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Running head: Metacognition, threat and worry

Relationships between metacognitive beliefs, social evaluative threat and worry

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1. Introduction

Cognitive tasks that are carried out under significant time pressure and result in attentional overload are a well-known source of stress states (Matthews, Campbell, Falconer, Joyner, Huggins, Gilliland, ... Warm, 2002; Matthews, Szalma, Panganiban, Neubauer, & Warm, 2013; Matthews, 2016). Stress state is defined as an internal tension felt when a person appraises his/her environment as “*taxing or exceeding his or her resources and endangering his or her well being*” (Lazarus & Folkman, 1984, p.19). The task-induced stress state is a multidimensional phenomenon labeled subjective stress state comprising affective (*distress*), motivational (*task engagement*) and cognitive (*worry*) dimensions (Matthews, Hillyard & Campbell, 1999). Each dimension corresponds to a cluster of stress-related outcomes (Matthews et al., 1999). For example, *distress* corresponds to the mood dimension, which provides the context for psychological functioning. It encompasses affective outcomes related to low hedonic tone, tension, confidence and perceived control. *Task engagement* corresponds to the motivational dimension, in particular high energetic arousal, task motivation and concentration (Matthews, Warm, Reinerman-Jones, Langheim, Washburn, & Tripp, 2010). Finally, *worry* corresponds to the cognitive dimension. It refers to self-referent beliefs, negative ideation, cognitive interference, and the use of perseverative rumination as a form of coping (Matthews et al., 1999).

Subjective stress states are thought to emerge from the interplay between the three levels of cognition embedded in the Self-Regulative Executive Function (S-REF) model (Wells & Matthews, 1994). The first (lowest) level is composed of a network of elementary processing units in which environmental stimuli undergo automatic, low-level processing (Wells & Matthews, 1994). For example, working memory (WM) tasks increase task engagement as they force participants to maintain a high level of effort in order to compensate for processing inefficiency. Conversely, monotonous vigilance tasks elicit a loss of

motivation, energy and a decrease in task engagement. Both WM and vigilance tasks require participants to maintain effort to manage tasks demands, and Matthews et al. (2002) evidenced that workload correlates highly with posttask distress. They argued that distress corresponds to the Hockey's (1997) overload mode combining tension, cognitions of lack of confidence and negative mood, hence high resource demanding tasks (e.g., WM and vigilance tasks) are expected to increase distress (Trouillet, Doron & Combes, 2016). On the other hand, they decrease worry because, in laboratory settings, participants are asked to follow a protocol determined by the experimenter. Therefore, such tasks are not perceived as a source of threat (Matthews et al., 2002).

The second level of the S-REF corresponds to executive functions. Consistent with the transactional model of stress (Lazarus & Folkman, 1984), executive functioning can be engaged by intruding beliefs resulting from the processing of social, psychological or physical threats. The role of executive functions is to appraise and regulate intrusive thoughts, in order to reduce perceived threats. This executive activity is ensured by two, main metacognitive functions: *monitoring* (the allocation of vigilance to information flowing from lower-level units); and *control* (coping processes that control or enable the strategic modification of information resulting from the monitoring activity). This metacognitive activity is guided by a third level, in which self-referent knowledge (e.g., metacognitive beliefs) is stored in long term memory. Metacognitive beliefs, as evaluated by the Metacognitions Questionnaire (MCQ) (Cartwright-Hatton & Wells, 1997), in particular, contribute to the appraisal and regulation of affective states (Wells & Matthews, 1996; Wells, 2000). For example, positive beliefs about worry, and general, negative beliefs about thoughts increase worry. Negative beliefs about the uncontrollability of thoughts and corresponding danger are positively related to distress dimension and they amplify the effect of environmental demands on distress dimension. Task engagement dimension is negatively related to a lack of confidence in one's

memory and concentration capacities (i.e., cognitive confidence) and positively related to negative beliefs about the need to control thoughts and the harmful consequences of not controlling them (i.e. SPR) (Cook, Salmon, Dunn, Holcombe, Cornford, & Fisher, 2015; Matthews et al., 1999; Roussis & Wells, 2008; Spada, Mohiyeddini, & Wells, 2008a; Spada, Nikčević, Moneta, & Wells, 2008; Trouillet et al., 2016).

To the best of our knowledge, only one study (Trouillet et al., 2016) has estimated the interaction between environmental demands and metacognitive beliefs on subjective stress state dimensions, as hypothesized by the S-REF model. The authors report that worry dimension was not significantly related to environmental demands, but was related to several metacognitive beliefs. Task engagement dimension was explained by both environmental demands and participants' metacognitive beliefs, while distress was the only dimension explained by the interplay between environmental demands and one form of metacognitive beliefs (negative beliefs about the uncontrollability of thoughts and corresponding danger). The latter study concluded that metacognitive beliefs and environmental demands were independent predictors of subjective stress state dimensions – with the exception of distress dimension. However, they underlined that their research was limited by the nature of the tasks they employed. Specifically, they used experimental tasks that were not appraised as threatening to the self (Matthews et al., 2002).

Against this background, in this study we examined the effect of metacognitive beliefs on the relationship between environmental demands and subjective stress state dimensions, in an experiment where participants were asked to complete an effortful task in a threatful context (Trouillet et al., 2016). We decided to focus on the relationship between metacognitive beliefs, task demands and worry dimension because previously-published results about worry are intriguing. Both Matthews et al. (2002) and Trouillet et al. (2016) used a complex WM task where each item consisted of a simple equation and a recall word.

Participants were asked to check whether the result of each equation was correct or not, and to memorize the word printed above the equation. Time pressure was increased by reducing the amount of time available to respond to each item – from six seconds (in initial trials) to three seconds (the last trials). Tasks performed under such time constraints are perceived as less controllable (Dickerson & Kemmeny, 2004), while less-manageable tasks are a source of worry. Moreover, a decline in cognitive control over a task increases uncertainty (Mushtaq, Bland & Schaefer, 2011). It has been shown that an increase in uncertainty intolerance is a risk factor in the worry process (for a review, see Behar, Dobrow DiMarco, Hekler, Molhman & Staples, 2009). Therefore, we could expect participants to report an increase in worry as they completed complex tasks under more demanding time constraints. How can we explain that neither Matthews et al. (2002), nor Trouillet et al. (2016) found such a result? This is the first issue addressed in our current research.

