# Maastricht Student Journal of Psychology and Neuroscience

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*Volume 3 Number 1 July 2014*

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*(eds.)*

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# LETTER FROM THE EDITIORIAL BOARD

Dear reader,

We are delighted to present the third edition of the Maastricht Student Journal of Psychology and Neuroscience (MSJPN). For the third consecutive year student authors and student reviewers have made an admirably contribution to the faculty's journal.

A total of 10 manuscripts have been accepted for publication in the journal. Out of those 10 manuscripts, six are reports of empirical studies conducted by the students at the faculty. Three manuscripts are literature reviews, and one is an essay. The 10 contributions cover topics in the domains of clinical psychological science, cognitive neuroscience, work and social psychology, and neuropsychology and psychopharmacology. As such, they appear to be a very good reflection of the work of the faculty's departments.

Therefore, we would like to express our gratitude to the student authors, but also to their supervisors who made it possible to conduct a study or a literature review and who encouraged their students to submit their work to MSJPN. Additionally, we also thank our reviewers who thoroughly read every manuscript and made them even better than they already originally were.

T his year the journal went through a big change. We have automated the submission procedure of articles, which means that documents can be uploaded via a dedicated authors' portal and that manuscripts can be easily reviewed via a reviewers' portal. This ascertains a standardized, objective and fast reviewing process. In addition, it lightens the workload of the editorial board.

Besides this change, we are also very pleased to have welcomed Laurien Nagels-Coune as a fifth member at the editorial board. This year, Laurien has reviewed a large number of papers and she will take over more editorial duties for the next edition of MSJPN.

With two students in the editorial board the journal is increasingly becoming a genuine student journal. Yet, there is still a need for more student involvement. Please feel free to contact any member of the board in case you are interested in participating in the development of the journal.

The editorial board
Anke Sambeth
Silke Conen
Luís Tojo
Laurien Nagels-Coune
Tim Leufkens

ASTRID MEESTERS

# The relationship between impulsivity, weight concern and the yoyo-effect in healthy women

Original Paper

Weight cycling, or the so-called yoyo-effect, is an unhealthy aspect of eating behaviour. It is hypothesized that being more impulsive is related to more weight cycling. Furthermore, the yoyo-effect is expected to follow from an interaction between impulsivity and weight concern; high-impulsive, high weight concerned eaters might experience the yoyo-effect to a higher degree than low-impulsive, high weight concerned eaters. In the current study, 214 women aged 25-50 were recruited. Weight cycling, weight concern and two concepts of impulsivity were assessed, namely trait impulsiveness and reward sensitivity. It is found that trait impulsive people and weight concerned people show a higher degree of weight cycling. The results do not reveal an interaction between both aspects of impulsivity and weight concern. This study suggests that impulsivity, as well as weight concern, might play a role in maintaining a healthy body weight and reducing the risks of the yoyo-effect.
**Keywords**: Weight cycling; yoyo-effect; impulsivity; weight concern; eating behaviour

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## INTRODUCTION

In western societies, the increasing prevalence of overweight and obesity is a reason for concern. In the last decades, the overall silhouette of people has changed dramatically from lean to overweight. The World Health Organization (WHO) has acknowledged obesity as a global epidemic (WHO, 2011). The WHO reported that worldwide 1.5 billion adults were overweight in 2008, of whom 500 million

obese. The consequences for obese individuals are, for instance, higher risks of cardiovascular diseases, diabetes, musculoskeletal disorders and certain types of cancer (WHO, 2011). Furthermore, we must not forget the impact of overweight and obesity on social and psychological aspects of life (i.e. discrimination, contempt of body image) (Wadden & Stunkard, 1985).

Today, people are living in tempting environments, as highly palatable, high calorific food is amply available. As a consequence, an imbalance between calorific intake and energy expenditure is easily achieved. The most popular method for decreasing bodyweight is dietary restraint. The problem arises when weight loss is achieved and diets are finished. People then tend to regain the weight loss and may even put on additional weight or become obese (Amigo & Fernandez, 2007). As a consequence, a lot of people experience weight cycling or the so-called yoyo-effect. When it comes to the overall health of a person, weight cycling appears to be a risk factor of mortality (Jefferey, 1996). For instance, Lissner et al. (1991) demonstrated that weight fluctuations are associated with ischaemic heart disease and cancer. Therefore, it is generally recommended to maintain a healthy body weight throughout life or when obese, try to lose the extra weight without weight cycling.

Multiple factors come into play when eating behaviour is studied. One psychological factor that is thought to be important in explaining differences in susceptibility to overeating is impulsivity. An impulsive act is defined as inaccurate or maladaptive behaviour that is executed without sufficient forethought, planning and control (Solanto et al., 2001). In the context of eating behaviour, impulsivity could, for instance, direct to unhealthy choices when eating on the spur of the moment. Instead of choosing healthy, nutritious foods, one might prefer foods that are high in fat, salt and sugars with greater rewarding value (Davis et al., 2007). Impulsivity can be measured by means of both self-report questionnaires and behavioural tasks. In general, the findings of those measurements correlate weakly (e.g., Wingrove & Bond, 1997) and associations between these tasks are weak (e.g., Marsh, Dougherty, Mathias, Moeller, & Hicks, 2002). This could imply that there are different aspects of impulsivity and this is why researchers recognize impulsivity as a multi-dimensional construct with several interrelated concepts.

The impulsivity construct can be divided into three main aspects, namely response inhibition, sensitivity to reward and self-reported trait impulsivity (Guerrieri et al., 2007; Guerrieri et al., 2008). Firstly, insufficient response inhibition, also known as premature responding, is mostly measured by behavioural tasks. Logan, Schachar, and Tannock (1997) suggested the stop-signal procedure as a paradigm for studying inhibitory control, which consists of a primary task (also referred to as the go task) and a stop task during which the participants have to inhibit their responses.

Secondly, sensitivity to reward is measured both by self-report and by behavioural tasks. The concept of reward-sensitivity is predominantly examined in addiction research. As is the case for nicotine, alcohol and drugs, it has been suggested that food has the potential for abuse (Kelley, Bakshi, Haber, & Steininger, 2002). Consequently, this concept is frequently used in eating related research. Reward-sensitive people are prone to stimuli that have a greater rewarding value

and tend to approach these stimuli (Davis et al., 2004). A link between reward-sensitivity and the Behavioural Activation System (BAS), as described by Gray (1987), can be made. The BAS (or the appetitive system/'go' system), is responsible for appetitive motivation and it is supposed to respond to signals of reward and non-punishment. The more sensitive the BAS is, the more one is believed to be impulsive.

Thirdly, impulsivity is thought to play an important role in personality systems. In this context, impulsivity is referred to as self-reported trait impulsivity or impulsiveness, which is measured by self-report questionnaires, exclusively.

With respect to eating behaviour, research has shown links between all three aspects of impulsivity and overeating. For instance, obese women with Binge Eating Disorder are found to be more impulsive as measured by self-report (Nasser et al., 2004). In addition, Nederkoorn, Smulders, Havermans, Roefs and Jansen (2006a) found that obese women could inhibit their responses less effective compared to normal weight women, as measured by the stop signal task. In the same study, no differences between obese women and normal weight women were found on self-report measures that measured trait impulsiveness and sensation seeking. As for obese children, Nederkoorn, Jansen, Mulkens, and Jansen (2006b) have shown that these children display higher scores of impulsivity as measured by self-report. Moreover, impulsivity acts as a predictor for treatment outcome in obese children; the children that were the most impulsive, assessed using the stop-signal paradigm, lost less weight during treatment (Nederkoorn et al., 2006b). Nederkoorn, Braet, Van Eijs, Tanghe and Jansen (2006c) found similar results, but they also demonstrated that obese children, who were least effective in inhibiting responses as measured by the stop-signal task, were also more sensitive to reward as compared to normal-weight children. In general, this suggests that obese people could be more sensitive to the rewarding value of food. Indeed, research has shown that reward-sensitive children consumed more during a taste test including foods that differed in colour, shape, taste and texture as compared to less reward-sensitive children (Guerrieri, Nederkoorn and Jansen, 2008).

Even in healthy, slender women impulsivity is connected with eating behaviour. By administering the bogus taste test (a test during which participants are asked to try different palatable products and rate the taste, while actually the level of consumption is measured) to normal-weight women, it was demonstrated that high-impulsives eat more when presented with palatable food compared to low-impulsives as measured by self-report, but no significant differences were found for the stop-signal task (Guerrieri, Nederkoorn and Jansen, 2007).

To sum up, it has been shown that impulsivity, measured with response inhibition, sensitivity to reward tasks, and with self-report questionnaires, is related to eating behaviour in healthy populations, obese populations, Binge Eating Disorder patients, and children, although there are exceptions (e.g., Nederkoorn et al., 2006a; Guerrieri et al., 2007).

Another important variable that is frequently examined in eating research is eating restraint. Restrained eaters are believed to worry about their weight and are constantly trying to lose weight. They are not content with their current figure. It has been demonstrated that restraint is important when examining eating behaviour.

For instance, restrained eaters are significantly worse at the stop-signal task (i.e., response inhibition) compared to unrestrained eaters (Nederkoorn, Van Eijs, & Jansen, 2004). Furthermore, Jansen et al. (2009) reasoned that overeating might be the result of an interaction between eating restraint and impulsivity, and indeed, high-impulsive high-restrained women appeared to eat more after exposure to a tasty preload compared to low-impulsive high-restrained women. No differences were found between the two low-restrained groups. In conclusion, impulsive restrained eaters have a greater tendency to overeat.

