the intervention phase. The post-test (maintenance) data are variable and no firm conclusions can be drawn, although there is apparently a deteriorating trend for the frequency data. The follow-up data indicate that the results obtained during the intervention phase are maintained in terms of frequency and improved in terms of intensity.

Regarding data overlap (Table 2), the NAP indicates that when the self-regulation programme was introduced, there was a medium-sized reduction in frequency (approximately 90% of the baseline sessions included more frequent outbursts than the intervention phase sessions) and in intensity (rate higher for 83% of the pre-intervention sessions). The SLC quantifications provided in Table 2 show that when the intervention was introduced, there was a reduction in frequency of anger outbursts: this progressive decrease was less than half an outburst per week (-0.43), plus an average decrease of

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3 almost one outburst ( $-0.88$ ) after the progressive change was taken into account. The  
4  
5 evidence about median intensity is mixed, as the change in level implies an overall  
6  
7 reduction, but there is an upward (i.e., deteriorating) trend. For the post-tests (i.e., the  
8  
9 CM comparisons; see Table 2), there is an increasing trend in terms of frequency ( $0.43$ ),  
10  
11 whereas the frequency in the follow-up phase is identical to that in the maintenance  
12  
13 phase. For intensity, the CM comparison indicates a decrease ( $-1.12$ ), which is also the  
14  
15 case when comparing the maintenance phase with the subsequent follow-up ( $-1.50$ ).  
16  
17  
18 However, slopes are not to be interpreted when only two values per phase are available.  
19

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21 In general, in quantitative terms, the intervention that proved more effective was  
22  
23 the self-regulation programme, and its effect was larger for the frequency of outbursts  
24  
25 than for their intensity.  
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29 Regarding perceived physical fatigue, the data (see Figure 3, Appendix C) suggest  
30  
31 that no changes took place with the introduction of the interventions for this variable.  
32  
33 However, there was a clear decrease of perceived fatigue from Intervention 1 to  
34  
35 Intervention 2 (approximately 50% for both frequency and intensity of the target  
36  
37 behaviour), which was likely due to the introduction of the positive airway pressure  
38  
39 device between the two interventions.  
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#### 42 43 ***d*-statistic**

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46 The *d*-statistic shows that there was an improvement associated with the two  
47  
48 interventions, both in terms of frequency and intensity: an average reduction of 0.46  
49  
50 standard deviations for frequency (SE = 0.53, 95% confidence interval ranging from  
51  
52  $-1.50$  to  $0.58$ ) and 0.12 standard deviations for intensity (SE = 2.90, 95% confidence  
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54 interval ranging from  $-5.80$  to  $5.56$ ). However, in both cases, the confidence intervals  
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56 include 0 and thus we cannot state that the results are statistically significant.  
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3 Nevertheless, in single-case data, statistical inference is not common and not justified  
4  
5 when referring to a population of individuals. Combining both results meta-analytically,  
6  
7 the overall result ( $d = 0.46$ , 95% confidence interval ranging from  $-1.47$  to  $0.57$ ) is  
8  
9 more heavily determined by the effect size for the frequency data for which the variance  
10  
11 of the indicator is smaller and the confidence interval narrower. A value of  $0.46$  can be  
12  
13 interpreted as a medium effect size using Cohen's (1992) criteria. Note that Shadish,  
14  
15 Hedges, Horner and Odom (2015) recommended to perform such  $d$ -statistic on at least  
16  
17 three cases which implies that the results reported here should be interpreted with  
18  
19 caution.  
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## 22 23 **Tasks and questionnaires**

### 24 25 *Emotion recognition*

26  
27 MD had difficulties in recognising fear (10% to 40% of correct responses) and to  
28  
29 a lesser extent anger (50% of correct responses), sadness (from 50% to 60% of correct  
30  
31 responses) and disgust (from 50% to 80% of correct responses) from static faces on the  
32  
33 three baseline measurements (Table 3). MD often confounded surprise and fear, anger  
34  
35 and sadness, or sadness and disgust.  
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40  
41 --INSERT TABLE 3 ABOUT HERE--  
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43 The eye-tracker data on the third baseline underlines that MD focused much more  
44  
45 on the mouth than on the area around the eyes when making a judgment. After  
46  
47 Intervention 1, not only did his rate of correct responses dramatically increase (from  
48  
49 65% to 92% of correct responses), but his performances also generalised to stimuli  
50  
51 taken from another battery, the KDEF (85% of correct responses). In addition, as  
52  
53 expected, the eye-tracker data revealed that after the intervention, MD's gaze fixations  
54  
55 were much more optimally distributed between the mouth and the area around the eyes  
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3 than they were before the intervention (Table 4). Finally, emotion recognition from the  
4  
5 voice (Table 5) did not improve after the intervention. Altogether, these data indicate  
6  
7 that the intervention strategy consisting of orienting MD's attention to relevant features  
8  
9 of the faces had positive and specific effects on emotion recognition from static faces.  
10

11  
12 --INSERT TABLES 4 AND 5 ABOUT HERE--  
13

14 Regarding the questionnaires completed by MD's spouse (Table 6), a slight  
15  
16 decrease was observed on the NPI after the first intervention on the  
17  
18 agitation/aggression, anxiety, and disinhibition/impulsivity subscales. After the second  
19  
20 intervention, symptoms of agitation/aggression continued to decrease, as did irritability.  
21

22  
23 --INSERT TABLES 6 ABOUT HERE--  
24

25 On the DEX, a slight decrease was observed on the behaviour subscale (e.g., "He  
26  
27 loses his temper at the slightest thing"; "He does or says embarrassing things when in  
28  
29 the company of others"), especially after the second intervention. Finally, there was no  
30  
31 improvement on the UPPS Impulsive Behaviour scale, which remained stable after the  
32  
33 two interventions.  
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### 38 **Qualitative data**