Furthermore, the Metacognitive Model (MCM) of Generalized Anxiety Disorder (GAD) predicts that worry can be explained by the interplay between environmental demands and metacognitive beliefs. This model differentiates two forms of worry. *Type 1* is reported when individuals face triggers (i.e., intrusive negative thoughts about external events, social or health-related concerns), and hold positive beliefs about worry (i.e., worrying is useful) (Wells, 2009). In this scenario, when negative beliefs about worry are activated, individuals start to worry about their worry. This ‘meta’ worry is coined *Type 2* worry, and is used to distinguish GAD patients from non-clinical individuals (Wells, 2005). As Trouillet et al. (2016) recruited non-clinical participants, we can assume that their complex WM task elicited Type 1 worry. According to the MCM, both triggers and positive metacognitive beliefs can explain Type 1 worry. In addition, the S-REF model postulates that the worry dimension is produced by the interaction between metacognitive beliefs and the processing of environmental demands, in order to appraise their personal significance (Wells & Matthews,

1994). How can we explain the fact that the results published by Trouillet et al. (2016) did not support this hypothesis? This is the second issue addressed by our research.

We argue that these two hypotheses are not supported by previously-published studies because the latter were based on non-threatening, experimental cognitive tasks. The worry process appears to be initiated by the detection of a potential threat, triggered by a stimulus (Matthews & Funke 2006) and, more specifically, by sources of social evaluative threat (Matthews & Wells, 1999). The processing of this stimulus is influenced by attentional processes, and worry increases when the processing of threat stimuli is prioritized. Once a stimulus is detected, it is appraised in order to encode its personal significance. The transactional model of stress (Lazarus & Folkman, 1984) argues that the person starts by appraising the threat posed by a stimulus and, subsequently, appraises his/her capability to cope with it. The appraisal of the external, potentially-threatening stimulus is guided by self-knowledge; the aim is to adapt to external demands and reevaluate the personal relevance of the situation. Metacognitive beliefs about worry are key components of the worry process, as positive beliefs about the utility of worry can drive ongoing worry via an internal feedback loop (Matthews & Junke, 2006). Therefore, an interesting question is whether the effect of the interaction “*metacognitive beliefs x environmental demands*” is to increase worry dimension measures when the task is appraised as a source of social evaluative threat. To the best of our knowledge, no experimental studies have addressed this issue.

We needed to identify the main characteristics of a threatening experimental task, likely to increase worry. We therefore based our research on the results of the meta-analysis carried out by Dickerson & Kemeny (2004). Their objective was to delineate the main conditions eliciting a cortisol response. The cortisol response is a biomarker of stress, and a reliable measure of hypothalamus-pituitary-adrenal axis adaptation to stress (Hellhammer, Wüst & Kudielka, 2009). They categorized stressors into five types: 1) public speaking/ verbal

interaction tasks (e.g. participants have to deliver a prepared speech on an assigned topic); 2) cognitive tasks (e.g., WM or Stroop tasks); 3) public speaking/ cognitive task combinations; 4) emotion induction (e.g. the presentation of emotion-eliciting material); and 5) noise exposure tasks (e.g., participants were exposed to jet engine noise). A second observation was that stressors elicited a higher level of response in laboratory settings when an aspect of the self could be negatively judged by others (i.e. social evaluative threat). A typical protocol involved recording the participant's performance and the presence of a critical audience during the experiment. Finally, uncontrollability was identified as a third source of stress. Uncontrollability is elicited when participants are asked to complete impossible tasks (e.g., impossible anagrams), tasks are performed under time constraints, or when they receive incorrect feedback that they performed poorly. In sum, Dickerson and Kemeny (2004) argued that the cortisol response was mainly explained by two characteristics: outcome uncontrollability and social evaluative threat, which were stronger predictors of the cortisol response than the type of task.

These principles have been embedded in the Trier Social Stress Test (TSST), which consists of public speaking (participants have to convince a committee that he/ she is the perfect applicant for his/ her 'dream job'), and five-minute mental arithmetic task (they are asked to serially subtract the number 17 from 2043 as fast, and as accurately as possible) (Kirschbaum, Pirke, & Hellhammer, 1993). Het, Rohleder, Schoofs, Kirschbaum and Wolf (2009) compared results from the TSST with a placebo version of the test. As expected, they found that post-task cortisol levels increased after the TSST and participants perceived the task as more threatening and challenging.

Participants in our study were asked to complete a WM task that exceeded their processing capacity and represented a high workload (Matthews et al., 2002; Trouillet et al., 2016). Half completed the task in a threatening context that combined outcome uncontrollability

and social evaluative threat (Dickerson & Kemeny, 2004; Het et al., 2009). The other half completed the task in a context where stressors were removed (the neutral, control context). This procedure was designed to test several hypotheses.

The first question concerned the effect of sources of threat on worry. In order to ensure that the threatful context increased worry, change over time in worry, distress and task engagement dimensions were estimated. We investigated the main effect of time on subjective stress state dimensions by comparing their pre- and post-task measures in threatful and control contexts. Specifically, we predicted a decline in worry dimension scores, but an increase in task engagement and distress dimensions scores (Matthews et al., 2006; Trouillet et al., 2016). The second hypothesis concerned the effect of the *time x context* interaction on subjective stress state dimensions. We predicted that post-task measures of worry dimension would decline over time in the control context, but increase over time in the threatful context (Matthews, 2016). Distress and worry dimensions measures in WM tasks are assumed to be inversely correlated (Matthews & Campbell, 2010); therefore, we expected that the increase in distress dimension over time would be lower in the threatful context than the control context. Finally, we hypothesized that task engagement dimension would decrease in the threatful context. These hypotheses enabled to check our manipulation. We used distress dimension as a measured manipulation check variable because worry and distress dimensions are expected to change in opposite directions (Matthews & Campbell, 2010). High workload tasks are expected to force attention away from personal concerns and to increase distress (for a review, see Trouillet et al., 2016). Conversely, high workload tasks are expected to decrease worry dimension as participants have little at stake. Our threatful context was designed to initiate the worry process and to force attention towards internal self-related concerns (i.e., inward) rather than towards the task (i.e., outward). We therefore expected that the threatful context positively moderates the effect of *Time* on Worry dimension, and the context variable

varies in the way we expected when the threatening context moderates negatively of the effect of *Time* on Distress dimension.

The second issue addressed by our research concerned the effect of the *metacognitive beliefs x sources of threat* interaction on worry. The worry process relies on metacognitive beliefs; hence we anticipated that positive beliefs about worry, general negative beliefs about thoughts, and cognitive self-consciousness would be positively related with worry dimension (Cook et al., 2015; Matthews et al., 1999; Roussis & Wells, 2008; Spada et al., 2008a; Trouillet et al., 2016). Finally, we hypothesized that an increase in worry dimension in the threatening context would be consistent with measures of positive metacognitive beliefs about worry (i.e., interaction “*Metacognitive beliefs*Threatful context*” effect on worry) (Matthews & Junke, 2006).

2. Method

2.1. Participants

We recruited 174 students from Paul Valéry University Montpellier 3 with a mean age of 20.18 years (standard deviation = 2.03). We randomly divided participants into two subgroups. Group 1 (n = 87; 69 women, mean age = 20.46, SD = 1.78) completed the task in the threatening context; Group 2 (n = 87; 64 women, mean age = 19.91, SD = 2.20) performed the same task in the control context.