Restraint eaters often try to lose weight using a hypocaloric diet, but seldom succeed (Brownell & Rodin, 1994). As a consequence, these restraint eaters often experience the yoyo-effect. It could be the case that weight cycling is related to impulsivity. One could imagine that extreme dieting and extreme overeating are displayed by impulsive people, while long-term lifestyle adaptations are more difficult to maintain for this group. Hence, impulsive people could experience weight fluctuations to a greater degree.

To further investigate the role of impulsivity in eating behaviour, the current study is the first to examine whether impulsivity, in combination with weight concern, is related to the degree of weight cycling or the so-called yoyo-effect. To examine whether aspects of impulsivity are differentially related to the yoyo-effect, the concept of impulsivity is operationalized as sensitivity to reward and as a self-reported personality trait using the Barratt Impulsiveness Scale (BIS) and the BAS scale of the BIS/BAS scales, respectively. It is hypothesized that there will be a main effect of impulsivity; that is, the more a person fails to inhibit impulsive acts, the more the person will experience weight cycling. Furthermore, it is hypothesized that the yoyo-effect follows from an interaction between impulsivity and weight concern; high-impulsive, high weight concerned eaters experience the yoyo-effect to a higher degree.

## METHODS

### Participants

Data of 214 women (mean age 39.2 +/- 7.3, mean BMI 25.7 +/- 5.5kg/$m^2$) recruited by Flycatcher Internet Research were collected, analysed and included in the study. Exclusion criteria were: age (i.e. below 25 and above 50), pregnancy and weight fluctuations caused by recent illness or illness in the past. In total, 55 participants were excluded before data analysis; 9 participants did not complete the questionnaires, 10 participants were excluded due to pregnancy, and 36 participants reported weight fluctuations caused by illness or pregnancy.

Flycatcher Internet Research is an independent research institute that has access to a panel that consists of 15.000 members, representative for the Dutch population. Background variables (such as age, gender, education) of these members are known and therefore, a relevant sample could be selected. The institute uses a special reward system; by participating in different studies conducted by Flycatcher, participants can collect a different number of points per participated research. After collecting 900 points, the participant receives a digital gift card worth 10 euros. After

participating in the present study, the participant received 80 points. Participants who did not meet the criteria were excluded from the sample. These participants received 20 points. The present study was approved by Maastricht University, Faculty of Psychology and Neuroscience Ethical Committee.

**Measures**

*Dieting Restraint*

The Restraint Scale (RS) developed by Herman and Polivy (1980), was used to reflect dieting restraint. The RS is a self-report questionnaire consisting of 11 items collecting information on current weight, weight fluctuations, dieting behaviour and concern about dieting and weight control. Factor analysis has shown that the RS can be divided into two subscales: subjective concern with dieting (CD) and weight fluctuation (WF) (Polivy, Herman & Howard, 1988). Items 1, 2, 3, 4, 7 and 9 correspond to the subscale CD and items 5, 6, 8, 10 and 11 correspond to the subscale WF. The WF subscale was used to verify the five self-construed weight cycling items (see next section). Scores range from 0 to 40. Restraint eaters are believed to obtain higher scores.
In the present study, only the subscale CD was used to measure dieting restraint, because the items of subscale WF would have acted as a confounder. Higher subscale CD scores imply higher eating restraint.

*Yoyo-effect*

In order to measure the yoyo-effect, five items were constructed. For instance, it was asked what the maximum weight loss of the participant was in one month and what the maximum weight gain was in one week. As mentioned before, these items were verified using the WF subscale of the RS.

*Impulsivity*

The Barratt Impulsiveness Scale

Trait impulsiveness was measured by the Barratt Impulsiveness Scale (BIS; Patton et al., 1995). The BIS is a 30-item questionnaire designed to measure three specific aspects of trait impulsiveness; motor impulsiveness (item 2, 3, 4, 16, 17, 19, 21, 22, 23, 25 and 30), attentional impulsiveness (item 5, 6, 9, 11, 20, 24, 26 and 28) and non-planning impulsiveness (item 1, 7, 8, 10, 12, 13, 14, 15, 18 and 27). Motor impulsiveness expresses itself when one does not sufficiently contemplate before action. Attentional impulsiveness involves easy distraction from the task at hand and non-planning impulsiveness comprises a lack of taking future events into account. Questions are rated on a 4-point scale (1 = rarely/never, 2 = occasionally, 3 = often, 4 = almost always/always). The summed score indicates the level of impulsiveness; the higher the summed score, the more impulsive one is believed to be. Item 1, 7, 8, 9, 10, 12, 13, 15, 20, 29 and 30 were reverse coded to avoid a response set (i.e. the tendency for participants to respond to the questions in such a manner that it leaves a certain impression).

The BAS scale of the BIS/BAS scales

Impulsivity as reward sensitivity was measured by the BAS scale of the BIS/BAS scales (Carver & White, 1994). This 20-item questionnaire consists of four subscales, one Behavioural Inhibition System scale and three BAS scales, namely Drive (DRV), Fun Seeking (FS) and Reward Responsiveness (RR). The BAS scale exists of 12 items and is developed to measure the Behavioural Activation System (BAS), as defined by Gray (1987). The items corresponding to the BAS are believed to measure impulsivity (higher BAS scores represent higher impulsivity). The BIS scores were not analysed in the current study.

**Procedure**

350 women who met the criteria to take part in the current study were selected by Flycatcher and received an email invitation that included a hyperlink. By clicking on this link a new webpage would be opened. First, the participants had to sign an informed consent. Then the participants were asked to report their current height and weight and whether they were pregnant at the time. Next, they completed the questions concerning the yoyo-effect, the RS, BIS, and BIS/BAS scales. Finally, the participants were thanked for participation, received a debriefing and earned 80 Flycatcher points. After sending the 350 selected members a reminder, 20 extra members were invited in order to obtain a sufficient number of participants.

**Data analysis**

The current study is observational and cross-sectional in nature. The study has a 2 (impulsivity: high vs. low) by 2 (weight concern: high vs. low) Between Subjects design with the yoyo-effect as the dependent variable and weight concern and impulsivity as the independent variables. Data were collected individually and analysed separately for the two different measures of impulsivity. Statistical analyses were conducted using the software programme the Statistical Package for Social Sciences version 20 (SPSS Inc., USA). In all tests, statistical significance was assumed to exist at $p < 0.05$. Items of the RS, BIS and BAS scale were recoded and overall scores were computed before data analyses could start.

First, descriptive statistics were studied. Reliability analyses were computed in order to study the internal consistency of the questionnaires. The data collected with the five questions that were added in order to measure the yoyo-effect were analysed by means of Pearson correlation coefficients to determine whether these questions give a good impression of the yoyo-effect. Furthermore, data from the questionnaires were analysed using two-way ANOVA. The data were analysed for the two different measures of impulsivity, separately.

## RESULTS

### General statistics

The total sample was divided into a high-impulsive and low-impulsive group, based on a median split for each measure of impulsivity (BIS: 60, BAS: 35), and in a high weight concern group and low weight concern group, based on a median split of the RS weight concern subscale (6). Participants with BIS scores of 60 and lower and BAS scores of 35 and lower were classified as low-impulsive (n = 101, n = 109), participants with BIS scores higher than 35 and BAS scores higher than 60 were classified as high-impulsive (n = 113, n = 105). Participants with weight concern scores of 6 and lower were classified as low weight concerned.

General statistics (means and standard deviations) are presented in Table 1 for impulsivity as trait impulsiveness and in Table 2 for impulsivity as reward sensitivity. In terms of internal consistency, the three questionnaires proved to be generally reliable. Cronbach's alpha's are summarized in Table 3. All alpha's are above 0.60 and varied between 0.63 and 0.83, except for the BAS fun seeking subscale ($\alpha$ = 0.48).

**Table 1** Means (standard deviations) for age, BMI, weight concern and impulsivity as trait impulsiveness (BIS)

| | **Low impulsive low weight concern** | **High impulsive low weight concern** | **Low impulsive high weight concern** | **High impulsive high weight concern** | **F(3,210)** |
|---|---|---|---|---|---|
| | n = 77 | n = 53 | n = 39 | n = 45 | |
| Age | 38.91 (7.72) | 38.62 (7.06) | 39.74 (7.24) | 40.07 (6.90) | 0.73 |
| BMI | 23.57a (3.93) | 24.51a (5.11) | 27.59b (5.30) | 28.89b (6.47) | 13.11** |
| Weight concern | 3.81a (1.58) | 4.13a (1.68) | 9.18b (2.04) | 9.60b (2.17) | 153.03** |
| BIS | 54.68a (4.83) | 67.77c (5.52) | 52.72d (5.31) | 68.91b (6.26) | 124.69** |

BMI; Body Mass Index = kg/m², RS; Restraint Scale, BIS; Barratt Impulsiveness Scale. Means with same superscript are not significantly different; means with different superscripts (a, b, c) are significantly different (Bonferroni corrected); ** $p < 0.01$. For instance, the mean BMI of low-impulsive, low weight concerned women does not significantly differ from the mean BMI of high-impulsive, low weight concerned women. However, it did significantly differ from the mean BMI of low-impulsive, high weigh concerned women.

