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# Processing of negative stimuli facilitates event-based prospective memory only under low memory load

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**ABSTRACT**
Event-based prospective memory (PM) is related to the ability to execute a previously planned action at the appropriate situation. Previous literature showed enhanced performance when emotional stimuli are used as PM targets. However, it was entirely unexplored whether this effect is susceptible to prospective memory load (PML), related to the number of target events that are relevant for the pending PM task. Here we presented participants with angry or neutral faces for an identity judgment (ongoing task). A different number of faces, depending on low vs. high levels of PML, served as PM targets. The results showed better PM performance following negative than neutral targets, but only under low levels of PML. This indicates that the bottom-up facilitation driven by negative stimuli serving as PM targets dramatically depends on the available attention resources allocated for monitoring the incoming information.

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Emotion; prospective memory; face processing; attentional monitoring; prospective memory load



## Introduction

Event-based prospective memory (PM) refers to the ability to remember and perform a previously programmed action upon the occurrence of a designated target event, which indicates the appropriate situation to execute the intended action (Einstein et al., 2005). It is by now well established that PM is articulated into a "retrospective" and a "prospective" component (Cohen, Dixon, Lindsay, & Masson, 2003). The retrospective component is related to the memory of the specific action and situation in which the action must be performed. By contrast, the prospective component is related to the ability to retrieve the intention of performing that action at the appropriate situation, which is thought to depend on strategic attentional control, such as planning, environment monitoring, self-initiation retrieval of intentions (Smith & Bayen, 2004). However, whether attentional resources are mandatorily required to perform a PM task or there are circumstances in which the recovery of PM intentions does not need of any attentional preparation is still a matter of debate (McDaniel, Umanath, Einstein, & Waldum, 2015; Smith & Bayen, 2004).

According to the Preparatory Attentional and Memory model (PAM, Smith & Bayen, 2004), retrieval is resource-demanding, irrespective of stimulus distinctiveness (or saliency). That is, attentional resources are always needed to notice a cue that may activate a PM intention, and failures occur when resources are not enough to perform both the ongoing and prospective tasks. Several task requirements were shown to influence the PM performance. For instance, an increasing number of targets relevant for the pending PM task (i.e. the "PM load" (PML); Kidder, Park, Hertzog, & Morrell, 1997; Meier & Zimmermann, 2015), typically interfere with the ongoing task (OT) performance, with participants compensating the increased number of to-be-remembered targets by devoting more resources to the PM than to the OT (Einstein et al., 2005).

However, there might be specific circumstances under which processing of PM targets can elicit successful performance without using any attentional

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and/or preparatory resource, e.g. when targets are highly salient. Indeed, highly salient targets typically led to high levels of PM retrieval, even when preparatory attention is not deployed (Harrison & Einstein, 2010). A theoretical account that may explain these results is provided by the dual process framework proposed by McDaniel et al. (2015): successful PM performance can occur due to spontaneous retrieval triggered by the PM targets or as a consequence of strategic monitoring (following increased top-down attentional control). Highly salient PM targets would automatically and spontaneously activate prospective retrieval, while not salient stimuli would require strategic monitoring and, thus, intentional retrieval (Einstein et al., 2005). In agreement with this view, a number of previous studies demonstrated that salient targets can enhance PM performance without the need of attentional resources (Cohen et al., 2003).

In emotion research, it has often been argued that social and biological relevant stimuli, such as emotional (mostly negative) facial expressions, are highly "salient" and then prioritised over emotionally neutral information (Öhman, Lundqvist, & Esteves, 2001). The increased saliency of negative stimuli might affect both perceptual and post-perceptual processes (Pedale & Santangelo, 2015; Santangelo & Macaluso, 2013; see, for a review, Santangelo, 2015). Accordingly, people are typically faster in detecting (Öhman et al., 2001) and slower in disengaging attention from angry than from neutral or happy faces (Belopolsky, Devue, & Theeuwes, 2011). Negative stimuli can enhance visual processing (Schupp, Markus, Weike, & Hamm, 2003) and are also remembered better than neutral stimuli in retrospective memory tasks (Buchanan & Adolphs, 2004). Consequently, it is reasonable to expect that negative stimuli, acting as highly salient stimuli, would enhance PM performance as well.