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40 After the first intervention, MD reported that he gained some insight into his own  
41  
42 functioning and that from now on he could better understand his own emotional  
43  
44 reactions. However, he described understanding what others are feeling as remaining  
45  
46 difficult, especially during stressful interactions "because everything goes so fast that it  
47  
48 is difficult to prevent myself from overreacting". His general satisfaction with the  
49  
50 intervention was low to moderate (6 of 10). These remarks were corroborated by his  
51  
52 wife. Her general satisfaction with the intervention was moderate (7 of 10).  
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3 During the second intervention, MD's remarks on the use of implementation  
4 intentions indicated that they are easy to use. He also acknowledged that the "stop and  
5 breathe" portion of the PREP constituted the basis of the strategy and that it was very  
6 helpful for him, which increased his motivation to use the strategy. During the  
7 intervention, he reported using the strategy four to six times a week and completing the  
8 whole PREP process on two of three occasions. He also described a spontaneous use of  
9 the strategy in a situation that he had not been directly trained for during the  
10 intervention (e.g., "If my daughter responds to me badly, then I do the PREP"). In that  
11 case, only the verbal part of the intentions was used because he had no time to imagine  
12 himself performing an adapted behaviour in that situation. However, in cases of failure  
13 (i.e., when an anger outburst occurred), he could not explain why the strategy failed.  
14 When specifically questioned, he hypothesised that situations that were too arousing or  
15 that arose when he was experiencing excessive fatigue may compromise its  
16 effectiveness. After the intervention, he reported being proud to be able to express his  
17 disagreement with his children in a more adapted way. His general satisfaction with the  
18 intervention was moderate to high (8 of 10). His wife observed the use of PREP during  
19 stressful situations, as she noted that he tended to stop and breathe deeply before  
20 reacting. She also reported that he was less stressed during potential conflictual  
21 situations. Her general satisfaction with the intervention was moderate to high (8 of 10).

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45 At the 8-month follow-up, both MD and his wife reported less frequent anger  
46 outbursts (either none or one, rarely two episodes per week) and better relationships  
47 with his children. His wife also noticed that he was more concerned about the children  
48 (e.g., he asked her questions about their children's activities more frequently) and he  
49 became more concerned about her when she had difficulties in her job. However, MD  
50 reported that he no longer used the implementation intentions in their entire form, but  
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3 still used the “stop and breathe” part to prevent himself from (re)acting impulsively one  
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5 or two times a week.  
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## 9 10 DISCUSSION

11 The patient described in this study sustained a severe TBI with persisting anger  
12 outbursts. These anger outbursts were very disturbing to MD and his family and he was  
13 motivated to benefit from an intervention that aimed to decrease both the frequency and  
14 the intensity of the anger outbursts. Consequently, we more specifically examined the  
15 efficacy of two successive and complementary interventions, namely a programme  
16 designed to improve emotion expression and recognition (Intervention 1) and a self-  
17 regulation programme including various features (psychoeducation, relaxation and  
18 assertiveness training) supported by implementation intentions (Intervention 2).  
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30 Globally, the results upheld the efficacy of these two interventions for decreasing  
31 the frequency and the intensity of anger outbursts. To the best of our knowledge, no  
32 previous single-case study has examined the effectiveness of these types of  
33 interventions designed to decrease anger outbursts after a TBI.  
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39 Regarding the first intervention, the results indicate that MD improved his ability  
40 to decode emotions from static faces after the intervention. These results corroborate  
41 previous data demonstrating an increase in emotion recognition performances in  
42 patients with TBI following an analogue intervention (Radice-Neumann et al., 2009;  
43 Neumann et al., 2015). Of note, the results also speak in favour of a specificity of the  
44 effect of the intervention. Indeed, emotion recognition improved for static faces,  
45 whereas no improvement occurred for voices. In addition, the pattern of visual  
46 exploration of the faces after the intervention indicates a better allocation of gaze  
47 fixations on relevant features of the face (eyes and mouth) than was the case before the  
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3 intervention. This result was expected, considering the strategy used during the  
4  
5 intervention, namely focusing attention on the relevant part of the face by using  
6  
7 vanishing cues. Furthermore, the results generalised to a battery of stimuli (KDEF) that  
8  
9 had not been presented before. Consequently, the improved performance in emotion  
10  
11 recognition on the Ekman face battery observed after the intervention cannot be  
12  
13 accounted for by multiple presentations of these stimuli.  
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16       Regarding the main outcomes, the results of the first intervention showed a  
17  
18 decrease in the intensity of anger outbursts, indicating a transfer of learning to everyday  
19  
20 life. This result is also supported by the decrease of disinhibition, irritability and  
21  
22 aggression/agitation symptoms reported by the spouse on the questionnaires after the  
23  
24 intervention. An interpretation of the positive effects of this intervention may be that  
25  
26 this better ability to decode emotions from faces enables MD to better adjust his  
27  
28 behaviours in relation to the emotions expressed by his interlocutors (e.g., to avoid  
29  
30 becoming confrontational if the interlocutor expresses sadness or to discontinue  
31  
32 behaving aggressively if the interlocutor displays fear).  
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36       However, the frequency of anger outbursts tended to increase at the post-test. One  
37  
38 potential explanation for this increase lies in the fact that MD showed elevated fatigue  
39  
40 before the introduction of the positive airway pressure device between the two  
41  
42 interventions, which may have prevented him from fully benefitting from the first  
43  
44 intervention. More generally, further studies should examine whether the benefits of the  
45  
46 intervention in terms of frequency and/or intensity of anger outbursts could be improved  
47  
48 and maintained in the long term by, for instance, practising emotion recognition with  
49  
50 family members, which could help to boost or extend the transfer of learning in daily  
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52 life.  
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3           Regarding the second intervention, the results indicate that the frequency of anger  
4  
5 outbursts slightly decreased after the intervention, but then increased at the post-test,  
6  
7 whereas intensity continuously decreased during intervention, at the post-test and at  
8  
9 follow-up. These results are also supported by the decrease in symptoms of  
10  
11 disinhibition, irritability and aggression/agitation reported by MD's spouse on the  
12  
13 questionnaires after the intervention.  
14  
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16           At a qualitative level, MD considered the PREP strategy easy to use and said that  
17  
18 stopping before overreacting tended to become a good habit. In addition, he reported  
19  
20 being proud to be able to express his disagreement with his children in a more adapted  
21  
22 way. One explanation for MD's positive reactions to the intervention may be that it  
23  
24 increased his sense of control over his internal and/or external environment and that this  
25  
26 feeling of mastery in turn improved his self-concept. Furthermore, according to his  
27  
28 spouse, MD stopped, tried to cool down and seemed less distressed in at-risk situations,  
29  
30 which speaks in favour of the use of the strategy in his daily life, although in the long  
31  
32 term, MD no longer used the strategy that he was trained in during the intervention.  
33  
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36           Overall, the results of this second intervention showed that a multicomponential  
37  
38 self-regulation programme that includes implementation intentions to facilitate transfer  
39  
40 of learning in the patient's daily life constitutes a relevant strategy to increase self-  
41  
42 control in a patient with a severe TBI. They also converge with previous data (e.g.,  
43  
44 Gollwitzer, 1999), indicating that the efficacy of implementation intentions principally  
45  
46 depends on automatic, involuntary processes, as MD had moderate impairments in  
47  
48 various laboratory measures of executive functioning, yet benefited from the strategy. In  
49  
50 addition, in contrast with the findings of Churchill and Jessop (2010, 2011), who  
51  
52 demonstrated that participants with a high level of urgency (defined as the tendency to  
53  
54 experience strong reactions in emotional contexts) did not benefit from implementation  
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Running head: REDUCING ANGER OUTBURSTS AFTER A TBI