**Table 2** Means (standard deviations) for age, BMI, weight concern and impulsivity as reward sensitivity

| | **Low impulsive low weight concern** | **High impulsive low weight concern** | **Low impulsive high weight concern** | **High impulsive high weight concern** | F(3,210) |
|---|---|---|---|---|---|
| | n = 67 | n = 63 | n = 42 | n = 42 | |
| Age | 40.81b (7.02) | 36.65a (7.31) | 41.31b (6.28) | 38.52b (7.50) | 5.26** |
| BMI | 24.28b (4.73) | 23.60a (4.15) | 30.11 (6.87) | 26.45b (4.22) | 16.82** |
| Weight Concern | 3.75a (1.72) | 4.14a (1.50) | 9.26b (2.19) | 9.55b (2.04) | 152.95** |
| BAS | 32.04a (2.69) | 39.76b (3.26) | 31.81a (2.59) | 39.29b (2.61) | 128.89** |

BMI; Body Mass Index = kg/m², RS; Restraint Scale, BAS; Behavioural Activation System of the BIS/BAS scale. Means with same superscript are not statistically different, means with different superscripts (a,b) are statistically different (Bonferroni corrected); ** $p < 0.01$.

**Table 3** General statistics (means, standard deviations and reliability coefficients) of the RS, the BIS and the BAS scale of the BIS/BAS scales

| | **Total sample** (N = 214) M (SD) | **α** |
|---|---|---|
| RS | 11.26 (5.33) | 0.80 |
| Weight Concern | 6.08 (3.24) | 0.71 |
| Weight Fluctuation | 5.17 (2.74) | 0.70 |
| BIS | 60.56 (8.96) | 0.83 |
| Motor Impulsiveness | 20.09 (3.50) | 0.66 |
| Attentional Impulsiveness | 16.41 (3.32) | 0.70 |
| Non-planning Impulsiveness | 21.64 (3.75) | 0.65 |
| BIS/BAS scales | | |
| BAS Drive | 9.65 (2.31) | 0.72 |
| BAS Fun Seeking | 10.45 (1.77) | 0.48 |
| BAS Reward Responsiveness | 15.60 (2.15) | 0.63 |
| BAS total | 35.69 (4.75) | 0.76 |

RS; Restraint Scale, BIS; Barratt Impulsiveness Scale, BAS; Behavioural Activation System of the BIS/BAS scale

### Yoyo-effect and RS subscale Weight fluctuation

Pearson product-moment correlations between the RS weight fluctuation subscale and the five yoyo-items were computed to test whether the yoyo-items were an adequate measure of weight cycling. There was a strong positive correlation between the two scales ($r = 0.62$, $p < 0.01$) and thus the five yoyo-items served as dependent variable in the subsequent analysis.

**Trait impulsiveness and the yoyo-effect**

A 2 (trait impulsivity: high vs. low) by 2 (weight concern: high vs. low) between-subjects analysis of variance (ANOVA) with the yoyo-effect as dependent variable was conducted to test the prediction that trait impulsive people will experience the yoyo-effect to a greater degree. Indeed, as is shown in Figure 1, impulsive participants showed higher weight cycling scores when trait impulsivity was measured by the BIS ($F(1, 210) = 4{,}18$, $p < 0.05$). This effect is only significant when classifying median scores of weight concern of 6 and lower as low weight concerned and median scores of BIS of 60 and lower as low impulsive. Non-significant effects pointing to the same direction are found when classifying weight concern and BIS median scores as high weight concerned and high impulsive. Furthermore, a strong effect of weight concern was found ($F (1, 210) = 86.97$, $p < 0.01$): the more one was concerned about one's weight, the more one experienced the yoyo-effect.

The second hypothesis stated that impulsive people who are at the same time concerned about their weight, will experience weight cycling to a higher degree. However, this hypothesis was not confirmed ($F (1, 210) = 0.01$, $p = 0.94$). Removing the non-significant interaction effect did not affect the main effects.

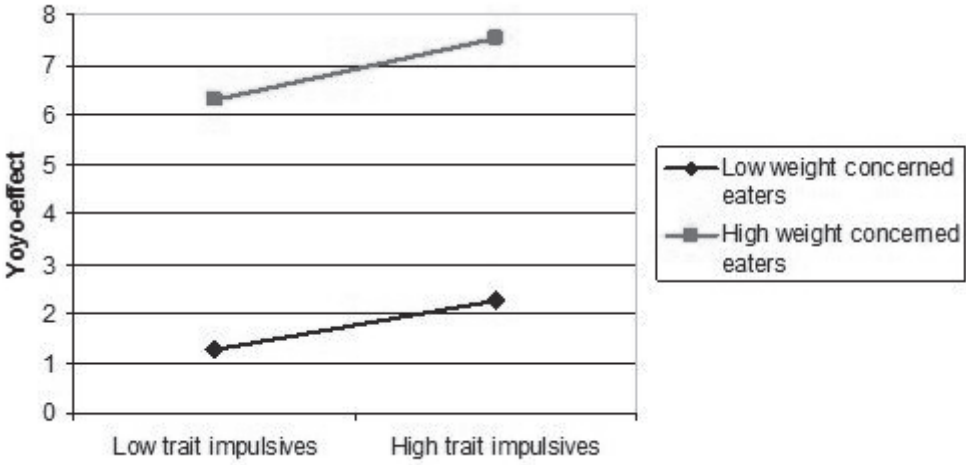


**Figure 1**. Estimated Marginal Means of the main effects of trait impulsiveness (low vs. high) and weight concern (low vs. high) on the yoyo-effect.

**Reward sensitivity and the yoyo-effect**

For the measurement of impulsivity as reward sensitivity, we utilised a 2 (impulsivity as reward sensitivity: high vs. low) by 2 (weight concern: high vs. low) between-subjects analysis of variance (ANOVA) with the yoyo-effect as dependent variable to test the prediction that reward sensitive people will experience the yoyo-effect to a higher degree. There appeared to be no significant main effect of impulsivity as measured by the BAS scale of the BIS/BAS scales ($F (1, 210) = 0.22$, $p = 0.64$).

Furthermore, our second hypothesis was also not confirmed. Reward sensitive

people, who are at the same time concerned about their weight, did not experience the yoyo-effect significantly more than reward sensitive, low weight concerned people ($F(1, 210) = 2.03$, $p = 0.16$). However, a strong main effect for weight concern was found ($F(1, 210) = 91.96$, $p < 0.01$), demonstrating that higher scores on weight concern are associated with weight cycling. Again, removing the non-significant interaction effect did not influence the main effects.

## DISCUSSION AND CONCLUSION

The current study aimed to investigate the effects of impulsivity and weight concern on weight cycling. It was examined whether two aspects of impulsivity (i.e. trait impulsiveness and reward sensitivity) by themselves and in combination with weight concern, are related to the yoyo-effect. First, for the measurement of trait impulsivity, it was found that impulsivity is related to the degree of weight cycling; the more impulsive one is, the more one experiences the yoyo-effect. A similar effect of weight concern was found; the more one is concerned about weight, the more the yoyo-effect is experienced. Second, when impulsivity was measured as reward sensitivity, weight concerned people proved to experience the yoyo-effect to a higher degree as well. However, results of this measurement did not reveal a significant association between reward sensitivity and the yoyo-effect. Furthermore, results from both measurements of impulsivity failed to show that weight cycling follows from an interaction between weight concern and impulsivity.

The first hypothesis was partly confirmed; impulsivity was related to the yoyo-effect when it was measured as trait impulsiveness. In addition, the concept of reward sensitivity was not related to the yoyo-effect. The fact that no strong association was found between reward sensitivity and the yoyo-effect could be due to the use of self-report questionnaires instead of behavioural tasks for impulsivity assessment. Self-report questionnaires provide a measurement for how participants perceive themselves, while behavioural tasks give an impression of actual behaviour. A study by Nederkoorn et al. (2006a) demonstrated different results for self-report and behavioural measures of impulsivity. Obese women appeared to be more impulsive when impulsivity was measured using a behavioural task, whereas three self-report measures did not reveal such effect. This denotes that behavioural tasks might be more appropriate to measure impulsivity in eating research. In the case of self-report, participants have to be able to introspect. Furthermore, participants could fill in the questionnaires in a manner that they think would be most appropriate, which leads to biased data. Therefore, it is suggested that future research should focus on whether impulsivity, as measured by behavioural tasks, is associated with the yoyo-effect.

Another explanation for the absence of a strong effect of impulsivity on weight cycling is that the role of impulsivity in eating behaviour is not as profound as previous research suggests. Maybe another variable plays an important role in eating behaviour and has not yet been discovered. A number of studies exist that did not find an influence of impulsivity on eating behaviour. For instance, a study by

Nederkoorn et al. (2006a) showed no differences in trait impulsiveness and sensation seeking between obese and normal weight women as measured by self-report. In addition, research revealed that anorexia nervosa patients (AN-R) score lower on self-report measures than purging-anorexia (AN-P), bulimia nervosa (BN) patients and controls as measured by self-report (BIS, BIS/BAS scale and Eysenck's Impulsiveness scale) (Claes, Nederkoorn, Vandereycken, Guerrieri, and Vertommen, 2006), but a significant difference between the different populations on the stop-go task was not discovered. These results do not prove that eating disordered populations that typically overeat are more impulsive; only AN-R patients are less impulsive than AN-P patients, BN patients and controls. Furthermore, high-impulsives eat more at a bogus taste test compared to low-impulsives as measured by self-report, but not when measured by a behavioural task (Guerrieri, Nederkoorn, & Jansen, 2007). Thus, further research has to be careful to not only focus on impulsivity as a variable in eating research.