The few studies that have explored the impact of emotional targets on PM performance confirmed this expectation (May, Owens, & Einstein, 2012; May, Manning, Einstein, Becker, & Owens, 2015; Schnitzspahn, Horn, Bayen, & Kliegel, 2012). However, these studies neglected whether the emotional enhancement is affected by the current level of PML. This manipulation may shed light on whether the capability of negative and/or threatening stimuli in capturing attention is automatic or depends on available processing resources (Pessoa, 2005). The "traditional" view posits that processing threatening stimulus is automatic (Vuilleumier, Armony, Driver, & Dolan, 2001). By contrast, the "competing" view proposes that threatening stimuli, in spite of their privileged access to attention, compete with all the other stimuli therefore requiring available attentional/processing resources (Pessoa, 2005). An increased PML (i.e. an increased number of PM targets) would increase task demands (Einstein et al., 2005), therefore allowing to properly test for the automaticity of negative stimuli in triggering PM intentions.

Here we assessed the impact of emotional PM targets under variable levels of PML. We presented participants with pairs of faces, being either angry or neutral. During the OT, participants had to judge whether the two faces were the same or different. Upon the occurrence of certain target faces (one or two previously studied target faces, according to the low or high level of PML), participants had to refrain from responding to the same/different task and instead press another response button (i.e. the PM task). The target face could appear with either neutral or angry facial expression. If the facilitation for negative PM targets were automatic and independent by the current availability of monitoring/processing resources (Vuilleumier et al., 2001) we would expect that negative targets, being more emotionally salient than neutral targets, enhance PM performance irrespective of the current level of PML. In contrast, if the facilitation for negative stimuli were not automatic (Pessoa, 2005), we would expect that a certain amount of processing resources is necessary to achieve successful PM performance also with negative targets. In this latter case we would expect that high PML, exhausting a greater amount of attention resource, reduces the facilitation effect driven by negative targets on PM performance.

## Methods and materials

### *Participants*

Twenty-two healthy volunteers (10 males) between the age of 20 and 31 ($M = 22.7$; $SE = 4.8$) participated in the main experiment, while 12 volunteers (6 males) between the age of 19 and 31 ($M = 24.6$; $SE = 7.1$) took part to a control experiment (see below). All participants had normal or corrected-to-normal vision. They all gave written informed consent and were naïve to the main purpose of the study, which was conducted in accordance with the principles of the Declaration of Helsinki.

### Stimuli and materials

The stimuli derived from the "Karolinska Directed Emotional Faces" database (KDEF; http://www.ki.se/cns/news/AKDEF-e.html). We selected 128 coloured photographs showing faces with a negative (angry) or a neutral expression, belonging to 64 actors (32 males). All images were modified using CorelDraw Graphics Suite (v. 12, Corel™) to achieve uniform face size. To minimise residual variance effect related to secondary attributes we removed hair by superimposing to each face an oval mask (see Figure 1A). Actors serving as PM targets were randomly selected for each participants among the pool of actors: One target actor or two target actors depending on low or high level of PML. The gender of the target actor in the low PML block was randomised across participants, while in the high PML block the two target actors were one male and one female.

### Procedure

Stimulus presentation and response collection were accomplished through Cogent2000 Toolbox (Wellcome laboratory of Neurobiology, University College London), implemented on MatLab 7.1 (The MathWorks Inc., Natick, MA). Prior to start the experiment participants practised with a short training session including 15 trials to familiarise with either the main or the control experiment.