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3 intentions, our data corroborate Burkard et al.'s (2013) results that showed that this self-  
4  
5 regulation strategy could be efficacious in persons with an elevated level of urgency.  
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7 This result is of particular importance because urgency has been strongly associated  
8  
9 with problematic behaviours, poor functional outcome and caregivers' burden after a  
10  
11 TBI (Rebetez, Rochat, Ghisletta, Walder, & Van der Linden, 2015; Rochat, Beni,  
12  
13 Billieux, Annoni, & Van der Linden, 2011). The fact that MD remained as impulsive on  
14  
15 the UPPS Impulsive Behaviour scale at pre- and post-interventions suggests that both  
16  
17 intervention strategies provided MD with knowledge and strategies to better control his  
18  
19 behaviours in at-risk situations, rather than decreasing impulsivity as a trait per se.  
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22  
23 The treatment for sleep apnoea by the positive airway pressure device and the  
24  
25 resulting improvements in the patient's symptoms of fatigue contributed to the decrease  
26  
27 of both frequency and intensity of anger outbursts in between the two interventions,  
28  
29 which might be explained by an increase of cognitive resources available for self-  
30  
31 control. In turn, it could explain, at least partially, why the second intervention was  
32  
33 more effective in that the patient was more focused during the second intervention than  
34  
35 during the first. More generally, the extent to which the second intervention benefited  
36  
37 from the first remains unclear. Indeed, the combined effect of the two interventions may  
38  
39 have also led to an incremental improvement in the patient's ability to control his  
40  
41 behaviour.  
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45 Another feature of the data deserves discussion: the effect of the interventions on  
46  
47 the frequency of anger outbursts is not immediate but delayed. Although we cannot rule  
48  
49 out that extraneous variables might explain this decrease because of the quasi  
50  
51 experimental design of the study, one cannot reasonably expect that the psychological  
52  
53 interventions used in the current study have an immediate effect on the target behaviour.  
54  
55 Indeed, the strategies had to be first discussed and learned before being applied in the  
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3 patient's everyday life, which might account for the delay observed in some of the  
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5 results.  
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7 Some limitations to the study must also be discussed. First, the AB design reduced  
8 the opportunity to gather evidence of experimental control over the target behaviours as  
9 a result of the interventions, inasmuch as uncontrolled factors might also account for the  
10 results (e.g., passage of time, maturation or environmental events; Tate et al., 2013).

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15 Further studies should thus use an experimental design (e.g., a multiple baseline design  
16 across participants) to increase internal validity. Second, the target behaviour was  
17 assessed with a home-made diary for which we could not provide any reliability data.  
18 Such a tool was used because, to the best of our knowledge, there is no available  
19 questionnaire or scale in French that specifically assesses the target behaviour. Third,  
20 regarding the specificity of the effect in the second intervention, we acknowledge that  
21 the number of features (relaxation, assertiveness training, discussion on emotion  
22 regulation strategies and an implementation intentions strategy) included in the  
23 programme make it difficult to appraise whether one of these features alone or their  
24 combination contributed to the results. Finally, although MD and his wife mainly  
25 attributed improvements to the stop and breathe strategy, there is no direct evidence that  
26 implementation intentions played a role in the use of this strategy inasmuch as just  
27 learning the stop and breathe strategy might be efficacious (i.e. learning of the PREP  
28 acronym). Consequently, further studies are needed to demonstrate the specific efficacy  
29 of implementation intentions to improve emotion regulation in patients with brain  
30 injury.  
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## 51 52 53 54 55 Conclusion

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3 This study demonstrated the efficacy of two successive and complementary  
4 psychological interventions, namely a programme to improve emotion recognition and  
5 expression and a self-regulation programme with various features, including  
6  
7 implementation intentions to decrease the frequency and intensity of anger outbursts in  
8  
9 a patient with a severe TBI. It remains to be determined whether the findings of the  
10  
11 current study generalise to other patients experiencing long-standing anger outbursts or  
12  
13 other socially maladapted behaviours. Future studies could also investigate whether the  
14  
15 observed gains are sustained in the longer term following the training period, as well as  
16  
17 ways to improve the efficacy of these interventions.  
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#### 25 **Acknowledgments**