The present study revealed, however, a strong association between weight concern and the yoyo-effect. In this study, the subscale weight concern of the RS was taken as a measure for eating restraint. The observed effect of weight concern on weight cycling is peculiar, as one would expect that especially participants who are concerned about their weight would want to loose and/or maintain weight. Earlier research indicates that restraint eaters have a greater tendency to overeat (Jansen et al., 2009). Taking this into account, it can be hypothesized that restraint eaters experience weight cycling to a greater degree, because of attempts to lose weight after committing the subjective sin of eating more food than a person permits oneself to eat.

Our second hypothesis stated that high-impulsive, high weight concerned eaters experience the yoyo-effect to a higher degree than high-impulsive, low weight concerned eaters. However, no interaction between weight concern and impulsivity was found, which rejects our second hypothesis. This is not in concordance with outcomes of a study by Jansen et al. (2009), who found that overeating is a result of an interaction between eating restraint and impulsivity. The difference in results could be due to the fact that Jansen et al. (2009) utilized a behavioural task for the measurement of impulsivity, while the present study relied on self-report measurements.

The current study suffered from some limitations. First, as noted before, only self-report measures were utilised. Second, the current design was cross-sectional in nature, which makes it impossible to establish a possible cause-effect relationship between impulsivity and weight cycling. A third shortcoming of this study is that only trait impulsiveness and reward sensitivity were measured and not response inhibition. Several studies have suggested that response inhibition is related to overeating (Nederkoorn et al., 2006a; Nederkoorn et al., 2006b, Nederkoorn et al., 2006c; Nederkoorn et al., 2010). Therefore, response inhibition seems to be an important variable in eating behaviour and further research is needed to explore the relationship between response inhibition and the yoyo-effect.

To conclude, key findings of the present study suggest a role for trait impulsiveness and weight concern in yoyo dieting. Trait impulsive people and weight concerned people show a higher degree of weight cycling. The hypothesis

that weight cycling is the result of an interaction between weight concern and impulsivity was not confirmed. Further research is warranted examining the underlying mechanisms of weight cycling. Discovering what makes some people yoyo-dieters and others not is of importance, as prevention and treatment of weight cycling would bring positive outcomes for individual's health.

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WIESJE PELKMANS

# $GABA_A$ receptor-mediated tonic transmission in sleep-wake cycles

Review

Sleep-wake cycles are an important physiological characteristic of the mammalian brain and essential for wellbeing and cognitive performance. In this review, a novel and comprehensive view on the organisation of sleep in the brain is described. Evidence is presented that sleep is regulated in a local manner and is dependent on prior cortical activity. Moreover, the composition, expression, and role of a specific type of GABA (γ-aminobutyric acid) inhibitory neurotransmission mediated by extrasynaptic δ-$GABA_A$ receptors, known as tonic $GABA_A$ transmission, is described. Furthermore, this article reviews findings linking the regulation of sleep to this tonic GABAergic conductance that is observed in the thalamo-cortical circuitry relevant to slow wave sleep. This will contribute to our understanding of the basic mechanisms underlying the contribution of GABAergic tonic transmission to the neural basis of sleep-wake regulation, to ultimately develop more efficient clinical interventions to treat sleep disorders.
**Keywords:** Sleep; GABA; Tonic; δ-$GABA_A$R; Local sleep

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## AN INTRODUCTION TO SLEEP AND ITS REGULATION

For several decades the importance of sleep has been recognised and confirmed in numerous research, including sleep deprivation (SD) studies (Banks & Dinges, 2007; Mahowald & Schenck, 2005; Zeplin, Siegel & Tobler, 2005). These studies indicated that sleep can be considered essential for health, wellbeing, productivity and cognitive performance (Krueger et al., 2008). In mammals and birds, sleep is

characterised by corresponding brain activity patterns that can be measured with a cortical electroencephalogram (EEG). These patterns can be divided into two stages: rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep (Zeplin et al., 2005). REM sleep is characterised by fast frequencies and low-amplitude waves resembling that of waking, accompanied by a loss of muscle tone and rapid movements of the eyes. Because neuronal activity during REM sleep and wakefulness are similar, REM sleep is also known as paradoxical sleep. In contrast, NREM sleep is characterized by high-amplitude slow waves. Deep NREM sleep is also classified as slow wave sleep (SWS) and considered important for sleep continuity (Dijk, 2009). Delta waves are associated with deep NREM sleep, encompassing the 0.75-4.5 Hz range. This slow wave rhythm originates from cortico-thalamic networks. The oscillations of this network depend on synaptic connectivity between thalamic relay neurons, neurons of the thalamic reticular nucleus, and cortical neurons (Crunelli & Hughes, 2010). The generation of these oscillations occurs by the synchronized switch of neuronal cells between a hyperpolarized and a depolarized state.

The regulation of sleep is thought to be attributable to the interaction of two processes (Borbély, 1982). One of these processes is an endogenous pacemaker in the suprachiasmatic nucleus (SCN) of the hypothalamus and is referred to as the circadian central biological clock. The output of this clock regulates most physiological processes and behaviours, including sleep. The appropriate entrainment of internal rhythms with light-dark cycles is controlled by this circadian system (Saper, Scammell & Lu, 2005). The other process tracks the time spent awake and is referred to as sleep homeostasis. Sleep-wake homeostasis enables organisms to compensate for the loss or the excess of sleep (Saper et al., 2005). Moreover, it reflects an increase in sleep pressure during wakefulness and a decline during sleep. Slow wave activity (SWA), i.e. delta activity, is considered a well-established EEG marker of NREM sleep intensity, and thereby of sleep homeostasis (Borbély, 1982).

This review will first summarise the basic mechanisms underlying sleep and a comprehensive view on how sleep is organised in a local and activity-dependent manner is described. Next, the properties of γ-aminobutyric acid$_A$ receptors ($GABA_ARs$) are clarified, and the individual δ-$GABA_AR$ subtype accounting for tonic inhibitory transmission is emphasised. Finally, possible mechanisms of GABAergic tonic transmission in cortico-thalamic regions relevant for sleep are examined. The overall aim of this review is to summarise and clarify the contribution of $GABA_AR$-mediated tonic transmission to the local, activity-dependent aspects of neuronal circuits across sleep-wake cycles. More refined knowledge on the underlying mechanisms of sleep-wake regulation, might eventually contribute to the wellbeing of those suffering from sleep disorders.

## LOCAL AND ACTIVITY-DEPENDENT ASPECTS OF SLEEP REGULATION

Sleep most likely has various functions. For example, it has been frequently proposed that sleep saves energy and restores behavioural performance (Krueger et al., 2008).

During sleep one gives up the opportunity to eat, drink, reproduce, or socialise, and becomes susceptible to predation. Therefore, it has been hypothesised that sleep must have an evolutionary crucial function. This concept has been acknowledged (Mignot, 2008), however it is not yet identified exactly what it is that sleeps at a molecular level.

Traditionally, sleep theories have assumed the occurrence of sleep at the level of the whole organism and the governance by central control mechanisms (Saper et al., 2005). This control system contains important neural regions such as the hypothalamus, the brainstem and the associated circulating neurotransmitters; serotonin, acetylcholine, adenosine, GABA, orexin (hypocretin), histamine, and noradrenaline. These theories approached the concept of sleep by the simplistic view of the animal or human either being in an awake or a sleep state. However, accumulating evidence imply a local aspect in sleep regulation. For instance, Mukhametov, Supin and Polyakova (1977) showed that dolphins engage in high amplitude delta wave sleep in only one hemisphere at the time. Correspondingly, following a 6 h SD in mice SWA was more enhanced in the frontal region than in the occipital region during the first hour of recovery and showed a faster decline (Huber, de Boer & Tobler, 2000). Also in humans, regional differences in brain activity (i.e. SWA) during a sleep episode have been observed (Werth, Achermann, Dijk & Borbely, 1997). Moreover, examination of surface evoked potentials (SEP) from several cortical columns during the sleep-wake cycle revealed that SEP frequently fluctuated independently from the whole animal vigilance state (Rector, Topchiy, Carter, & Rojas, 2005). In other words, cortical columns can display a wake-like state during whole animal sleep and vice versa, which suggests that sleep is a property of local neuronal networks rather than of the whole animal.