The main experiment consisted of two blocks of trials, each including a different level of PML (low vs. high). Each block of trials was preceded by a study phase, in which the target actor(s) was(were) presented simultaneously with neutral and angry emotional expression (resulting in two to-be-studied pictures in the low PML block and four to-be-studied pictures in the high PML block; Figure 1A). Participants had unlimited time to study the PM target stimuli and each experimental block

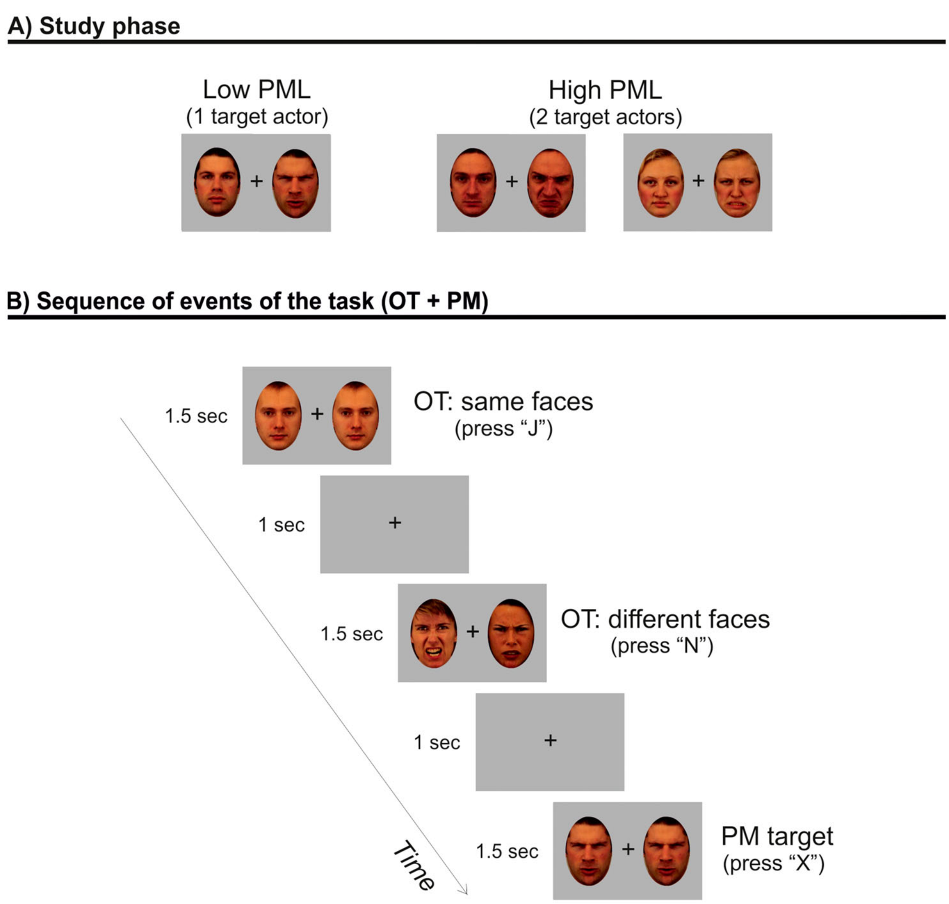


**Figure 1.** (A) Study phase involving the memorisation of one or two target actor(s), depending on the current level of the PML (low vs. high). Each target actor was displayed with both neutral and angry emotional expression. (B) Example of sequence of events during the task, consisting of the OT and the PM task. Each trial involved the presentation of a pair of either neutral or angry faces, displayed for 1.5 s, with an inter-trial interval of 1 s. [To view this figure in colour, please see the online version of this journal.]

began only when they were ready to start. The sequence of events in the experimental block is illustrated in Figure 1B. Each trial consisted in a pair of faces (randomly selected from the entire pool of faces) displayed on a grey background for 1.5 s, with 1 s of inter-trial interval between each pair of faces. The two faces were placed on the left and right side of a fixation cross. Each face was displayed with a visual angle of 18 × 12°. Responses to the OT were "J" or "N" on a keyboard with either the middle or index finger of the right hand according to whether the two faces in the current pair were the same or not. Each pair of faces was always presented with the same emotional expression, either angry or neural. As an additional constraint, the two faces of each pair belonged to the same gender thus to avoid any confound in the identity discrimination task.