2.2. Assessments

2.2.1 Metacognitive beliefs

We used the French version of the MCQ (Larøi, Van der Linden, & d’Acremont, 2009), which assesses five metacognitive traits via 65 items noted on four-point Likert scale (from 1 “do not agree” to 4 “very much agree”). Traits assessed concern positive beliefs about worry – MCQ1 (19 items, e.g., “*Worrying helps me solve issues*”), negative beliefs about the uncontrollability of thoughts and corresponding danger – MCQ2 (16 items, e.g., “*Worrying is*

dangerous for me”), cognitive confidence – MCQ3 (10 items, e.g., “*I have a poor memory*”), negative beliefs about thoughts in general – MCQ4 (13 items, e.g., “*Not being able to control my thoughts is a sign of weakness*”), and cognitive self-consciousness – MCQ5 (7 items, e.g., “*I think a lot about my thoughts*”). Previous testing has shown that results from the French MCQ-65 are reliable (Cronbach’s α ranges between .65 and .87) and provide valid measures of metacognitive traits (Larøi et al., 2009). In this research, Student *t*-tests did not reveal any significant differences between participants enrolled in the threatful and control conditions with respect to these five metacognitive measures (absolute values of the *t*-test ranged from .14 to 1.81).

2.2.2. Subjective stress state dimensions

We used the French version of the Short Stress States Questionnaire (Trouillet et al., 2016) consisting of 24 items covering three subjective stress state dimensions. Trouillet et al. (2016) reported a low item whole correlation for the sixth item (pre-task and post-task form of the distress scale), the 2nd and 22nd items (pre-task and post-task form of the Task-Engagement scale), the 14th, 15th, 16th, and 18th items (pre-task and post-task forms of the worry scale). Removing these items improved the internal consistency. The score of Distress was obtained by summing the 1st, 3rd, 4th, 7th, 8th, 9th and 10th items. The score of Task Engagement was obtained by summing the 5th, 11th, 12th, 13th, 17th and 21th items. The score of Worry was obtained by summing the 19th, 20th, 23th and 24th items. All items are rated using five-point response scales. Pre- and post-task measures of subjective stress for the three states were obtained by asking participants to complete the SSSQ before and immediately after they carried out the task. Trouillet et al. (2016) report a three-factor solution that explains 49 % (pre-task version) and 54 % (post-task version) of the variance. They report that these three scales have good internal consistency (Cronbach’s α ranges from .70 to .83) and we replicated these results using our own data as we reported Cronbach’s α ranging from .70 to .86.

2.3. The complex WM task

We implemented the complex operation word span task (a WM task) used in previous studies (Matthews et al., 2002; Trouillet et al., 2016). This was because the task elicits both physiological (Gianaros, van der Veen, & Jennings, 2004) and psychological stress states (Matthews et al., 2002). Participants were asked to look at series of five items. Each item was displayed on a screen and consisted of a simple arithmetic equation, such as “ $(6/2) + 5 = 8?$ ” and a word to be recalled later. They were asked to check a box, printed on a sheet of paper, if the equation was correct, or to leave the box blank if the equation was incorrect. At the end of each series of five items, they were asked to write on the form, in order of appearance, the words presented with each calculation. The task consisted of sixteen blocks of five arithmetic equations and five neutral words (Syssau & Font, 2005), making a total of five words for each block. Time pressure was imposed by reducing the amount of time available to study each equation – from six seconds in the first block, to three seconds in the final block.

2.4. Procedure

A researcher welcomed participants to the laboratory. After obtaining the informed consent, each individual, working alone, completed the questionnaires in a quiet waiting room (pre-task version of the SSSQ and the 65-item version of the MCQ). Then, they were accompanied by the researcher to the room where the experiment was run and asked to sit at a table in front of a computer screen. A sheet of paper was placed on the table. They were asked to respond to the WM task using the form printed on the sheet of paper. A camera with a microphone was placed on the table in front of the participant.

Half of the participants (Group 1) completed the task in the condition designed to elicit social evaluative threat. As recommended by Dickerson and Kemmeny (2004), a two-person committee sat at a table to the right of the participant. Participants were not allowed to speak to the committee through the duration of the task. They were informed that they would be

recorded throughout the duration of the task to further analyze their verbal and non-verbal behaviors. The first committee member was introduced as a psychologist who was trained to monitor and analyze verbal and non-verbal behavior; the second member was the experimenter who sat in front of a computer with a fake USB connection to the computer used to run the task. The experimenter was close enough to the participant to be able to see what they wrote on the form.

The participant was told that the experimenter would record their responses using software that compared their responses to those of the average student. They were told that feedback would be provided on their screen in the form of a colored rectangle (7x 14 cm), via the USB connection, after each block of ten trials. A green rectangle would appear when their mean score was above average (positive feedback), while a red rectangle would appear when it was below average (negative feedback). This experimental design was expected to increase the credibility of feedback (Appelgren, Penny, & Bengtsson, 2014; Podsakoff & Farth, 1986). Feedback was displayed in a fixed order. Participants first received three negative feedbacks followed by one positive, one negative, one positive and, finally, two negative feedbacks. Most feedback was negative (red rectangle) because it has been shown to be a robust factor in creating a sense of uncontrollability over the task (Dickerson & Kemmeny, 2004). It is also a reliable method to induce an ego threat (Leary, Terry, Allen, & Tate., 2009). Most negative feedback was provided after the first and last block of trials, as information presented at the beginning and the end of a task tends to be better-retained (primacy and recency effects).

The remaining participants (Group 2) completed the same WM task in the control context, which was the same as the threatful context except that sources of social evaluative threat and uncontrollability were removed. Participants completed the task next to the experimenter, who sat at a table in front of a computer. They were told that the presence of the experimenter was unrelated to the task, and that the person was simply working on an

article. Colored rectangles (feedback) were replaced by neutral messages. Participants were told that a series of system file checks were planned for the computer running the task and that a message would be reported by the system after each check. This message consisted of a fake window (7 x 14 cm) that appeared on the screen showing the message “System check complete” (Helton, Dember, Warm & Matthews, 1999). The same window was displayed after each block of ten trials, and we ensured that it was consistent with the graphics of the operating system to increase credibility. Participants were instructed to ignore this message and press a key to continue the task.

After the WM task, all participants completed the post-task version of the SSSQ, and were debriefed. They were told that it was almost impossible to complete the task, given the increase in time pressure as it progressed, and that the aim of the experiment was simply to do as much as they could. For Group 1 (the threatful context), the psychologist was revealed to be confederate who had not, in fact, recorded any information during the experiment. They were also informed that no recordings had, in fact, been made and the camera was opened up to show that there was no videotape inside. Finally, they were made aware that the two computers were connected by a fake USB connection and that their responses were not compared to the average student. Thus, the feedback that was provided was unrelated to their actual performance. Then, the experimenter and the confederate answered any questions from participants. In the control context, participants were also debriefed, and told that there were no system checks and that the system messages were fake.