26  
27 The authors declare no conflict of interest.  
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For Peer Review Only

## Appendix A

### First intervention: Emotion recognition and expression programme

The main objectives of the first intervention were to train MD to focus on relevant facial features and to associate these features with basic emotions (anger, joy, surprise, sadness, disgust, fear), as well as to increase awareness of his own emotions through imitation and introspection so that his own emotional experience could help him to identify others' feelings (Radice-Neumann et al., 2009; Neumann et al., 2015). Four main learning strategies were used: vanishing cues (i.e., cues that guide MD's attention toward relevant features of the faces), repetition, imitation and feedback. Modelling was also used in that, before each exercise, the therapist demonstrated how to do it.

The programme adapted from "Faces intervention" (Radice-Neumann et al., 2009; Neumann et al., 2015) is a computer-based programme of emotional faces (NimStim Faces; Tottenham et al., 2009) that vary in gender and race and that express the six basic emotions. The programme contains six modules:

**(1) Psychoeducation.** The goal of treatment and the importance of emotion expression and recognition for appropriate behaviours were discussed and basic emotions defined. Following Neumann et al. (2015), we described the purpose of the programme (to help MD better recognise how people feel), the importance of being able to recognise others' emotions in daily life (e.g., to more adequately interact with other people, to develop skills to be compassionate with others) and the importance of understanding one's own emotions to better recognise others' emotions.

**(2) Emotion identification; brief description of emotional events; mirror use.** This module aimed to train MD to focus on relevant features of faces to better recognise the expressed emotion. For each static face, MD was asked to select, from a list of the six

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3 basic emotions, the emotion that best described how the person was feeling. Visual (i.e.,  
4 thin red circles) and verbal cues were initially used to highlight the relevant facial  
5 features, but these cues gradually vanished. After each response, feedback was  
6 provided. Following incorrect answers, all the verbal and visual cues that described the  
7 characteristics of the features and the emotion being expressed were displayed on the  
8 screen. Each training exercise was scored for the percentage of correct answers. Scores  
9 below 83% (e.g., <20 of 24 correct responses) required that the exercise be repeated.  
10 This threshold was used throughout the programme. There was no time limit and MD  
11 had to produce the right answer before proceeding to the next trial.  
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23 This module was divided into three parts. In the first exercise (“identify  
24 emotion”), MD was asked to correctly identify the emotion of each presented face  
25 among six labels. For the first 24 faces, both visual (red circles surrounding the mouth  
26 and the eyes) and verbal cues (a brief description of the main features of the face) were  
27 presented. Provided MD attained >83% of correct responses, 24 additional faces were  
28 presented with the visual cues only and finally, 24 emotional faces were presented  
29 without any cues at all (vanishing cues). The second exercise (“identify emotion and  
30 describe personal experiences”) followed the same structure, except that there were only  
31 18 faces (six with both verbal and visual cues, six with only visual cues, six with no  
32 cues). For the last six faces, MD was also asked to briefly describe six personal events  
33 that matched each basic emotion. These descriptions were reused and more deeply  
34 analysed in Module 4 (see below). The third exercise (“identify emotion and imitate”)  
35 included 12 faces and after each identification, MD was asked to imitate as precisely as  
36 possible the identified emotion on a small portable mirror. ~~When necessary, the~~  
37 ~~therapist encouraged and helped MD by giving him instructions to improve the quality~~  
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of the imitation (e.g., “Good, but try to put more tension in the jaw and the mouth as if you were really angry”).

**(3) Similarity/discrimination exercises.** This module was divided into two parts. In the first series of exercises, MD was presented with two different faces (in terms of identity) at the same time and was asked to judge whether the faces expressed the same emotion or not. In the case of similarity, he was asked to correctly identify the emotion expressed by the faces. Visual cues were presented for the first block of 24 trials and vanished for the second block of 24 trials. After each correct response, MD had to justify his response (i.e., to provide a description of the features that were similar or dissimilar). In the second series of exercises, MD was shown five faces (one target and four distractors) at a time and was asked to identify, among the distractors, the one that matched the target in terms of emotion. Visual cues were presented for the first block of 24 trials and vanished for the second block of 24 trials. After each correct response, MD had to justify his response (i.e., to provide a description of the features that were similar between the target and the identified distractor). MD was then asked to name and imitate the emotion on the mirror.

**(4) Expression and recognition of internal signals (body reactions) related to each basic emotion; deep understanding of emotions.** In this module, MD was first asked to describe the physical and physiological changes of the body associated with each emotion (e.g., fear is associated with an increased heart rate, butterflies in the stomach). In the second part of the module, MD was asked to recall the personal events described in the first module as vividly as possible and was encouraged to feel what he “felt” at the time of the situation. He was asked to (a) describe the event in more detail, (b) describe his feelings and associated physiological reactions, (c) think about the reasons that he felt these emotions, (d) describe his response to the situation (both his