Besides evidence for a local aspect in the regulation of sleep, it was also demonstrated that the duration of the localised sleep state was dependent of the prior wake state (Rector et al., 2005). Thus, the longer a cortical column was in an awake-like state, the more likely it would transition to a sleep-like state. This supports the hypothesis that the transition is driven by homeostatic regulation. Furthermore, research by Vyazovskiy, Welker, Fritschy and Tobler (2004) suggested that an increase in sleep intensity in stimulated areas might reflect a higher metabolic activation. The authors investigated the EEG SWA during sleep after 6 h of SD and unilateral whisker stimulation in mice, and assessed metabolic activation of cortical areas with 2-deoxyglucose (2-DG) uptake levels. An interhemispheric asymmetry of 2-DG uptake and EEG delta power was found immediately after whisker-stimulated SD. This suggested that regional SWA interhemispheric differences are use-dependent and may be related to the regional pattern of metabolism of the waking episode. The phenomenon of localised afferent stimulation during waking leading to an increase in EEG delta wave power in the subsequent NREM sleep has been supported by studies in many species (e.g. rodents and humans) (Cottone, Amado, & Squires, 2004; Kattler, Dijk & Borbély, 1994; Vyazovskiy, Borbély & Tobler, 2000). A representative study by Kattler et al. (1994) aimed to selectively stimulate a specific brain area in humans by prolonged stimulation of one hand with a standardized vibration before sleep onset. After stimulation of the right dominant hand, EEG analysis showed a shift in power in the low-frequency range to the left hemisphere

in the sensorimotor cortex.

Overall, these findings lead to the conclusion that sleep occurs not only at the level of the whole organism, but sleep-wake states can also be seen as a local feature of cortical columns, and sleep may occur in any brain region in response to use. Notwithstanding the crucial influence of the SCN as a central control mechanism, it is highly unlikely that this is the single sleep promoter.

## TONIC GABAAR-MEDIATED TRANSMISSION

Multiple studies point towards the importance of inhibitory transmission on sleep-wake regulation (Curie, et al., 2013; Lu & Greco, 2006; Winsky-Sommerer, 2009). GABA is the main inhibitory neurotransmitter in the mammalian central nervous system (CNS), synthesised from glutamate by glumatic acid decarboxylase (Roberts & Frankel, 1950). It is estimated that at least one third of all neurons in the CNS use GABA as their primary neurotransmitter (Kullmann et al., 2005). Moreover, the core modulator of the circadian system within the SCN, has established GABA as the principal neurotransmitter in virtually all SCN cells (Cardinali et al., 1998). Neuronal connectivity and excitability are regulated by excitation and inhibition, which mainly depend on glutamatergic and GABA-ergic transmission, respectively, throughout the CNS. Most of the GABAergic neurons are interneurons and therefore have a major influence on neuronal firing patterns and activity levels of neuronal networks (Vithlani, Terunuma & Moss, 2011). In the CNS, a structural and functional distinction of $GABA_A$Rs divides ionotropic $GABA_A$Rs and $GABA_C$Rs, and metabotropic $GABA_B$Rs on which GABA acts. In this review, the action of $GABA_A$R-mediated transmission will be focused on. $GABA_A$Rs play a critical role in controlling the neuronal firing rate and adjusting neuronal excitability in mammals, making it a suitable mechanism in sleep and cognition. Furthermore, $GABA_A$Rs play a crucial role in the control of our sleep rhythms, and are a major site of action for the treatment of sleep disorders (Mohler, 2006). For many decades, drugs such as benzodiazepines and zolpidem that bind to $GABA_A$Rs, are most widely prescribed for insomnia (Lu et al., 2006). Insomnia can be defined as a sleep disorder accompanied by complaints of difficulty initiating sleep, difficulty maintaining sleep, waking up too early, and poor sleep quality, whereas sufficient sleep opportunity is present (Zeplin et al., 2005).

Different types of $GABA_A$R-mediated transmission can be distinguished. Traditionally, GABA transmission refers to phasic inhibitory postsynaptic currents (IPSCs) that follow activation of synaptic receptors by a transient high concentration of GABA released from the presynaptic terminal (Cardinali & Golombek, 1998). The hyperpolarisation of the membrane potential and shunting of excitatory currents is attributed to the direct activation of the ion channel and the resulting influx of chloride. This can be referred to as phasic inhibition. Recently, in contrast, there is growing evidence that extrasynaptic or perisynaptic $GABA_A$Rs, i.e. receptors located outside the synaptic cleft in somatic, dentritic and axonal membranes of neurons, are involved in tonic transmission and are of major importance for GABA

transmission as well (Brickley & Mody, 2012). These extrasynaptic $GABA_A$Rs are continuously activated by low concentrations of ambient GABA in the extracellular space, to generate 'background' tonic inhibition, see Figure 1 (Farrant & Nusser, 2005). GABA spillover from synapses on neighbouring cells is thought to be the main source that activates extrasynaptic $GABA_A$Rs (Semyanov, Walker, Kullmann, & Silver, 2004).

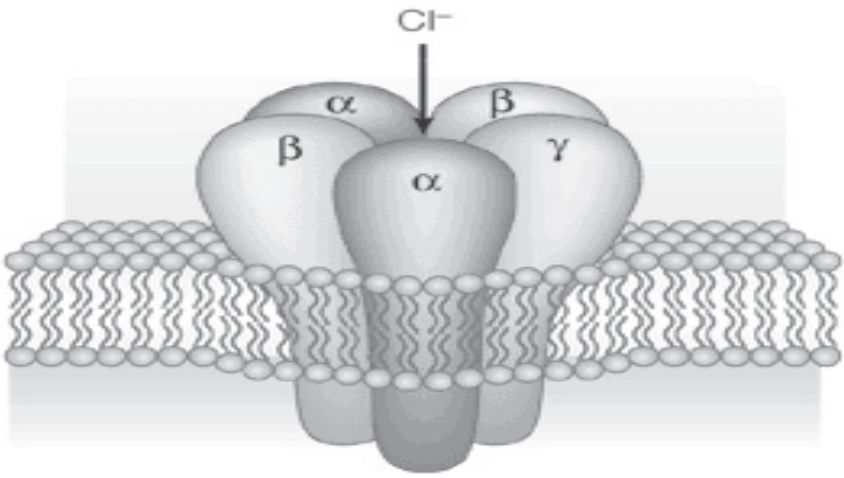


**Figure 1**. Illustration of different forms of GABAergic transmission. GABA is released into the presynaptic cleft. Binding of neurotransmitters to synaptic GABAARs results in fast inhibitory postsynaptic potentials (IPSPs). Activation of extrasynaptic GABAARs results in tonic conductance, that may play a significant role in the membrane potential. Figure taken from Rudolph and Knoflach, (2011).

Persistent active currents following activation of tonic $GABA_A$Rs make a major contribution to the total charge in the membrane (Kullmann, et al., 2005). One can speculate that in this manner the overall excitability of the system is controlled, by generating a steady conductance that is essential for reducing the gain in neuronal input and output. Thus, tonic transmission modulates both cell and network behaviour (Brickley et al., 2012). To summarise, phasic inhibitory postsynaptic currents result from the synchronous opening of synaptic $GABA_A$Rs, and tonic inhibitory currents result from the persistent opening of several extrasynaptic $GABA_A$Rs channels, both controlling the excitability of the membrane.

## $GABA_A$ receptor structure and anatomical expression

$GABA_A$Rs are heteropentameric complexes that function as ligand-gated chloride ion channels. They are composed of receptor subunits, of which a total of 21 have been identified, α1-6, β1-3, γ1-3, δ, ε, π, ρ1-3, and θ, see Figure 2 (Vithlani et al., 2011). This diversity in receptor composition leads to considerable anatomical, functional, and pharmacological heterogeneity. As a consequence, the $GABA_A$ subtype identity

reflects their differential contribution to phasic or tonic conductance (Farrant et al., 2005). The $GABA_A$ δ-subunit containing receptors are found almost exclusively at extrasynaptic sites and mediate tonic conductance (Nusser, Sieghart & Somogyi, 1998). To illustrate, the α4 and α6 subunits form channel complexes with δ subunits (α4βδ, and α6βδ), and are exclusively extrasynaptic, mainly accounting for tonic conductance in the thalamus and cerebellum, respectively (Nusser, Hajos, Somogyi & Mody, 1998).

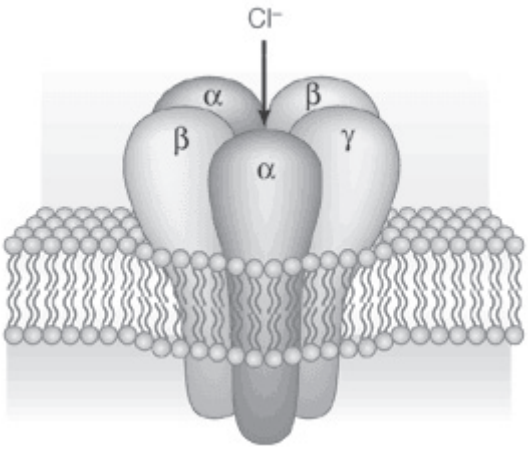


**Figure 2**. Schematic representation of the GABAAR complex, showing five protein subunits from seven subunit subfamilies (α, β, γ, δ, ε, π, and θ) that form a heteropentameric chloride permeable channel. In the majority of cases, GABAARs contain α and β subunits, and a γ, δ, ε, π, or θ subunit in a 2:2:1 stociometry. GABA binds at the interface between the α and β subunits, and triggers the opening of the channel allowing the influx of Cl- into the cell. Figure taken from Belelli & Lambert, (2005).