2.5. Analyses

We performed a series of preliminary statistical analyses with the *lm* function in the R software package (R Core Team, 2013). The objective was to ensure that our two groups of participants did not significantly differ with respect to their subjective stress state dimensions measures prior the completion of the task (see Table 2). For this purpose, we modeled *Context*

factor as a dummy—with the control context as the reference level (control context =0; threatful context=1). The Shapiro Wilk's test was applied to estimate the deviation of residuals from a normal distribution. This found that residuals of models including *Distress* ($W = .68, p < .001$), *Task Engagement* ($W = .98, p = .006$) and *Worry* ($W = .94, p < .001$) significantly deviated from the normal distribution. Therefore, we tested our models using the Maximum Likelihood Robust (MLR) estimator that produces a robust Chi² statistic and Huber-White's robust standard errors (see Maronna, Martin and Yohai, 2006) using the R package *lavaan* (Rosseel et al., 2014). This did not find a significant effect of *Context* on pre-task measures of either *Distress* ($B = .40; p = .47$), *Task Engagement* ($B = 1.02; p = .07$) or *Worry* ($B = -.18; p = .74$). Descriptive statistics are shown in Table 1.

Insert Table 1 about here

We used the *rlmer* function in the *robustlmm* package in R (Koller, 2019) to assess the fit of the data to mixed-effects models. This function was chosen because our preliminary analyses had revealed that residuals deviated significantly from the normal distribution, and *rlmer* has the advantage of providing robust estimates of linear mixed-effects models. Mixed-effects models were tested because measures for each participant are interdependent (i.e., a repeated measures design was adopted). Consequently, we adjusted estimates of model parameters for 'subjects' (van Montfort, Johan, & Ghidya, 2014) by estimating between-subject variance in the mean of the dependent variable (i.e. random intercepts). We computed the amount of variance between levels of the factor included in the random part of the model by adding the random effect to the intercept. The intercept, subsequent covariates, and their interactions were modeled using fixed-effects parameters: *Time* was modeled as a dummy, with SSSQ pre-task measures as the reference level (pre-task measures=0; post-task measures=1); *Context* was modeled as another dummy, with the control context as the

reference. Measures of metacognitive beliefs were included as covariates. We computed a 95% confidence interval to assess two-tailed statistical significance.

We first tested models including *Distress*, *Worry*, or *Task Engagement* scores as the dependent variable. These mixed-effects models incorporated the intercept, *Time* and *Context* dummies, the *Time x Context* interaction term, and the random effect of *Subject*. The objective was to assess the contribution of the *Time x Context* interaction to the overall regression, over and above the individual first-order effects of *Time* and *Context* (Cohen, Cohen, West & Aiken, 2003).

We then compared the first model that included *Worry* score as the dependent variable with a second model that incorporated metacognitive traits as covariates. Because of the intercorrelations between MCQ subscales (Larøi et al., 2009), we used the *leaps* package in R (Lumley & Miller, 2015) to select which of the five metacognitive traits to add to our regression as explanatory variables. A stepwise forward selection was applied to search for models that provided the best fit to the data, and lay within the range of including none of the five metacognitive belief measures and including all of them. The quality of the model's fit was estimated using the Akaike information criterion (AIC). Given that a log likelihood is not defined for the robust estimates returned by *rlmer*, we used the *lmer* function to obtain the likelihood function for our models, and to calculate AIC values. The *lmer* function was only used for stepwise forward selection. The significance of the improvement in the quality of the model's fit was estimated using the distributed chi-squared likelihood-ratio test (L Ratio). The significance was set at $p \leq .05$. The fit of the M_{1W} model (AIC=1912.8) was improved by including MCQ1 (AIC=1897.2; L-Ratio=17.55; $p < .001$), MCQ2 (AIC=1881.5; L-Ratio=33.28; $p < .001$), MCQ3 (AIC=1895; L-Ratio=19.76; $p < .001$) and MCQ4 (AIC=1873.6; L-Ratio=47.19; $p < .001$). These metacognitive beliefs were included in the second model that included *Worry* score as the dependent variable. This model was compared with a third series

of models to which we added *metacognitive beliefs x dummies modeling the task factor* interaction terms.

3. Results

Results for *Distress* scores showed that the *Time* dummy was significant ($B=5.08$; 95% CI (4.03, 6.11)), but the *Context* dummy was not ($B=.49$; 95% CI (-.54, 1.53)). The *Time x Context* interaction showed that the threatening context negatively moderated the effect of *Time* on *Distress* scores ($B=-1.93$; 95% CI (-3.40, -.46)). Results for *Task Engagement* scores showed that neither *Time* ($B=-.53$; 95% CI (-1.52, .45)) and *Context* ($B=.89$; 95% CI (-.31, 2.09)) dummies, nor the *Time x Context* interaction ($B=-.75$; 95% CI (-2.15, .64)) were significant. Finally, results for *Worry* scores revealed that neither the *Time* dummy ($B=-.61$; 95% CI (-1.37, .15)) nor the *Context* dummy ($B=-.18$; 95% CI (-1.42, 1.06)) were significant. However, the *Time x Context* interaction was significant ($B=1.34$; 95% CI (.30, 2.45)).

We then tested a model incorporating *Worry* scores as the dependent variable and metacognitive beliefs as predictors. We found significant effects of MCQ1 ($B=.06$; 95% CI (.01, .12)), MCQ3 ($B=.11$; 95% CI (.03, .20)) and MCQ4 ($B=.14$; 95% CI (.05, .23)). We finally tested a series of models that included *metacognitive beliefs x dummies modeling the task factor* interaction terms. Our results revealed that none of the interaction terms were significant. Therefore MCQ1 ($B=.01$; 95% CI (-.09, .11)), MCQ3 ($B=-.01$; 95% CI (-.17, .15)) and MCQ4 ($B=.003$; 95% CI (-.13, .14)) did not significantly moderate the effect of the context that triggered threats leading to *Worry*. Our last models were therefore discarded, and statistical estimates of the remaining models are shown in Table 2.

Insert table 2 about here

4. Discussion

In line with our expectations, we found an increase in post-task scores of *Distress* and a non-significant change in post-task scores of *Worry* compared to pre-task scores. Scores of *Task Engagement* did not significantly change across contexts, or between pre- and post-task periods. The effect of the *Time x Context* interaction on *Task Engagement scores* was not significant, but it was significant for both *Distress* and *Worry* Scores. Our results confirmed our expectation that the control context does not threaten self-image, because participants' can meet the experimenter's expectations and stressors are removed. Our work confirms previously-published findings by showing that the completion of the WM task in the control context elicited an increase in *Distress* scores as pressure on cognitive resources increased, and a decrease in *Worry* scores (Matthews et al., 2002; Trouillet et al., 2016).