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3 behaviours and the emotional expression on his face and body), (e) think about others'  
4 perception of his emotional reactions and others' feelings, and (f) describe others'  
5 behaviour (including facial expression) and feelings in reaction to his own behaviour  
6 (for more details on this module, see Neumann et al., 2015). This exercise was repeated  
7 for each of the basic emotions and associated events described by MD in Module 1.  
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14 **(5) Emotion attribution and role playing.** In the first part of this module, MD saw a  
15 series of pictures presented one at a time depicting everyday life situations, with a short  
16 sentence describing the situation. For each situation, MD was asked to choose from  
17 among the six emotions represented by "emoticons" on the screen to indicate what he  
18 would have been feeling himself in this situation, to imitate this emotion and then to  
19 describe how another person (e.g., his children, his wife) would have been feeling in  
20 that situation. ~~For instance, a picture depicts someone preparing a move with the~~  
21 ~~following text: "Your son learned today that his best friend is moving to another~~  
22 ~~country". Under the image, two sentences are displayed: "Your son feels \_\_\_\_\_ . With~~  
23 ~~respect to your son, you feel \_\_\_\_\_".~~ Twenty-four images were presented. In half of  
24 them, MD was the central character of the situation and was asked what he would have  
25 been feeling in that situation and then how his relative would react to his feelings; in the  
26 other half, ~~as in the example above~~, he was asked to predict one of his relative's feelings  
27 and then his own feelings with respect to his relative. For each response, MD had to  
28 briefly justify his answers. In the second part of this module, MD was trained in  
29 emotion expression and recognition by role playing situations taken directly from his  
30 everyday life (e.g., MD meeting his son returning home too late on a Saturday night).  
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53 **(6) Recapitulation.** In this module, we reviewed with MD all the acquired competences  
54 learned in the previous modules. In addition, as he still tended to confuse one emotion  
55 with another (e.g., surprise vs. fear, disgust vs. anger) on some trials during the  
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3 exercises, we presented each pair of confounded emotions on a screen and repeated the  
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5 exercises by focusing MD's attention on the relevant part of the face and emphasising  
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7 the differences between the features of each expressed emotion.  
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## 10 11 **Appendix B**

### 12 13 **Second intervention: The self-regulation programme**

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15 The main objective of the second intervention was to provide MD with a strategy  
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17 to better control his behaviour in at-risk situations. ~~More specifically, by using various~~  
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19 ~~components (including intention implementations), we trained MD to stop emotional~~  
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21 ~~overreactions when they arise and to replace anger outbursts with appropriate assertive~~  
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23 ~~behaviours.~~ This intervention contained four modules:  
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30 **(1) Identification of self-control strategies and assertiveness (Session 1).** In the first  
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32 session, we discussed different self-control strategies (e.g., behaviour interruption,  
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34 putting in perspective, suppression, distraction, relaxation) that were or were not used  
35  
36 by MD and their possible applications, as well as their advantages and disadvantages.  
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39 MD used behaviour interruption (e.g., he left the place where the argument took  
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41 place) most often as a way of coping with stressful situations. However, he felt annoyed  
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43 and frustrated with this strategy because he could not share his emotion and  
44  
45 communicate his disagreement with his interlocutors. Therefore, one objective of this  
46  
47 second intervention was to provide a new strategy to cope with anger that might  
48  
49 advantageously replace, when possible, behaviour interruption. In this context, an  
50  
51 overall orientation to assertiveness (see Nezu, Nezu, & Arean, 1991), including  
52  
53 definitions and modelled examples of assertive, passive and aggressive behaviours, was  
54  
55 presented and discussed with MD. At this point, MD was clearly able to acknowledge  
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3 that his mode of communication was generally aggressive and sometimes passive,  
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5 which prevented him from developing appropriate relationships with his children and  
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7 provoked a lot of frustration.  
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10 Components of assertive behaviour were discussed with MD, including voice  
11  
12 intensity (soft vs. loud), latency of response (appropriate vs. impulsive), eye contact  
13  
14 (focused vs. unfocused), voice quality (assertive vs. angry), body language (appropriate  
15  
16 vs. threatening) and listening ability (listening to the other person vs. talking constantly)  
17  
18 (Nezu et al., 1991). Examples of various anger-provoking situations were presented,  
19  
20 allowing the therapist to model assertive versus aggressive responses during role play.  
21

22  
23 ~~For example, in response to the situation in which “a neighbour falsely accuses you of~~  
24 ~~throwing rubbish into his garden”, MD was taught to respond only when the person had~~  
25 ~~finished talking and not to interrupt, to use a calm voice, to not threaten the person, to~~  
26 ~~look directly at the person when talking, to concretely and gently tell the person that he~~  
27 ~~did not throw rubbish into his garden and to tell the neighbour how that accusation~~  
28 ~~made him feel (e.g., angry, sad; see Nezu et al., 1991).~~ The objective of this short  
29  
30 assertiveness training was to build new interpersonal skills to better manage stressful  
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32 situations associated with aggressive responding.  
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41 Brief relaxation training with deep breathing was also delivered for 5 to 10 min at  
42  
43 the end of each session so that MD could experience the benefits of this technique to  
44  
45 cool down. ~~Relaxation training with deep breathing has been shown to improve~~  
46 ~~cognitive functioning and to reduce stress after a traumatic brain injury (Hanna-Pladdy,~~  
47 ~~Berry, Bennett, Phillips, & Gouvier, 2001; Lysaght & Bodenhamer, 1990) and was thus~~  
48 ~~continuously used during the intervention.~~  
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55 **(2) An alternative assertive behaviour to anger outbursts: “PREP” (Session 2).** In  
56  
57 this module, we proposed to MD an alternative behaviour to anger outbursts. More  
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Running head: REDUCING ANGER OUTBURSTS AFTER A TBI

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specifically, we elaborated the acronym PREP, representing four steps towards an adequate and assertive behaviour that could be easily encoded and remembered by using spaced retrieval. The four letters of the acronym were defined as follows

(French/English):

**P** = **Pause**: Je m'arrête [Pause: I stop].

**R** = **Respirer profondément** [Breathe deeply].

**E** = **Evaluer ma colère** sur un thermomètre allant de 1 "légère irritabilité" à 10 "agressivité avec contact physique". Si la colère < 3, aller à l'étape 4. Sinon, continuer à respirer ou quitter la pièce (interruption comportementale). [Assess my anger on a thermometer from 1 "slight irritability" to 10 "aggressive outburst with physical contact". If anger is <3, then go to Step 4. If not, continue breathing or leave the place (behaviour interruption)].