The composition of subunits is also a major determinant of the binding and gating properties of the ion channel. The extrasynaptic α6βδ and α4βδ subunit compositions display the highest affinity for GABA (Nusser et al., 1998). Thus, δ-containing receptors require low concentrations of GABA to reach the threshold of membrane potential. In addition, αβδ subunit containing receptors desensitise more slowly in comparison with the synaptic $GABA_A$Rs (Yeung et al. 2003). Another important finding is that δ-subunit containing receptors are highly sensitive to 4,5,6,7-tetrahydroisoxazolo(5,4-c)pyridin-3-ol (THIP) (Brown et al., 2002), also known as gaboxadol, a selective extrasynaptic GABA agonist. THIP is thought to act primarily through extrasynaptic receptors, on which THIP has higher efficacy than GABA (Brown et al., 2002). A 5μM administration of THIP in mice produced

a larger tonic current in dentate gyrus granule cells than GABA (Maguire, Stell, Rafizadeh & Mody, I, 2005). Also, extrasynaptic receptors are important targets for other neurodepressive drugs, including, anaesthetics, neurosteriods, and alcohol. Altogether, δ-$GABA_A$Rs that generate tonic inhibitory conductance have unique properties to generate significant inhibiting function despite of low extracellular GABA concentrations.

Immunohistochemical studies have demonstrated that each one of the $GABA_A$R subtypes has a distinct regional and cellular distribution within the brain (Kullman et al. 2005; Sun et al. 2004). Initially, mediation by α6βδ subunit containing receptors was first shown in cerebellar granule cells, *in vitro* (Nusser et al., 1998), and *in vivo* (Chadderton, Margrie & Häusser, 2004). Moreover, tonic $GABA_A$ activation has been demonstrated in the hippocampus abundantly as well, including dentate granule cells, mossy fibres, and interneurons in the CA1 region (Semyanov, et al., 2004). Tonic conductance has also been reported in hypothalamus (Park, Skalska, Son & Stern, 2007), medium spiny neurons of striatum (Ade, Janssen, Ortinski & Vicini, 2008), neocortical layer 2/3 pyramidal cells (Drasbek & Jensen, 2006), spinal cord (Takahashi, Mashimo & Uchida, 2006), and in the thalamus (Cope, Hughes & Crunelli, 2005). To conclude, the extrasynaptic receptor subtype is highly expressed in structures which are essential in the regulation of vigilance states, i.e. the thalamus, hippocampus and cortex.

## TONIC INHIBITION IN BRAIN REGIONS AND CELL POPULATIONS RELEVANT FOR SLEEP

Studies investigating the molecular correlates of sleep loss (Cirelli, 2006) have identified that the effects of SD probably reflect altered neuronal excitability and synaptic communication in neuronal networks implicated in cognition and vigilance states. *In culture* studies showed that increased activity through maintained wakefulness led to increased $GABA_A$R density accompanied by increased inhibitory currents on hippocampal neurons (Marty, Wehrle, Fritschy & Sotelo, 2004). Moreover, an immunostaining experiment by Modirrousta, Mainville and Jones (2007) performed a 3 h total SD in rats, and showed a significant enhanced expression of $\beta_{2\text{-}3}$ subunit of $GABA_A$Rs on basal forebrain cholinergic cells. These effects were only seen in prolonged wakefulness and reversed after 3 h of recovery sleep. Thus, an acute short-lasting SD may immediately influence the expression of GABAergic tonic transmission.

The preceding paragraph described the predominant expression of δ-subunit containing receptors in regions that play a crucial role in sleep regulation, such as the ventro-basal nucleus of the thalamus and the neocortex (Peng et al., 2002; Pirker et al., 2000). The strong expression of δ-$GABA_A$Rs in thalamic nuclei suggests that the functions of the δ subunit are important in these nuclei, which controls the sleep-wake state, processes specific sensory and motor information and interacts reciprocally with specific regions in the cerebral cortex (Saper et al., 2005). The crucial role of thalamic nuclei in sleep has been demonstrated in multiple studies.

For example an imaging study by Maquet et al., (1999) revealed that differences in regional cerebral blood flow in the thalamus correlate with a specific state of consciousness and sleep. Moreover, the rodent ventrobasal (VB) thalamus contains a large population of thalamocortical (TC) neurons which receive excitatory input from the vibrissae and the somatosensory cortex (Jiménez-González, Pirttimaki, Cope & Parri, 2011). TC neurons in the VB thalamus mainly exhibit tonic $GABA_A$ inhibition. That is, over 80% of $GABA_A$Rs-mediated inhibition in TC neurons is tonic (Bright, Aller & Brickley, 2007; Cope et al., 2005). A study by Herd et al., (2009) using $GABA_A$Rs δ subunit knockout (KO) mice showed reduced inhibition in TC neurons, whereas IPSCs were largely unaffected. That is, research using genetically modified mice which lack the genes encoding for δ subunits implicate that extrasynaptic $GABA_A$Rs are required in sleep processes (Herd et al., 2009; Peng et al., 2002). Furthermore, behavioural state-dependent physiological cortico-thalamo-cortical oscillations are mainly influenced by the thalamus (Saper et al., 2005). Tonic inhibition generated by δ-$GABA_A$Rs may be involved in modulating the magnitude and frequency of network oscillations typical for a vigilance state and the corresponding behaviour. Tonic $GABA_A$R-mediated conductance in the thalamus promotes burst firing of thalamic relay neurons, essential for the generation of slow EEG NREM rhythms (Bright et al., 2007; Cope et al., 2005). Bright et al. (2007) demonstrated that stimulation of tonic $GABA_A$Rs in thalamic slices promotes the firing characteristics of NREM sleep; conversely, blocking tonic $GABA_A$ transmission mimics transitions from NREM to REM/wakefulness.

Findings on the major influence of tonic inhibitory transmission in sleep are supported by studies using pharmacological agents. A study by Winsky-Sommerer et al., (2007) suggests that δ-GABAARs mediate the effect of THIP on sleep. The authors administered THIP to wild-type and δ-GABAARs KO mice, resulting in large NREM EEG changes in wild-type mice, while no significant changes were observed in the δ-subunit-deficient mice. In humans, THIP showed enhanced EEG slow waves, improved sleep continuity, and total sleep time. Thus, the effect of THIP on extrasynaptic GABAARs is associated with an EEG pattern of deep sleep. The GABAAR agonist has undergone clinical trials as a deep sleep-inducing hypnotic but has been terminated in Phase III clinical trial (Winsky-Sommerer, 2009). More effective δ-GABAAR selective agonists are being developed (Wafford et al., 2009). Taken together, numerous studies confirmed the essential role of the thalamus in governing sleep by generating thalamocortical oscillations and mediating the abundant tonic transmission in this brain structure. As a result, alterations in thalamo-striatal-cortical network, may involve alterations in extrasynaptic δ-GABAAR function, and likely underlie many sleep disorders.

## CONCLUSION

This review provided an innovative and comprehensive view on the organisation of neural sleep and an overview of previous work on the role of extrasynaptic inhibitory transmission in sleep, ranging from molecular studies to behavioural experiments.

Evidence is presented that sleep is initiated locally as a consequence of use, and is then consolidated by central control mechanisms. Additionally, the most recent findings on the heterogeneity of the $GABA_AR$ and the anatomical, functional and pharmacological profile of the δ-containing subtype were reviewed. The differences between synaptic and extrasynaptic $GABA_ARs$ and their relation to phasic and tonic inhibition were described as well, paying special attention to the contribution of extrasynaptic receptors to neuronal excitability in thalamic nuclei. Finally, the role of $GABA_ARs$ in sleep-wake cycles is further clarified. The review demonstrated the strong expression of extrasynaptic $GABA_ARs$ and its associated abundant tonic inhibition in brain regions which control the sleep-wake state. Because of the heterogeneity of receptors that mediate GABA activity, with various distributions and physiological characteristics, there was need to highlight the expression and action of the $GABA_AR$ subtype, and the δ-$GABA_AR$ has proven itself essential in the regulation of sleep. Because of the increasing quantity of information on this topic, there is a need for researchers and clinicians to have a concise source of information on the role of extrasynaptic $GABA_AR$-mediated transmission in cortico-thalamic regions and associated sleep regulation.

Accumulating evidence indicates that extrasynaptic $GABA_ARs$ play an essential role in sleep-wake cycles, and therefore as targets for drugs for sleep disorders such as insomnia. The concluding observations from population-based longitudinal studies is that approximately 20-30% of adults experience one or more symptoms of insomnia: difficulty initiating sleep, difficulty maintaining sleep, waking up too early, and poor quality of sleep (Morphy et al., 2007; Ohayon & Sagales, 2010). These findings are of great concern, due to the chronicity of insomnia it is associated with serious impairments in the quality of life. However, the exact role of extrasynaptic $GABA_ARs$ is only beginning to be clarified. A greater understanding of the mechanisms underlying sleep and detailed knowledge of the molecular composition and anatomical expression of specific $GABA_AR$ subtypes is crucial to understand the actions of GABA within the brain. Because of the major impact of tonic inhibition on neuronal excitability, its pharmacological profile, and its distribution in neural circuits involved in the generation of sleep, this form of inhibition could be an important novel pharmacological target for the treatment of most sleep disorders, and multiple neurological and psychiatric disorders as well. Drugs acting at δ containing receptors may increase sleep continuity, increase EEG power in the SWA range, and improve the subjective sleep quality (Winksy-Sommerer et al., 2007). In view of the fact that most sedative drugs are associated with side effects, such as day-time sedation and addiction, more detailed knowledge will aid in developing subtype selective clinical relevant drugs. Orser (2006) hypothesised that besides the involvement in sleep-wake cycles, extrasynaptic GABAergic receptors are also involved in consciousness and memory processes. Therefore, the development of compounds with hypnotic effects, that do not influence cognition, is challenging for the future. Research on the specific role of $GABA_AR$ subtypes might contribute to this, for example by the development of subunit specific KO and knock-in animal models.