The PM task consisted in detecting the target faces (one or two faces according to the PML, with two expressions each; Figure 1A) presented in the study phase, irrespective of their emotional expression. Target presentation was equally distributed in the "same" (both faces of the pair consisted on the target face) or "different" condition (only one of the two faces consisted on the target face), i.e. 12 PM target events each. In the "different" condition, the appearance of the target was equally distributed on the left and right side of the fixation cross (six targets on the left and six on the right side). When the PM target occurred participants were instructed to interrupt the "same vs. different" face discrimination task and press the "X" letter on the PC keyboard with the index finger of their left hand (Figure 1B).

The order of the low and high PML block was counterbalanced across participants. Each block lasted approximately 19 min, and included 456 trials: 432 OT (94.74%) and 24 PM trials (5.26%). The interval between PM trials ranged between 30 s and 1 min. Between each block the participants were allowed to rest until they were ready to proceed. After the PM task, participants also performed other tests to measure working memory capacity and completed some questionnaires on anxiety and depression, but these results were not the purpose of the current study.

Along with the main experiment, we also designed a control experiment to provide a baseline measure for disentangling the contribution of the PM on the OT. This consisted of 2 blocks of 456 trials counterbalanced across participants: (1) a "baseline" block in which participants performed the OT as in the main experiment without any PM task; and (2) a low PML block that was exactly the same as that used in the main experiment.

### Data analysis

The reaction time (RT) and the accuracy data derived from the ongoing and the PM task of the main experiment were analysed using two separate 2 × 2 × 2 mixed analysis of variance (ANOVA). These included the within-subject factors of Face valence (negative vs. neutral) and PML (low vs. high), and the between-subjects factor of Order of block presentation (low PML first vs. high PML first). This latter factor was included to control for carry-over effects due to the block order (Boywitt & Rummel, 2012). Similar 2 × 2 × 2 mixed-ANOVAs were used to analyse RT and accuracy data derived from the OT in the control experiment, including the within-subject factors of Condition (baseline vs. low PML) and Face valence (negative vs. neutral), and the between-subjects factor of Order of block presentation (baseline first vs. low PML first). RT and accuracy differences in the PM task depending on Face valence (negative vs. neutral) were analysed by means of paired sample *t*-tests. All the analyses were carried out with SPSS (Statistical Package for Social Science) v. 13.

## Results

### Main experiment

#### Ongoing task (OT)

The ANOVA on the RTs revealed a main effect of PML [$F(1, 20) = 21.78$, $p < .001$, $\eta^2 = 0.521$], indicating slower RTs under conditions of high PML ($M = 934$, $SE = 18$, 95% confidence intervals (CI) [897, 971]) than under conditions of low PML ($M = 889$, $SE = 19$, 95% CI [849, 930]); compare bars 3 and 4 vs. bars 1 and 2 in Figure 2A, right graph. Similarly, the ANOVA on the accuracy data revealed a main effect of PML [$F(1, 20) = 4.61$, $p = .044$, $\eta^2 = 0.187$], indicating higher accuracy under conditions of low PML ($M = 94.7$, $SE = 0.8$, 95% CI [93.1, 96.3]) than under conditions of high PML ($M = 93.1$, $SE = 0.9$, 95% CI [91.2, 95]); compare bars 1 and 2 vs. bars 3 and 4 in Figure 2A, left graph. Both results confirm that our manipulation on PML was efficient in modulating the availability of attention resources, and indicate a likely increase in monitoring/attentional