**P** = **Partager calmement mon émotion ou mon désaccord avec autrui** [Share my emotion or my disagreement peacefully with others].

**(3) Implementation intentions: definition; training the "if-then" contingency through scenario analysis and imagery training** (adapted from Burkard, Rochat, Blum, et al., 2014) **(Sessions 3-4)**. Implementation intentions (the "if-then strategy") were introduced and presented as a complementary self-regulation strategy to those already discussed in Module 1 (e.g., putting into perspective, relaxation, behaviour interruption). This psycho-educational part of the programme was illustrated with concrete, real-life examples.

After this introduction, the programme aimed to train MD in the verbal and then the visual components of implementation intentions separately, before training him to use combined verbal-visual implementation intentions. The verbal component was taught via scenarios in which a protagonist was in a stressful situation in which he might

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3 experience an anger outburst. Here, MD was trained to formulate a correct, precise “if-  
4  
5 then” sentence with the PREP acronym in the “then” component.  
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8 After MD was familiar with the verbal part of implementation intentions, he was  
9  
10 trained in the visual component in parallel with the verbal component. We particularly  
11  
12 insisted on the whole implementation intention being visualised; MD had to imagine  
13  
14 himself performing the action in the situation, as in a short mental movie that had to be  
15  
16 visualised from the actor’s perspective rather than from the observer’s perspective  
17  
18 (Burkard, Rochat, Blum, et al., 2014). ~~These mental movies can be multimodal  
19  
20 (including visual or contextual elements, but also physiological reactions, others’  
21  
22 remarks or behaviours, etc.). Visualisation exercises were then carried out. MD was  
23  
24 invited to close his eyes and imagine a situation (e.g., the living room where he has  
25  
26 frequent arguments with his children) in order to form a “mental movie”. While  
27  
28 imagining these situations, visualisation was fostered by asking questions about sensory  
29  
30 and contextual information. Finally, he practised visualising implementation intentions  
31  
32 (situational cue and to-be-performed behaviour). One central aspect of the programme  
33  
34 was to define with MD specific, precise and relevant cues that trigger the action defined  
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36 in the implementation intentions.  
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38~~

39  
40 We also explained the difference between controlled and automatic processes and  
41  
42 mentioned that implementation intentions relied principally on automatic processes.  
43  
44 These explanations were proposed to prevent MD from believing that the technique  
45  
46 worked by repeating the “if-then” sentences continuously until the appropriate time  
47  
48 came for the intended behaviour to be performed (Burkard, Rochat, Blum et al., 2014).  
49

50  
51 **(4) Application of PREP in daily life by using implementation intentions (Sessions**  
52  
53 **5-8).** To allow the transfer to real-life situations, MD was prompted to give examples of  
54  
55 his own anger outbursts and to observe which real-life situations would be appropriate  
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Running head: REDUCING ANGER OUTBURSTS AFTER A TBI

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3 as triggers for the “if” part of implementation intentions. Specific situations associated  
4  
5 with frequent anger outbursts were practised during these sessions, and then used by  
6  
7 MD at home.  
8

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10 We specifically focused on situations in which anger arises when MD had an  
11  
12 argument with his children, as these situations were very painful to him. For instance,  
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14 he had recurrent arguments with his son regarding the fact that his son wanted to replace  
15  
16 some parts of his scooter with prohibited parts that make it dangerous to drive. Here,  
17  
18 MD formulated an implementation intention (“If my son tells me that he wants to drive  
19  
20 his scooter with non-approved parts, then I’ll do the PREP”), and then repeated it three  
21  
22 times. In addition, with the help of the therapist, MD formulated the alternative  
23  
24 assertive behaviour to adopt in the last step of the “PREP” (e.g., “I gently tell him that I  
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26 do not agree because it might be dangerous”) before imagining himself acting in the  
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28 situations and practising the intention.  
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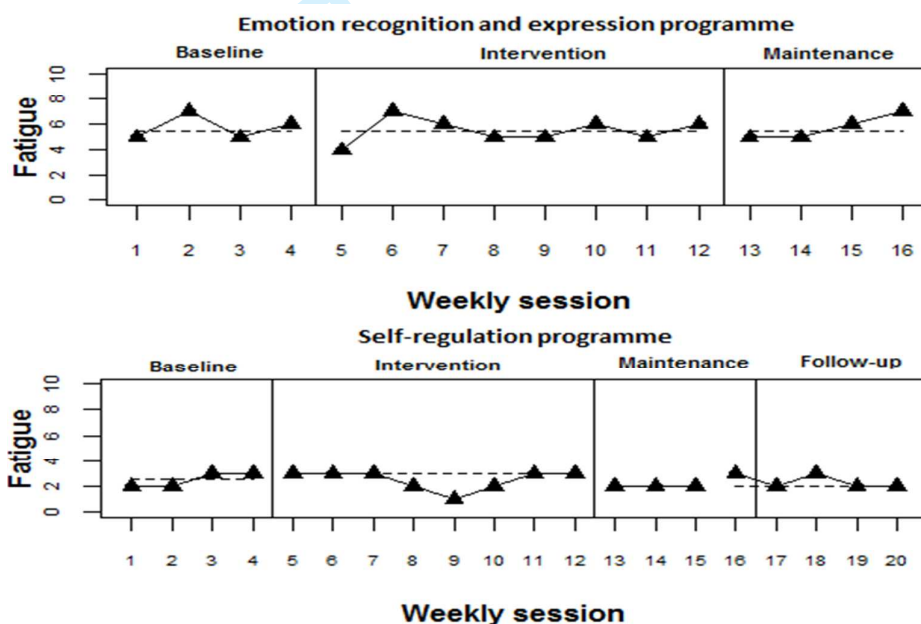
31  
32 When MD was familiar with the procedure, he was also prompted to include  
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34 previously identified physiological signals (see Intervention 1, Module 4) associated  
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36 with a rise in anger (e.g., warmth in the hand and cramps in the left leg) when  
37  
38 formulating and then imagining the intention. In general, during each session, MD was  
39  
40 trained in two specific implementation intentions. At the beginning of each session  
41  
42 (Sessions 6 to 8), MD described whether he used the “if-then” strategy during the week,  
43  
44 whether he used both verbal and visual components, and whether or not the  
45  
46 implementation intentions were successful and the reason for potential failure. This  
47  
48 information was discussed with the aim of optimising the use of implementation  
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50 intentions in everyday life.  
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54 We also did an important check during each session: that MD was not too  
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56 emotionally aroused before formulating the implementation intentions, as arousal  
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constitutes a potential limit in the use of this strategy (Burkard et al., 2013). For this purpose, we used a single item that assessed his arousal state on a 10-point Likert scale from 1 (*very calm*) to 10 (*very excited*). In each session, MD's score on this scale varied from 1 to 3, which seemed appropriate for the implementation intentions to be efficacious.