One of our objectives was to show that sources of social evaluative threat could modify subjective stress states elicited by the WM task used in this research. The worry process is initiated by the detection of a potential threat, which can be triggered by external stimuli (Matthews & Funke, 2006); therefore we expected that the completion of the WM task in a context that combined uncontrollability and social evaluative threat would increase it (Dickerson & Kemeny, 2004). Our results confirmed that these two factors increased the level of *Worry* but reduced the increase in the post-task score of *Distress*. These results support the assumption that a threatful context may modify the balance between internal and external foci of attention (Matthews et al., 2013). To the best of our knowledge, only one previous study has tested this hypothesis, using impossible anagrams (Matthews et al., 2006). Although the task was expected to elicit outcome uncontrollability (impossible anagrams have no solution) and increase the internal focus on attention and worry, the authors failed to find an increase in the post-task measure of worry. The originality of our research is to combine outcome uncontrollability with social evaluative threat. Our findings show that this combination is

more effective in forcing attention inwards, towards self-related concerns (e.g., “*I am worried about looking foolish*”) (Matthews & Zeidner, 2004), than outcome uncontrollability alone (Dickerson & Kemmeny, 2004).

With respect to the Self-Regulative Executive Function model, our results indicate that the interplay between time and context may have modified participants’ self-regulative modes. Results obtained in the control context are congruent with the Hockey’s (1997) description of overload in the self-regulative control mode: worry scores decrease and distress scores increase because the person perceives that they are under emotional strain as she/ he maintains their efforts to accomplish the task and reduce any damage it may provoke (see Matthews et al., 2002 for similar results). It appears that the completion of the WM task in the threatful context elicits an alternative form of the self-regulative mode (Wells & Matthews, 1994). In this context, participants believed that they could be negatively judged by others. Consequently, self-evaluation prevailed over task demands and attention was forced inwards. As a result, the level of worry dimension increased.

Our research advances knowledge in the field by showing that we can change distress and worry levels in two ways, depending on the task context. Furthermore, our results confirm previous work by showing that worry is a subjective stress state dimension that is sensitive to sources of social evaluative threat. This result could explain why past studies failed to report a significant increase in worry, as they only manipulated environmental demands on cognitive resources (Matthews et al., 2002; Trouillet et al., 2016).

The appraisal of potential threatening stimuli is thought to be guided by self-knowledge, in order to evaluate the personal relevance of the situation (Matthews & Junke, 2006). Therefore, we predicted that the effect of the threatful context on worry dimension would be moderated by metacognitive beliefs, notably positive beliefs about worry. To the best of our knowledge, our study is the first to address this issue. We found that worry scores

increased for participants who tended to believe that worry helps to solve problems (i.e., who hold positive beliefs about worry), who have a lack of confidence in their memory and concentration capacities (i.e., lack cognitive confidence), and who hold negative beliefs about the need to control thoughts and the harmful consequences of not controlling them. Thus, our results support the premise that worry dimension is related to positive metacognitive beliefs about using worry as an efficient coping style (Matthews et al., 1999; Wells, 2007; Wells & Matthews, 2015; Trouillet et al., 2016). Our results support the hypothesis that worry dimension is related to negative forms of metacognitive beliefs. Wells (2010) proposed that negative metacognitive beliefs lead to the appraisal of the worry process as being uncontrollable and dangerous. They are higher in Generalized Anxiety Disorder patients than healthy controls and patients with social phobia or panic disorder (Wells & Carter, 2001). In our research, we recruited nonanxious individuals but they completed the WM task in a threatful context combining uncontrollability and social evaluative threat. Within the S-REF model, worry dimension would reflect the activity of the executive system attempting to remove the self-discrepancy related to themes of threat. Worriers are concerned about the negative evaluation elicited by their perceived failings, the lack of confidence in one's memory and concentration capacities (i.e., beliefs about cognitive confidence – MCQ3) would therefore increase worry states and lead participants to be on guard for any validation of those fears (Matthews & Funke, 2006). Negative metacognitive beliefs concerning superstition, responsibility and punishment – SPR- (MCQ4) would increase the need to control thoughts and to focus attention on perceived threat. Positive beliefs would motivate continuous worrying (Wells, 2000). We surmise that these three forms of metacognitive beliefs would foster an increase in worry dimension to support our participants' threat preparation in order to remove the self-discrepancy related to themes of threat (Matthews & Funke, 2006). For example, in the S-REF system, worry may help to avoid arousal associated with the

threatful context by diverting attention to more minor sources of threat (Wells & Matthews, 2015).

Secondly, we tested the hypothesis that worry dimension would result from the interplay between low-level (environmental demands) and high-level (metacognitive beliefs) units of the S-REF cognitive model (Wells & Matthews, 1994, 1996). To date, only one experimental study has addressed this issue (Trouillet et al., 2016), but the authors only reported one significant interaction: the effect of *metacognitive beliefs* x *environmental demands* on *Distress* scores. The latter authors argued that the interaction was not significant for *Worry* scores because the experimental task was not assessed as threatening the self (Matthews et al., 2002). Therefore, in the present study we predicted that, in the threatening context, worry scores would increase as participants hold positive beliefs about it, via an internal feedback loop (Matthews & Junke, 2006). Our results did not support this hypothesis because the effect of the threatening context on the post-task score of worry was not significantly moderated by metacognitive beliefs (i.e., positive beliefs about worry, cognitive confidence, negative beliefs about thoughts in general).

The originality of our research is that it demonstrates that a threatening context that combines outcome uncontrollability and social evaluative threat can succeed in eliciting a subjective stress state associated with the worry process (i.e., there was a decrease in *Distress* scores and an increase in *Worry* scores). This means that the detection of sources of threat and metacognitive beliefs are two, additional factors in the worry syndrome. These results challenge the hypothesis that worry results from an interplay between the three levels of the S-REF model (Wells & Matthews, 1994,1996). Instead, they are compatible with the hypothesis that the executive level interacts with the first level in order to monitor and control attentional resources that make it possible to appraise and cope with environmental demands. The activity of the executive level is guided by metacognitive beliefs, but processing units at

the first level are unlikely to be moderated by metacognitive beliefs. These results are compatible with the view of cognitive intrusions related to worry as the product of parallel processing at the lower level where top-down influences facilitate the lower-level activation (Wells & Matthews, 1994) in both threatful (as evidenced by our results) and less threatful contexts (Trouillet et al., 2016).