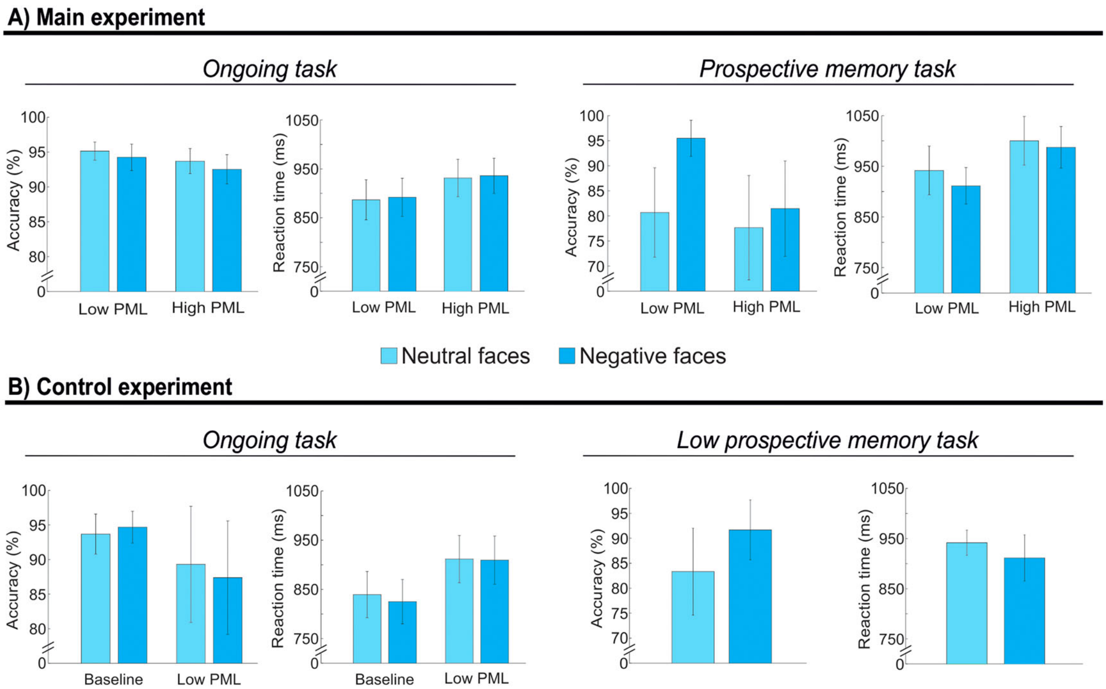


**Figure 2.** (A) Mean accuracy and mean RT in the OT (left panel) or in the PM task (right panel) for neutral or angry pairs of faces under low or high PML in the main experiment. (B) Mean accuracy and mean RT in the OT (left panel) or in the PM task (right panel) for neutral or angry pairs of faces at the baseline or under low PML in the control experiment. In all graphs, the error bars represent 95% CI. [To view this figure in colour, please see the online version of this journal.]

requirements when participants had to detect more PM targets (see, for consistent findings, Einstein et al., 2005). These effects were modulated by the order of block presentation, as evidenced by a significant interaction between PMLand order both on the RT and accuracy data ([$F(1, 20) = 25.79$, $p < .001$, $\eta^2 = 0.563$] and [$F(1, 20) = 217.35$, $p < .001$, $\eta^2 = 0.476$], respectively). These results indicate that starting the experiment with the high load block decreased RTs and increased the accuracy of the OT at the following low load block to a greater extent ("high PML first" minus "low PML first" = 92 ms, $p < .001$, −4.4%; $p < .001$) than the opposite order, in which task difficulty increased across blocks("low PML first" minus "high PML first" = 4 ms, $p = .774$, −1.6%; $p = .151$; Table 1).

Additionally, the ANOVA on the accuracy data revealed a main effect of faces valence [$F(1, 20) = 4.77$, $p = .041$, $\eta^2 = 0.192$], indicating that the "same vs. different" discrimination task was carried out

**Table 1.** Mean RTs and accuracy (ACC) ± 95% CI at the OT following neutral (N) or emotional (E) pairs of faces under conditions of high or low PML. Results are divided according to the order of block presentation for both the main and control experiment.