**Appendix C**

**Data on perceived fatigue**





**Table 1.** Neuropsychological assessment conducted with MD in March 2014

Domain	Test	Raw scores	Statistical scores and comments
Working memory	Digit span (direct)	5	Normal
	Digit span (indirect)	4	Normal
	Corsi block-tapping test	4	Normal
	Updating (TAP; Zimmermann & Fimm, 1995)	RT: <b>1,029 ms</b> ( $\pm$ 373) Omissions: <b>11</b>	Pc 4 (Pc8) < Pc1
Episodic memory	Shape test (Doors and People test; Baddeley et al., 1994)	Total: 32/36 Delay: 11/12	< Pc 95
	Doors test (Doors and People test; Baddeley et al., 1994)	Part A: 12/12 Part B: <b>5/12</b>	Pc 90 Pc 5
	Pyramid and Palm Tree Test (Howard & Patterson, 1992)	50/52	Normal
	Executive functions	Divided attention (TAP; Zimmermann & Fimm, 1995)	RT: <b>785 ms</b> ( $\pm$ 307) Omissions: <b>6</b>
Executive functions	Go/No Go (TAP; Zimmermann & Fimm, 1995)	RT: 642 ms ( $\pm$ 89) False alarms: 2	Pc 8 (Pc 31) Pc 24
	Color Trails A and B (D'Elia et al., 1996)	Part A: 43 s (0 errors) Part B: <b>234 s (3 errors)</b>	Pc 73 < Pc 1 (< Pc1)

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2				
3		Non-verbal fluency (5-	24 productions, 1 perseveration	Normal
4				
5		point test)		
6				
7				
8		Key test (BADS;	Profile score: <b>1</b>	Impaired
9				
10		Wilson et al., 1996)		
11				
12	Attention	Alertness (TAP;	Without signal: 257 ms ( $\pm$ 31)	Pc 31 (Pc 76)
13				
14		Zimmermann &	With signal: 259 ms ( $\pm$ 50)	Pc 24 (Pc 27)
15				
16		Fimm, 1995)	Index: -0.008	Pc 21
17				
18		D2 (Brickenkamp &	GZ = 334	Pc 8.1
19			F = 27	Pc 25-50
20		Zillmer, 1998)	F% = 8.08	Pc 11.5
21			GZ-F = 307	Pc 25-50
22			SB = 15	Pc 21.2
23		Code (WAIS-III;	<b>36</b>	Std note = 5
24				
25		Wechsler, 1997)		
26				
27	Face recognition	Benton Face	27/27	Normal
28				
29		Recognition Test		
30				
31		(Benton et al., 1994)		
32				
33	Facial emotion	Ekman 60 Faces Test	Total: 39/60	
34			Surprise: 9/10	
35	recognition	(Ekman & Friesen,	Sadness: 6/10	Limit
36			Joy: 10/10	
37		1976)	Disgust: 8/10	
38			<b>Fear: 1/10</b>	Impaired
39			Anger: 5/10	Limit

*Note.* Scores in bold indicate impairments. RT = reaction time; TAP = Test of Attentional Performance;

BADS = Behavioural Assessment of the Dysexecutive Syndrome battery; WAIS-III = Wechsler Adult

Intelligence scale-III.

**Table 2.** Two-phase comparisons for the two types of intervention (emotion recognition and self-regulation) carried out using the non-overlap of all pairs and the slope and level change procedures

<b>Emotion recognition</b>		Non-overlap of all pairs	Slope change	Net level change
Frequency	AB	59.37	-1.52	-0.04
	BM	53.13	-0.48	6.98
Intensity	AB	93.75	0.13	-0.42
	BM	10.00	0.20	-0.30
<b>Self-regulation</b>		Non-overlap of all pairs	Slope change	Net level change
Frequency	AC	90.63	-0.43	-0.88
	CM	29.69	0.43	0.80
	MF	50.00	0.00	0.00
Intensity	AC	83.33	0.20	-1.08
	CM	41.67	0.30	-1.12
	MF	12.50	0.00	-1.50

*Note.* A = first baseline phase; B = intervention phase (emotion and recognition programme); C = intervention phase (self-regulation programme); M = maintenance (post-test); F = follow-up.

**Table 3.** Performances on emotion recognition task (Ekman faces) before and after

Intervention 1

	Happiness	Anger	Fear	Sadness	Surprise	Disgust	Total
BL 1	100	50	10	60	90	80	65
BL 2	100	50	10	50	90	60	60
BL 3	100	50	40	60	90	50	65
Post-test	100	90	90	90	90	90	92
KDEF	100	90	80	70	80	90	85

*Note.* Performances are expressed as percentage of correct responses. BL = baseline; KDEF = Karolinska

Directed Emotional Faces battery administered at the post-test.