5. Conclusion

In conclusion, our results call into question the validity of the hypothesis that assumes that worry results from an internal feedback loop, which is motivated by positive beliefs about worry (Matthews & Junke, 2006). As noted above, Wells (2004) distinguished two types of worry. Type 1 encompasses worries about social events and physical symptoms. It refers to normal, everyday worries that are associated with positive beliefs about worry. These metacognitive beliefs drive the selection of worry as a coping strategy and reduce anxiety by shifting attention away from stressful information. In the metacognitive GAD model, Type 1 worry activates negative metacognitive beliefs (“*Worrying is abnormal and people will reject me if they know I worry*”), which, in turn, leads people to negatively interpret their worry. This “worry about worry” (or “Meta” Worry) is termed Type 2 worry, and it increases levels of both perceived threat and anxiety. Type 2 worry is characteristic of clinical anxiety, and results from the interaction between the person and their situation (Wells & Matthews, 1994; Wells, 2000). As, in this research, we recruited non-clinical participants, we can assume that our combination of social threat and uncontrollability fostered Type 1 worry triggered by both sources of threat and metacognitive beliefs. Wells (2004) also argued that metacognitive beliefs are primary factors in the development and maintenance of GAD. Consequently, we can surmise that sources of threat and metacognitive beliefs are two, independent predictors of worry dimension as measured by the SSSQ – but their interaction could explain Type 2 worry – the hallmark of GAD patients.

The present research has a number of limitations. We surmised that the interaction between sources of threat and metacognitive beliefs could explain type 2 worry. This hypothesis needs further research where a group of GAD patients would be compared to a control group with respect to their measures of both worry dimension using the SSSQ and type 2 worry (worry about thoughts and worry about worrying) using the Anxiety Thoughts Inventory (Wells, 1994). We could expect that GAD patients would obtain higher type 2 worry scores than control group and this form of worry would be explained by the interaction between sources of threat and metacognitive beliefs. An other limitation of our work is that we did not manipulate the effect of the demands of the cognitive task on worry dimension. Further research is needed to estimate the relative effects of environmental demands and sources of social evaluative threat by asking participants to complete tasks that differ with respect to both their cognitive demands (e.g., vigilance vs WM tasks) and their context (threat vs. control context). Finally, we expected that metacognitive beliefs would moderate the relationship between sources of threat and worry dimension because the interrelations between the three cognitive levels of the S-REF are a core aspect of the Self-Regulative Executive Function model (Wells & Matthews, 1994, 1996). Yet, we could also surmise from the metacognitive model of GAD that metacognitive beliefs would mediate the effect of threats on worry dimension. In this model, triggers in the form of negative thoughts or negative events activate positive metacognitive beliefs about worry. Individuals with GAD use worry as a coping strategy to deal with threats “*by virtue*” of positive metacognitive beliefs about worry (Wells, 2005). We could therefore surmise that positive metacognitive beliefs about worry would explain the effect of threats on worry dimension. Future studies should address this issue and test the hypothesis that the effect of threats on worry dimension is mediated by positive metacognitive beliefs about worry.

Declarations of interest: none

References

- Appelgren, A., Penny, W., & Bengtsson, S.L. (2014). Impact of feedback on three phases of performance monitoring. *Experimental Psychology*, *61*(3), 224-33. doi: 10.1027/1618-3169/a000242.
- Behar, E., Dobrow DiMarco, I., Hekler, E.B., Mollman, J. & Staples, A.M. (2009). Current theoretical models of generalized anxiety disorder (GAD): conceptual review and treatment implications. *Journal of anxiety disorders*, *23*(8),1011-23. doi: 10.1016/j.janxdis.2009.07.006.
- Cartwright-Hatton, S & Wells, A. (1997). Beliefs about worry and intrusions: the Meta-Cognitions Questionnaire and its correlates. *Journal of anxiety disorders*, *11*(3), 279-296.
- Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/ correlation analysis for the behavioral sciences* (3rd ed.). Hillsdale, NJ: Erlbaum.
- Cook, S. A., Salmon, P., Dunn, G., Holcombe, C., Cornford, P., & Fisher, P. (2015). The association of metacognitive beliefs with emotional distress after diagnosis of cancer. *Health Psychology*, *34*(3), 207–215.
- Dickerson, S.S., & Kemeny, M.E. (2004). Acute Stressors and Cortisol Responses: A Theoretical Integration and Synthesis of Laboratory Research. *Psychological bulletin*, *130*(3), 355-391. DOI: 10.1037/0033-2909.130.3.355.
- Gianaros, P.J., van der Veen, F.M., & Jennings, J.R., (2004). Regional cerebral blood flow correlates with heart period and high-frequency heart period variability during working-memory tasks: Implications for the cortical and subcortical regulation of cardiac autonomic activity. *Psychophysiology*, *41*(4), 521-530.
- Hellhammer, D. H., Wüst, S., & Kudielka, B. M. (2009). Salivary cortisol as a biomarker in stress research. *Psychoneuroendocrinology*, *34*(2), 163–171.

- Helton, W.S., Dember, W.N., Warm, J.S., & Matthews, G. (1999). Optimism, pessimism, and false failure feedback: Effects on vigilance performance. *Current psychology, 18*(4), 311-325.
- Het, S., Rohleder, N., Schoofs, D., Kirschbaum, C., & Wolf, O.T. (2009). Neuroendocrine and psychometric evaluation of a placebo version of the 'Trier Social Stress Test'. *Psychoneuroendocrinology, 34*(7):1075-86. doi: 10.1016/j.psyneuen.2009.02.008.
- Hockey, G.R.J. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive-energetical framework. *Biological Psychology, 45*, 73–93.
- Kirschbaum, C., Pirke, K.M., & Hellhammer, D.H. (1993). The 'Trier Social Stress Test' - a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology, 28*, 76-81.
- Koller, M. (2019). *Robust Linear Mixed Effects Models*. R package “robustlmm” version 2.3. Retrieved from <https://github.com/kollerma/robustlmmL>.
- Larøi, F., Van der Linden, M., & d'Acremont, M. (2009). Validity and reliability of a French version of the metacognitions questionnaire in a nonclinical population. *Swiss journal of psychology, 68*(3), 125-132.
- Lazarus, R. S., & Folkman, S. (1984). *Stress appraisal and coping*. New York: Springer.
- Leary, M.R., Terry, M.L., Allen, A.B., & Tate, E.B. (2009). The Concept of Ego Threat in Social and Personality Psychology: Is Ego Threat a Viable Scientific Construct? *Personality and social psychology, review, 13*(3), 151-164. doi: 10.1177/1088868309342595.
- Lumley, T., & Miller, A.(2015). *Regression subset selection* (R package “Leaps” version 2.9).