| | Main experiment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Low PML first | | | | High PML first | | | |
| | Low PML | | High PML | | High PML | | Low PML | |
| | OT_N | OT_E | OT_N | OT_E | OT_N | OT_E | OT_N | OT_E |
| RTs (ms) | 922 ± 63 | 924 ± 62 | 916 ± 70 | 922 ± 63 | 947 ± 43 | 949 ± 44 | 852 ± 54 | 859 ± 50 |
| ACC (%) | 93.9 ± 2.1 | 91.9 ± 3.2 | 94.7 ± 2.1 | 94.3 ± 2.7 | 92.7 ± 3.1 | 90.7 ± 3.3 | 96.3 ± 1.5 | 96.5 ± 1.5 |
| | Control experiment | | | | | | | |
| | Baseline first | | | | Low PML first | | | |
| | Baseline | | Low PML | | Low PML | | Baseline | |
| | OT_N | OT_E | OT_N | OT_E | OT_N | OT_E | OT_N | OT_E |
| RTs (ms) | 838 ± 81 | 822 ± 78 | 924 ± 84 | 928 ± 80 | 894 ± 64 | 884 ± 76 | 841 ± 74 | 829 ± 69 |
| ACC (%) | 95.2 ± 2.7 | 95.8 ± 2.1 | 92.8 ± 3.7 | 90 ± 3.6 | 84.4 ± 24.9 | 83.7 ± 24.9 | 91.6 ± 7.5 | 93.2 ± 6.2 |

more accurately for pairs of neutral ($M = 94.4$, $SE = 0.7$, 95% CI [92.7, 95.9]) rather than angry faces ($M = 93.4$, $SE = 1$, 95% CI [91.4, 95.4]); compare bars 1 and 3 vs. bars 2 and 4 in Figure 2A, left graph. However, also this effect was modulated by the order of block presentation, as evidenced by the significant interaction between valence, PMLand order [$F(1, 20) = 19.38$, $p = .020$, $\eta^2 = 0.243$]. This suggests that the interference elicited by angry faces on the "same/different" discrimination task was greater in the first blocks of trials ($p = .021$ and $p = .044$) than in the second blocks of trials ($p = .796$ and $p = .661$). This effect was not affected by the current level of load (see Table 1), indicating the need of practice to copy with the distraction triggered by emotional faces. No other significant effects were observed in the two ANOVA tests (all $F$s < 1.29; all $p$s > .270).

### PM task

The ANOVA on the RT data revealed a main effect of PML [$F(1, 20) = 13.86$, $p < .001$, $\eta^2 = 0.409$], indicating slower response time in the high ($M = 994$, $SE = 21$, 95% CI [949, 1,038]) than in the low PML block($M = 927$, $SE = 20$, 95% CI [884, 969]; compare bars 3 and 4 vs. bars 1 and 2 in Figure 2A, right graph, irrespective of the emotional valence of the target faces. This result may indicate a possible cost in detecting PM targets under conditions of high PML, as a consequence of the increased number of to be monitored and maintained targets. The analysis of the accuracy data also revealed a main effect of target valence [$F(1, 20) = 11.08$, $p = .003$, $\eta^2 = 0.356$]. This finding highlights an overall emotionally-related enhancement of PM performance, with higher accuracy in detecting negative ($M = 88.4$, $SE = 3.1$, 95% CI [81.9, 95]) than neutral target faces ($M = 79.2$, $SE = 4.6$, 95% CI [69.6, 88.8]; compare bars 2 and 4 vs. bars 1 and 3 in Figure 2A, left graph). Crucially, this effect was due to the low PML block as evidenced by a significant interaction between target valence and PML [$F(1, 20) = 4.82$, $p = .040$, $\eta^2 = 0.194$]. This interaction highlights performance differences in detecting angry vs. neutral target faces only under conditions of low PML (mean difference = 14.8%, $p = .002$), but not under conditions of high PML (mean difference = 3.8%, $p = .254$; compare bar 2 minus 1 vs. bars 4 minus 3 in Figure 2A, left graph). Overall, these findings may indicate that as attention resources are allocated in maintaining and controlling for target-related information, bottom-up facilitation driven by negative stimuli serving as PM targets vanishes. No other significant effects were observed in the two ANOVAs (all $F$s < 3.04; all $p$s > .097).[1]