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MARIAN SCHNEIDER & INGO MARQUARDT

# The negative neural correlates of consciousness

Essay

For a long time, scientists and philosophers alike have been speculating about the neural correlates of consciousness (NCC). Although definitions differ, usually an NCC denotes neural events whose occurrence correlates with our phenomenal experiences. In this essay, we motivate the introduction of the concept of a 'negative neural correlate of consciousness' (NNCC). The NNCC can be conceptually understood as neural events whose occurrence inversely correlates with a given phenomenal experience. We wish to introduce this concept for two reasons. First, it is an elegant solution to the problem of sufficiency that so far has unduly been neglected in the NCC debate. Secondly, based on the Integrated Information Theory of Consciousness, we argue that only by pairing up each NCC with a corresponding NNCC will scientists ever be able to predict conscious experience from brain data. We discuss empirical implications of and potential objections to the suggested NNCC framework.
**Keywords**: Consciousness, Neural Correlates of Consciousness, Philosophy of Mind, Cognitive Neuroscience, Integrated Information Theory of Consciousness

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## INTRODUCTION

In his seminal essay "What is a Neural Correlate of Consciousness?" David Chalmers (2000) discussed important conceptual aspects and caveats of the notion of a neural correlate of consciousness (NCC). He roughly approximated an NCC as a neural system N whose state correlates directly with states of consciousness.

Taking this approximation as a starting point, he then focused his attention on two aspects: what the relevant states of consciousness are and what it means for a state to correlate directly. With respect to the first point—the states of consciousness—he differentiated between states of merely being conscious vs. unconscious, background states of consciousness (awake, asleep, dreaming, under hypnosis), and contents of consciousness. The contents of consciousness are the fine-grained states of subjective experience that one is in at any given time (e.g. experience of a particular visual image, of a particular sound pattern, of a detailed stream of conscious thought). Accordingly, Chalmers defined a content NCC as a neural system N such that the content of N directly correlates with the content of consciousness. Regarding the second point—the nature of the correlation—he concluded that the NCC state should be minimally sufficient for the conscious state. Consequently, he arrived at the following formal definition of an NCC:

> "An NCC is a minimal neural system N such that there is a mapping from states of N to states of consciousness, where a given state of N is sufficient, under conditions C, for the corresponding state of consciousness" (Chalmers, 2000, p.22).

If one is specifically interested in the contents of consciousness, the definition can be put in more specific terms:

> "An NCC (for content) is a minimal neural representational system N such that representation of a content in N is sufficient, under conditions C, for representation of that content in consciousness" (Chalmers, 2000, p.22).

Several authors have pointed out potential shortcomings and blind spots of these definitions. Noe and Thompson (2004) noted that the concept of an NCC rests on an internalist assumption and that this assumption by itself is still a matter of debate within philosophy of mind. Cleeremans (2005) drew attention to the fact that we should not only focus our search on *neural* correlates but also on *computational* correlates of consciousness. Finally, de Graaf, Hsieh and Sack (2012) argued that the term 'correlate' in 'neural correlate of consciousness' is ambiguous and needs to be refined. In their argumentation, de Graaf et al. (2012) pointed out that an NCC may fall into one of three distinct categories: It may be a prerequisite, a consequence, or the actual substrate of a conscious experience. Prerequisites and consequences of a conscious state are likely to be very general and may for example include neural mechanisms that are also associated with arousal and wakefulness. For instance, there are neural systems in the brain stem that are most likely important for general arousal and wakefulness, but these systems are probably not directly relevant for the specific content of conscious experience. Although prerequisites and consequences by definition always co-occur with a conscious experience, they do not directly underlie its subjective phenomenal content—as the neural substrate does. Only the neural substrate is the neural state that is directly underlying the experience and is neither a result nor a precondition for a specific conscious percept. It is the neural substrate that is most relevant to the consciousness debate (de Graaf et al., 2012). Overall, Chalmers' original NCC concept has led to a very productive debate, and

several refinements to the original definition have been proposed.

In this essay, we would like to present a further complement to the traditional concept of an NCC. An important aspect that has often been only implicitly assumed (or even neglected) in the past conceptual debate about the NCC is that the concept of correlation implies both positive and negative correlation. This becomes apparent when revisiting Chalmers (2000) definition and reconsidering the mapping of states from a neural system N to states of consciousness. As we argue below, representation of content in N will only be sufficient for the representation of that content in consciousness if, at the same time, the content in systems other than N is prevented from being mapped to consciousness. This additional qualification can be captured conceptually as negative correlation. In this context, a positive correlation means that if a neural event $N_1$ is present, a corresponding state of conscious experience $P_1$ is present ($r = 1$). By contrast, a negative correlation can be conceptually understood as the absence of specific neural events $N_2$ to $N_n$, while a phenomenal experience $P_1$ is fully present ($r = -1$). The new specification (that the absence of neural events $N_2$ to $N_n$ will be as crucial as the presence of event $N_1$ for conscious content) has not, or only implicitly, been considered in the past conceptual debate. Chalmers' definition, for example, makes no explicit mention of such an additional qualification. We suggest calling neural events $N_2$ to $N_n$ the negative neural correlate of consciousness (NNCC). By making an implicit assumption explicit, we hope to offer a new exciting conceptual framework, able to motivate new hypotheses and research.

Although the NNCC concept is based on a fairly simple idea we believe that it is not trivial. In fact, we argue that the concept of negative correlation matters for the search for NNCs, for two main reasons. First, as has long been recognized in the philosophy of science, a set of events can only be *sufficient* to produce an effect-event if the set includes an open-ended *ceteris paribus* clause excluding the presence of potential disruptors that could intervene to prevent *E* (Hoefer, 2010; Russell,1912). Thus, if we want a neural event N to be (minimally) sufficient for a corresponding conscious state, we will be forced to include an open-ended list that ensures the absence of potential 'content disrupters'. Content disrupters can be understood as neural events that interfere with the otherwise sufficient mapping of content from representative neural systems to conscious experiences. Here, we suggest that a more elegant solution to this problem is to pair each NCC with a corresponding NNCC, which is defined in global terms. Secondly, there is a strong additional motivation to complement the conventional ('positive') NCC by a corresponding NNCC. We argue that an NCC by itself is not able to account for the content of a corresponding conscious experience. To fully predict the content of a conscious experience, the NCC needs to be paired up with an NNCC. Consequently, an NCC (in the 'positive correlation' sense) will not be minimally sufficient for a corresponding conscious state. This argument is based on the Integrated Information Theory of Consciousness (IITC; Tononi, 2004, 2008, 2012). For these reasons, we think that the concept of a NNCC has important implications for the debate about consciousness and the search for the brain states corresponding to conscious experience.

## FIRST REASON: THE SUFFICIENCY PROBLEM

The basic assumption underlying the search for an NCC over the last 20 years has been that it is possible to find minimal neural events that will be sufficient to produce conscious experiences. However, the concept of sufficiency is fraught with problems, as has long been recognized in the philosophy of science (Russell, 1912). To understand why that is the case, imagine that we say that a set of events A, B, C will be sufficient to "make me go to the fridge to get a beer". For illustrative purposes, let us say that these three events are: I am thirsty (A), I want to quench my thirst with a beer (B) and I assume there is beer in the fridge (C).

If the set A, B, C is present, I will go to the fridge and have my beer. No worries here. However, let us consider three alternative scenarios. Imagine that the set A, B, C is present but that just when I am about to go to the fridge my friend tells me that there is no more beer in the fridge. Or, imagine that just when I want to get up from the sofa I suffer a sudden stroke and fall unconscious. And yet in a different case, imagine that when I am already in the kitchen a bird crashes into the kitchen windowpane and because I am much of a bird carer I hurry to its rescue. These scenarios highlight the point that suddenly the set of events A, B, C will not be sufficient anymore for me to go to the fridge and have a beer. Although A, B, and C are conjointly present and on every usual day would have been enough to make me have a beer, in these scenarios they were not.

Confronted with this problem, one could start making ad-hoc modifications. One could say that A, B, and C will still be sufficient to make me have a beer if my friend does *not* tell me that no beer is left, I do *not* suffer a sudden stroke, and *no* bird crashes into the kitchen window. Yet, as becomes easily apparent the list of things that do *not* have to happen for A, B, C to still be sufficient for the effect-event will be endless. We would, for example, also need to exclude that one of my ancestor died before she could participate in the reproduction relevant for my case, and that I did not choke on a pretzel the day before I wanted to get my beer, and so forth. More generally and formally, to achieve the desired sufficiency, we would be forced to accept an open-ended list of negative conditions. Such an open-ended *ceteris paribus* clause is certainly unsatisfactory from a philosophical point of view.