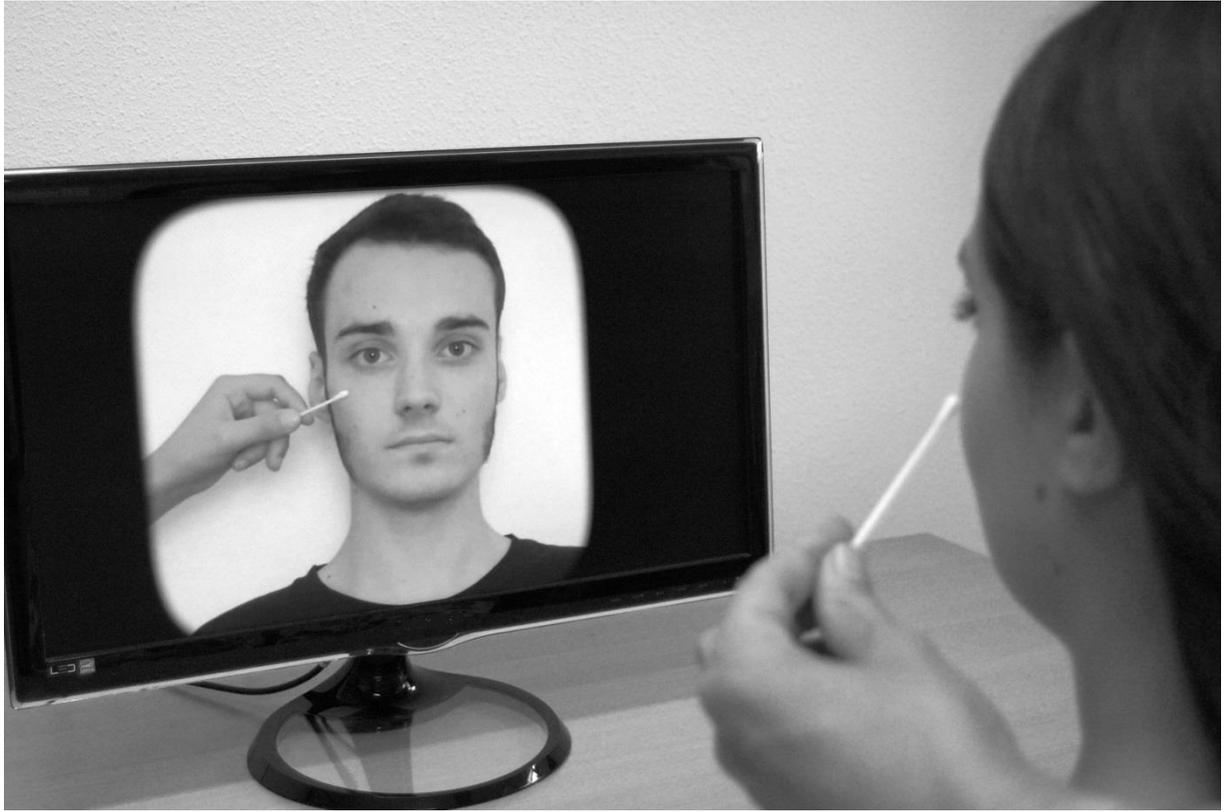
- Matthews, G., & Wells, A. (1999). The cognitive science of attention and emotion. In T. Dalgleish & M. Power (Eds.), *Handbook of cognition and emotion* (pp. 171–192). New York: Wiley.
- Matthews, G., Hillyard, E. J., & Campbell, S. E. (1999). Metacognition and maladaptive coping as components of test anxiety. *Clinical Psychology & Psychotherapy*, 6(2), 111-125.
- Matthews, G., Campbell, S. E., Falconer, S., Joyner, L. A., Huggins, J., Gilliland, K., ... Warm, J. S. (2002). Fundamental dimensions of subjective state in performance settings: task engagement, distress, and worry. *Emotion*, 2(4), 315-340.
- Matthews, G. & Zeidner, M. (2004). Traits, states and the trilogy of mind: An adaptive perspective on intellectual functioning. In D. Dai & R.J. Sternberg (Eds.). *Motivation, emotion, and cognition: Integrative perspectives on intellectual functioning and development* (pp. 143–174). Mahwah, NJ: Lawrence Erlbaum.
- Matthews, G. & Funke, G.J. (2006). Worry and information-processing. In C.L. Davey & A. Wells (Eds.), *Worry and its psychological disorders: theory, assessment and treatment* (pp.51-67). Chichester, West Sussex: John Wiley & sons Ltd.
- Matthews, G., Emo, A.K., Funke, G., Zeidner, M., Roberts, R.D., Costa, P.T., & Schulze, R. (2006). Emotional intelligence, personality, and task-induced stress. *Journal of experimental psychology: applied*, 12(2), 96-107. doi: 10.1037/1076-898X.12.2.96
- Matthews, G., Warm, J. S., Reinerman-Jones, L. E., Langheim, L. K., Washburn, D. A., & Tripp, L. (2010). Task engagement, cerebral blood flow velocity, and diagnostic monitoring for sustained attention. *Journal of Experimental Psychology: Applied*, 16(2), 187.

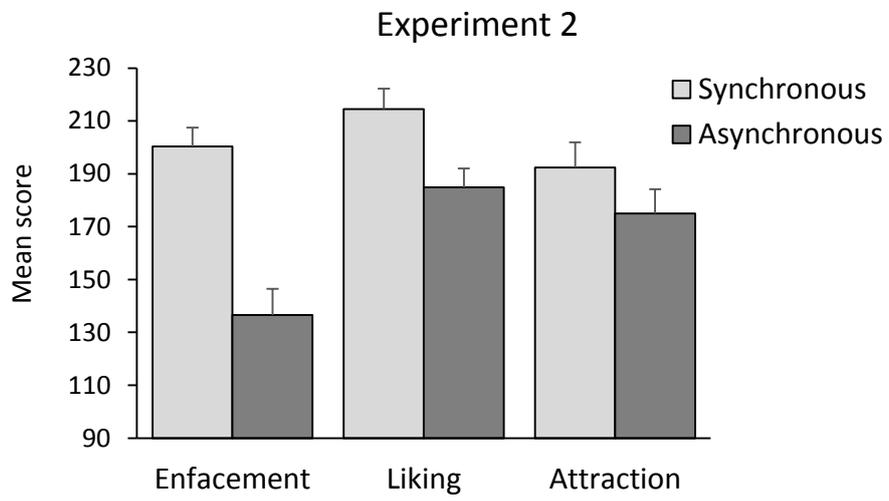
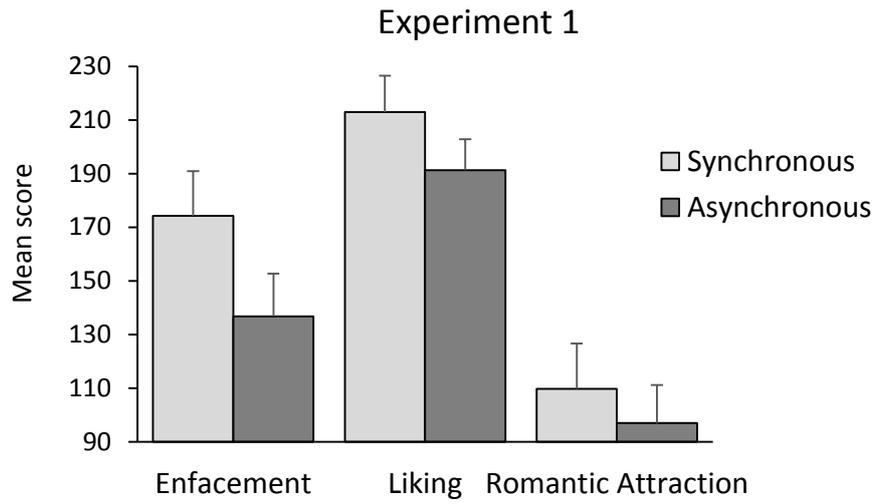
- Matthews, G. & Campbell, S. E. (2010). Dynamic relationships between stress states and working memory. *Cognition and Emotion*, 24(2), 357-373.
<http://dx.doi.org/10.1080/02699930903378719>.
- Matthews, G., Szalma, J., Panganiban, A. R., Neubauer, C., & Warm, J. S. (2013). Profiling task stress with the Dundee Stress State Questionnaire. In L. Cavalcanti & S. Azevedo (Eds.), *Psychology of stress: New research* (pp.49-90). Hauppauge: Nova Science.
- Matthews, G. (2016). Multidimensional Profiling of Task Stress States for Human Factors: A Brief Review. *Human Factors*, 58(6), 801-813.
- Mushtaq, F., Bland, A.R., & Schaefer, A. (2011). Uncertainty and Cognitive Control. *Frontiers in psychology*, 2, 1-14. doi: 10.3389/fpsyg.2011.00249.
- Podsakoff, P.M., & Farh, J.L. (1989). Effects of feedback sign and credibility on goal setting and task performance. *Organizational Behavior and Human Decision Processes*, 44(1), 45-67.
- R Core Team (2013). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>
- Rosseel, Y., Oberski, D., Byrnes, J., Vandrabant, L., Savalei, V., Merkle, E., ..., Barendse, M. (2014). *Latent Variable Analysis* (R package "lavaan" version 0.5-17). Retrieved from <http://lavaan.org>.
- Roussis, P., & Wells, A. (2008). Psychological factors predicting stress symptoms: metacognition, thought control, and varieties of worry. *Anxiety Stress and Coping*, 21(3), 213–225. <http://dx.doi.org/10.1080/10615800801889600>.
- Spada, M.M., Mohiyeddini, C., & Wells, A. (2008a). Measuring metacognitions associated with emotional distress: Factor structure and predictive validity of the metacognitions questionnaire 30. *Personality and Individual Differences*, 45, 238–242.
doi:10.1016/j.paid.2008.04.005.