### Control experiment

The control experiment was designed to highlight the impact of PM task on the OT performance. The ANOVA on the RT data derived from the OT revealed a main effect of condition [$F(1, 10) = 13.01$, $p = .005$, $\eta^2 = 0.565$], indicating faster response latencies in the baseline ($M = 832$, $SE = 21$, 95% CI [786, 878]) than in the block in which participants had also to perform the PM task ($M = 911$, $SE = 22$, 95% CI [864, 959]; compare bars 1 and 2 vs. bars 3 and 4 in Figure 2B, right graph). This confirmed an interference effect elicited by the additional monitoring required by the PM task, producing detectable cost on the "same vs. different" discrimination task. The ANOVA also revealed a main effect of face valence [$F(1, 10) = 5.81$, $p = .037$, $\eta^2 = 0.367$], with shorter RTs following emotional ($M = 867$, $SE = 21$, 95% CI [828, 923]) than neutral faces ($M = 875$, $SE = 21$, 95% CI [820, 914]); compare bars 2 and 4 vs. bars 1 and 3 in Figure 2B, right graph. The analysis of the accuracy data revealed a significant interaction between face valence and condition, [$F(1, 10) = 6.10$, $p = .033$, $\eta^2 = 0.379$]. This indicated that the "same vs. different" discrimination task was carried out more accurately for pairs of angry faces ($M = 94.7$, $SE = 1$, 95% CI [92.4, 97]) rather than neutral faces ($M = 93.7$, $SE = 1.3$, 95% CI [90.7, 96.6]) in the baseline block; but the opposite pattern - higher

[1]Additionally, we controlled whether load manipulation was confounded by stimulus repetition, i.e. while in the low PML block the same target face was presented 24 times, in the high PML block the 2 target faces were presented 12 times each. Accuracy and RT data derived from the 24 PM targets were divided into 4 equal parts, including 6 sequential PM targets each (i.e. from PM target no. 1 to PM target no. 6; from PM target no. 7 to PM target no. 12; etc.). These data were entered into two 2 × 4 ANOVAs (one for the accuracy and one for the RT data), including the within-subject factor of PML (low vs. high) and PM target presentation (in the first, second, third, or fourth part of the block). If the greater number of target repetitions in the low PML block affected differently retrieval of PM intentions, we would expect an interaction between the two factors. This would indicate enhanced performance in detecting PM targets from the beginning to the end of the block selectively for the low load condition, which included more target repetitions. However, we just found a main effect of PM target presentation (accuracy: [$F(1, 21) = 5.05$, $p = .036$; $\eta^2 = 0.194$]; RT: [$F(1, 21) = 35.08$, $p < .001$; $\eta^2 = 0.626$]), but not other significant effects (all $F$s < 0.928; all $p$s > .346). These results revealed increased performance in detecting PM targets along the block, irrespective of the PML condition (i.e. irrespective of the current amount of stimulus repetition). The absence of the interaction between the two factors also ruled out the possibility that an increased number of targets in the high PML condition resulted in an increased effort to monitor for the targets along with the duration of the block.

accuracy for pairs of neutral faces ($M = 89.3$, $SE = 3.8$, 95% CI [80.9, 97.7]) rather than angry faces ($M = 87.4$, $SE = 3.7$, 95% CI [79.2, 95.5]) - was found when participants were involved in the PM task (compare bar 2 minus 1 vs. bars 3 minus 4 in Figure 2B, left graph). This result suggests that the facilitation vs. interference effect for emotional stimuli was related to the specific task demand, with a detrimental impact of the PM task on the OT performance. No other significant effects were observed in the two ANOVAs (all $Fs < 3.55$; all $ps > .089$).

Finally, the *t*-test on the accuracy data derived from the low PM task replicated the emotionally related enhancement observed in the main experiment during the low PML condition [$t(11) = -2.87$, $p = .015$, $d = 0.829$], with higher accuracy in detecting negative ($M = 91.7$, $SE = 2.7$, 95% CI [85.7, 97.7]) than neutral target faces ($M = 83.3$, $SE = 3.9$, 95% CI [74.6, 92.1]); see Figure 2B, left graph. Accordingly, negative PM targets were detected faster ($M = 860$, $SE = 21$, 95% CI [814, 906]) than neutral targets ($M = 895$, $SE = 12$, 95% CI [869, 920]); see Figure 2B, right graph, although this effect was not statistically significant ($t(11) = 2.05$; $p = .065$, $d = 0.592$). These results substantially replicated the bottom-up facilitation driven by negative stimuli serving as PM targets in the low PML condition observed in the main experiment.