**Table 4. Distribution of gaze fixation within eyes and mouth area**

	Eyes	Mouth
BL 3	22.04	77.96
Post-test	42.59	57.41

*Note.* Performances are expressed as mean percentage of fixations related to total number of fixations within the relevant area for all emotional categories. BL = baseline.

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**Table 5.** Performances on emotion recognition task (prosody) before and after Intervention 1

	Happiness	Anger	Fear	Sadness	Neutral	Total
BL 1	16.66	42.86	20	50	25	30.90
BL 2	33.33	57.14	40	62.5	0.5	38.70
BL 3	33.33	42.86	20	62.50	50	41.74
Post-test	16.66	42.86	20	50	50	35.90

*Note.* Performances are expressed as percentage of correct responses. BL = baseline.

**Table 6.** Scores on questionnaires before and after treatment for both interventions

Scales		Intervention 1			Intervention 2		
		BL 1	BL 2	Post-test	BL 1	BL 2	Post-test
<b>NPI</b>	Agitation/aggression	12	-	9	8	-	4
	Depressed mood/dysphoria	9	-	9	6	-	6
	Anxiety	9	-	6	4	-	6
	Exaltation/euphoria	0	-	1	0	-	0
	Disinhibition/impulsivity	9	-	3	3	-	3
	Instability/irritability	9	-	9	8	-	6
	Total	48	-	37	29	-	25
<b>DEX</b>	Behaviour	29	32	28	24	28	20
	Cognition	7	6	7	8	7	6
	Emotion	6	7	8	6	7	5
	Total	42	45	43	38	42	31
<b>UPPS</b>	Urgency	12	12	12	10	10	12
	Lack of premeditation	12	14	12	10	8	12
	Lack of perseverance	14	14	14	10	8	10
	Sensation seeking	5	4	4	4	4	5

*Note.* BL = baseline; NPI = Neuropsychiatric Inventory; DEX = DysExecutive Questionnaire;

UPPS = UPPS Impulsive Behavior Scale.

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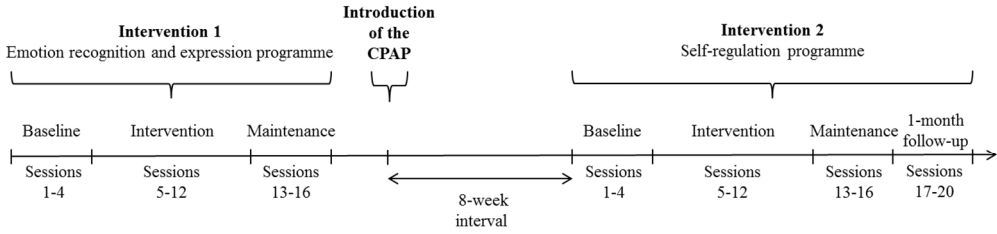
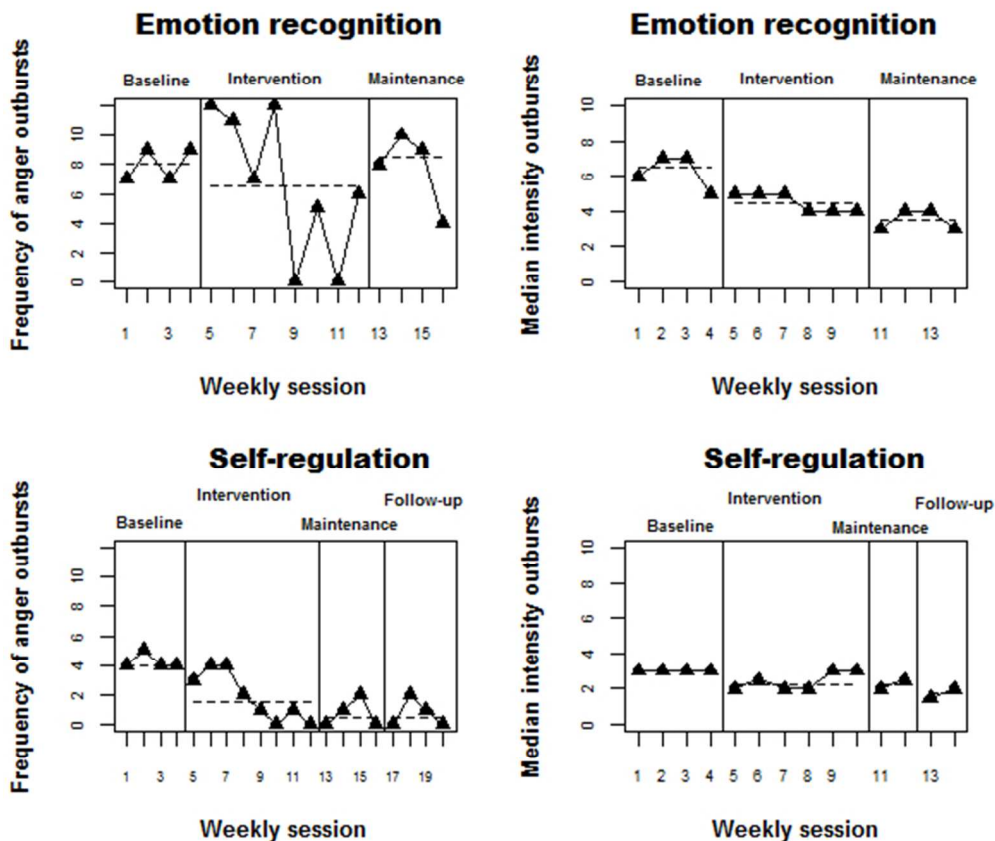


Figure 1. Schema representing the progress of the interventions. CPAP = continuous positive airway pressure.

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Graphical representation of the data obtained for frequency and intensity of anger outbursts under the two interventions. The dashed lines represent within-phase medians.