- Spada, M. M., Nikčević, A. V., Moneta, G. B. & Wells, A. (2008b). Metacognition, perceived stress, and negative emotion. *Personality and Individual Differences*, 44(5), 1172-1181.
- Syssau, A., & Font, N. (2005). Evaluation des caractéristiques émotionnelles d'un corpus de 604 mots. *Bulletin de psychologie*, 58(3), 361-367.
- Trouillet, R., Doron, J., & Combes, R. (2016). Metacognitive beliefs, environmental demands and subjective stress states : a moderation analysis in a French sample. *Personality and individual differences*, 101, 9-15.
- van Montfort, K., Johan, H.L.O., & Ghidry, W. (2014). *Developments in Statistical Evaluation of Clinical Trials*. New York: Springer.
- Wells, A. (1994). A multidimensional measure of worry: Development and preliminary validation of the Anxious Thoughts Inventory. *Anxiety, Stress and Coping*, 6, 289–299.
- Wells, A. (2000). *Emotional disorders and metacognition: Innovative cognitive therapy*. Chichester, UK: Wiley
- Wells, A. (2004). A cognitive model of GAD: Metacognitions and pathological worry. In R.G. Heimberg, C.L. Turk, & D.S. Mennin, (Eds.), *Generalized anxiety disorder: Advances in research and practice* (pp. 164–186). New York: Guilford Press.
- Wells, A. (2005). The metacognitive model of GAD: assessment of meta worry and relationship with DSM-IV generalized anxiety disorder. *Cognitive therapy and research*, 29, 107-121. <http://dx.doi.org/10.1007/s10608-005-1652-0>
- Wells, A. (2007). Cognition About Cognition: Metacognitive Therapy and Change in Generalized Anxiety Disorder and Social Phobia. *Cognitive and Behavioral Practice* 14, 18-25. [doi:10.1016/j.cbpra.2006.01.005](https://doi.org/10.1016/j.cbpra.2006.01.005).

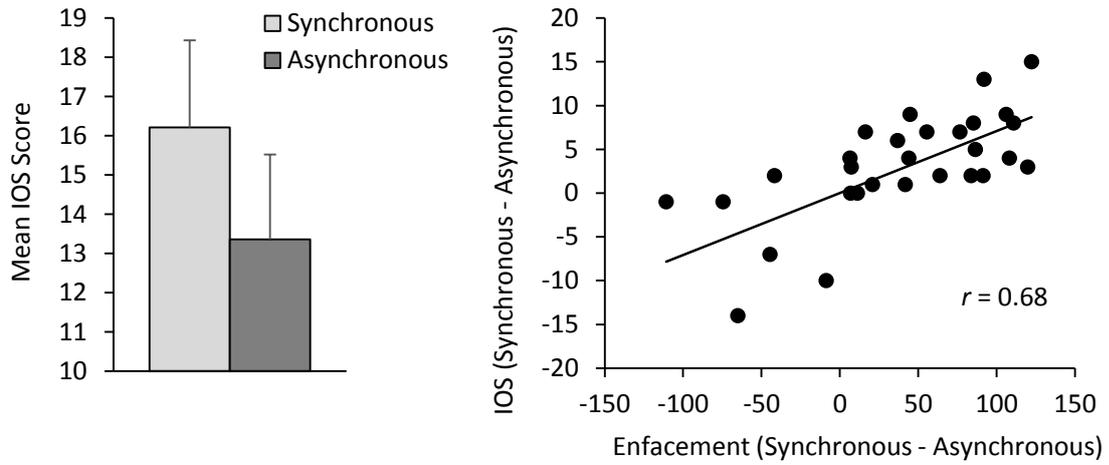
- Wells, A. (2009). *Metacognitive therapy for anxiety and depression*. New York, NY: the Guilford Press.
- Wells, A. (2010). Metacognitive Theory and Therapy for Worry and Generalized Anxiety Disorder: Review and Status. *Journal of experimental psychopathology*, 1(1), 133-145. doi:10.5127/jep.007910.
- Wells, A., & Matthews, G. (1994). *Attention and Emotion: A Clinical Perspective*. Hove, UK: Lawrence Erlbaum.
- Wells, A., & Matthews, G. (1996). Modelling cognition in emotional disorder: The S-REF model. *Behaviour research and therapy*, 34(11), 881-888.
- Wells, A., & Carter, K. (2001). Further Tests of a Cognitive Model of Generalized Anxiety Disorder: Metacognitions and Worry in GAD, Panic Disorder, Social Phobia,

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Experiment 1



Experiment 2