## Discussion

The main aim of the current study was to investigate whether negative targets enhance the recovery of intentions in an event-based PM task and whether this effect was automatic or modulated by the current PML (i.e. by the amount of information relevant for the pending PM task). Our results revealed an effect of emotional valence (angry vs. neutral) on both the ongoing and PM performance.

In the OT, participants were more accurate in discriminating "same vs. different" angry than neutral faces but only when they did not perform the concurrent PM task, within the baseline task (cf. control experiment). Conversely, doing both tasks in the same block yielded a reverse pattern of performance with higher accuracy in discriminating "same vs. different" neutral than angry faces. At the same time, the inclusion of the PM task yielded a decrease in the OT performance. These findings are therefore in agreement with the notion that negative emotional stimuli are efficient for OT performance only under conditions of low task demands (Pessoa, 2005).

This view is consistent with the current pattern of results during the PM task in the main experiment (cf. the interaction between target valence and PML). Here we show for the first time that boosting of PM intentions by negative targets considerably depends on the current level of PML. The enhancement of PM performance following negative targets resulted under a low but not a high level of PML (Figure 2A, right panel, left graph). This suggests that under a low level of PML the saliency (or distinctiveness) of negative targets may have reduced the need for deliberate monitoring, thus improving PM performance (Einstein et al., 2005; see also for consistent results May et al., 2012; May et al., 2015; Schnitzspahn et al., 2012). However, under conditions of high PML the facilitation for negative stimuli serving as targets on the recall of intentions entirely vanishes, suggesting that the "saliency" of negative stimuli may be subordinated to the availability of attention resources (Pessoa, 2005).

These findings might contribute to the debate concerning whether the capacity of negative and/or threatening stimuli in capturing attention is automatic (traditional view; Vuilleumier et al., 2001) or rather depends on available attention resources (competing view; Pessoa, 2005). In the latter case, negative stimuli are assumed to access perceptual and post-perceptual processes prior than neutral stimuli, but they necessitate (at least) a certain amount of available resources to be processed. This is in agreement with the existence of efficient top-down regulation mechanisms of emotional processing (Ochsner & Gross, 2005). When all attention and processing resources are devoted to a high-demanding task it is possible that emotional information is not detected at all (Pessoa, 2005). Our findings seem to support this latter view by demonstrating that threatening stimuli (i.e. angry faces) have a prioritised access to attention, but only under low PML. In the lower demanding condition, negative stimuli easily captured participants' attention, promoting the spontaneous retrieval of PM intentions. Nevertheless, when an increased level of PML required the deployment of more attention and monitoring resources, negative targets were less efficient in facilitating the recovery of PM intentions, evidencing a decreased impact of emotionally negative stimuli on PM performance.

The decreasing of emotional capture under high PML may also provide support for the dual process hypothesis, which posits that successful PM requires capacity-consuming intentional retrieval at high levels of task demands (McDaniel et al., 2015). In accordance with this account, under high levels of PML participants would devote more attention resources in maintaining and checking for a higher number of targets with the probable consequence of having fewer attention resources available to detect PM targets, irrespective of their emotional nature. Specifically, the "suppression" of emotional salience under high PML, might originate from two different but co-occurring causes that reasonably contributed to exhaust participants' attention resources (Guynn, 2008). First, the need of maintaining an increased number of targets in memory in the high PML blockcould have affected the retrieval mode mechanism. Second, the increased number of targets required additional strategic monitoring for target detection during the whole duration of the task, impairing the target checking mechanism. Both factors can here have jointly contributed to suppress the emotional enhancement occurred instead under a low level of PML.

In conclusion, our results provided additional support to the notion that negative targets can enhance PM performance, revealing however that this effect is not automatic. It rather depends on current task demands, supporting the idea that the facilitation for negative stimuli in triggering PM intentions requires available attention resources, which are drastically reduced under increased task demands.

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