Why do these considerations matter for the concept of a (content) NCC? Let us assume that there is a minimal neural event N1. And let us furthermore assume that N1 is the perfect content NCC for the conscious experience P1. Thus, whenever N1 occurs a corresponding state of conscious experience P1 will also occur. According to Chalmers' (2000) definition, we could say that N1 is minimally sufficient for P1. However, consider the case that simultaneously to N1 another neural event N2 also occurs. This co-occurrence does not necessarily cause the phenomenal experience P1 anymore but might cause a fundamentally different phenomenal experience P2 (see below for a concrete example). Again, we could modify and say that N1 will still be sufficient for P1 unless N2 occurs. Yet—just as in the example with the beer—this would leave us with an open-ended list of potential disrupters that we would need to exclude. We suggest calling events like N2 *content disrupters*, for their occurrence disrupts the otherwise sufficient mapping of content from representative neural systems to conscious experiences like P1. As we hope to have shown in this section,

if we wanted a neural event N to be (minimally) sufficient for a corresponding conscious state, this would force us to include an open-ended *ceteris paribus* clause excluding the presence of potential content disruptors that could intervene to prevent P1.

## SECOND REASON: THE INFORMATION INTEGRATION THEORY OF CONSCIOUSNESS

In addition to the before mentioned philosophical motivation for introducing an NNCC, we think that the NNCC can be further motivated and sustained by the help of a thought experiment. The thought experiment is inspired by Guilio Tononi's Integrated Information Theory of Consciousness (2004, 2008) as well as by his recent book "Phi" (2012).

## THE PHOTODIODE THOUGHT EXPERIMENT

Imagine that you are standing in an empty room, that the light is switched off and that all sounds are absent. The sound of your own breathing can be neglected for now. Assume further that you have regular functioning of your body including your brain and that you are awake and thus fully conscious. Everything is black and you have the conscious experience of seeing black only; the room is perfectly quiet and you are not exposed to any other sensory sensations. Imagine too that there is also a photodiode in the room. A photodiode is an electronic component that senses light. The photodiode in this thought experiment can differentiate between two states: dark or light. If one were to ask you now whether you experience darkness or lightness, you would in all likelihood say 'darkness' since the room is dark. If one were to consult the photodiode about the same question, it would equally signal 'darkness'. Does that mean the photodiode has the same phenomenal experience you have? The intuitive answer is 'no'. We guess that most people would intuitively deny that the photodiode has any conscious experience at all. Yet, we cannot be sure of this since there is no consciousness meter to check, and intuition can trick us into conclusions that are very remote from the truth.

In order to ground answers in a sounder framework, let us refer to Guilio Tononi's (2004, 2008) Integrated Information Theory of Consciousness. According to this theory, consciousness corresponds to the capacity of a system to integrate information. This proposition is based on two phenomenological properties of consciousness: the unity of conscious experience (conscious experience is always integrated) and the availability of a large number of different conscious experiences (differentiation). Information is generated by differentiating between conscious states. Furthermore, the theory suggests measuring the degree of integrated information as the phi value of a system. According to the theory then, both the human and the photodiode in the dark room are conscious. Yet, the human is

conscious to a much higher degree than the photodiode is (the human has a much higher phi value). One might wonder how that is possible even though both human and the photodiode are confronted with the same situation—total darkness, total black—and both signal the same responses. The theory claims that the capacity of the human to integrate information is higher than that of the photodiode. The difference between the human and the photodiode in this case does not lie in the integration aspect, which should be similar, but it lies in the information aspect. The human integrates much more information than the photodiode does. In this context, information is understood as the reduction of uncertainty among a number of alternative states. Thus, information is mainly a measure of which phenomenal experiences are excluded by the current phenomenal experience. If the photodiode is in the conscious state of experiencing 'dark', it only excludes one single other state ('light') and therefore does not generate much information. By contrast, if the human is in the conscious state of only experiencing 'dark', this excludes a myriad of other possible phenomenal states. If a human only experiences the blackness of a dark room, this experience excludes the possibility that the human at that moment experiences blue, green, yellow, white, and any other colour. Yet, it does not only exclude the possibility of experiencing colours or seeing anything else (shapes, faces, words). It furthermore excludes the possibility that the human was, at that moment, experiencing any other sensation be it a sound, smell, touch or an itchy right foot. Moreover, the example phenomenal state excludes experiencing any possible combination of the aforementioned sensations. Thus, this one particular phenomenal experience excludes an unlimited number of alternative phenomenal states for the human, while it excludes only a single other states for the photodiode. In different words, the photodiode's repertoire is minimally differentiated, while the one of the human is immensely so. As a result, the human is much more conscious than the photodiode; yet, the photodiode is still conscious with one bit because it knows to differentiate between two states (Tononi, 2004).

## IMPLICATIONS OF THE PHOTODIODE THOUGHT EXPERIMENT

What implications do the insights gained above have for the search for an NCC? We think that the thought experiment with the photodiode and the Integrated Information Theory of Consciousness imply the concept of a negative neural correlate of consciousness (NNCC). The total absence of light, as in the thought experiment, is a special case because the absence of light implies the absence of any colour. Therefore, let us now assume that the room is illuminated in blue. In this case, the human in the room would have the phenomenal experience of seeing blue. To predict this first-person perspective of experiencing blue from the third-person perspective of brain data, researchers can proceed in two steps: First, they can try to identify the content NCC for experiencing blue (via bridging principles). Second, if this content NCC is present, they can predict the corresponding phenomenal experience to occur. If the content NCC were absent, they would predict the absence of the phenomenal experience. This is what we call a *positive* content NCC. As

science stands at the moment, the occurrence of particular neural events within brain areas $V_4$ and V8 are hot candidates for a positive content NCC of experiencing colours.

Consider the ideal case (for a neuroscientist) that a particular neural event in brain areas $V_4$ and V8 would produce the conscious experience of the colour blue, and all other brain activity that correlates with this experience could be classified as neural prerequisites or neural consequences of consciousness. Hence, there would be a perfect (positive) correlation between the experience of blue and the identified neural events. If we wish to predict the content of experience from brain data, would it be right then to conclude that only this particular content NCC is relevant for our experience of blue? Could we really ignore all other neuronal events in areas $V_4$ and V8 as well as in the rest of the brain? We believe that this is not the case. Those neuronal events in areas $V_4$ and V8 that negatively correlate with the experience of blue (and positively correlate with the experience of colours other than blue) equally contribute to our experience of blue, namely by their absence. This may sound odd at first. However, we just established that what makes the human conscious experience different from the conscious experience of a photodiode, for example, is that being in a particular phenomenal state excludes a myriad of other possible phenomenal states. The phenomenal state of experiencing only blue excludes all other possible states of colour experience. Thus, when we want to predict a given first-person perspective of a human from brain data, we cannot only focus on those neural events that *do* occur (e.g. a certain neural events in areas $V_4$ and V8). Additionally, we need to consider other possible neural events that *do not* occur. Those off-states also contribute to our experience because it is only for them that information is generated and we are conscious the way we are. Only by considering those off-states too, will we be able to fully account for the experience of what it is like to be in a blue room for a human, as opposed, for example, for a photodiode.
There is no reason to restrict the NNCC to the colour domain or even the visual domain. The same reasoning equally applies to other sensory domains such as sound, smell, taste and touch. Moreover, internally generated sensations, thoughts, or states of mind cannot be ignored either and likewise have to be considered in the search for negative content NCCs.

## NNCC – ATTEMPT OF A FORMAL DEFINITION

Correlation also implies negative correlation. Thus, for the definition of an NCC it may not only be important which neural events are *present*, but also which ones are *absent*. According to our proposal, the quality and content of phenomenal experiences is not only determined by the presence, but also by the absence of neural events. Hence, the definition of a neural event that is minimally sufficient to produce a particular phenomenal experience would not only have to include the presence of certain neural events, but also the absence of others. This idea of an NNCC can be expressed more formally.

## NNCC EQUALS NOMOLOGICAL POSSIBILITY SPACE MINUS NCC OF THE GIVEN EXPERIENCE

Assume that there is a set S of neural events $N_1$ to $N_n$. Let us further assume that each of these neural events qualifies as a content NCC, in the 'positive' way it has been traditionally understood. Each of these neural events $N_1$ to $N_n$ represents content of some sort. Thus, if one of these neural events, for example event $N_i$, occurred, one may predict the occurrence of a corresponding phenomenal experience $P_i$. In accordance with Chalmers' (2000) conceptual framework, $N_i$ would be minimally sufficient for the phenomenal state $P_i$. However, we claim that the quality and content of the phenomenal experience $P_i$ is just as much determined by the absence of the set of neural events $S \neg N_i$. We suggest calling this set $S \neg N_i$ the *negative neural correlate* of the conscious experience $P_i$ since its occurrence relates inversely to $P_i$.

In fact, as we have argued, the set S should be global and include *all* neural events for which there is a possibility that the event be an NCC. First, this is because not including all those events would force us to make endless additional specifications to each NCC by excluding the occurrence of content disrupters whose presence could intervene to prevent $P_i$. Secondly, it should include all neural events because it is the exclusion of these events that generates information and thus eventually conscious experience. If we do not account for all of them, we will not be able to predict the difference between the conscious experience of a photodiode and a human when perceiving darkness.

When we say that the set S has to include all neural events that could possibly be NCCs, we are concerned with nomological possibility and not with logical possibility. In other words, the set S has to include all neural events that could be an NCC, given the way an individual brain is structured and functions, and given the laws of nature that determine how brains produce phenomenal experiences. In contrast, the set S does not have to include all neural events that could hypothetically be an NCC in differently structured nervous systems or even under different psychophysical laws, as this would unnecessarily inflate the concept. For these reasons, we propose to call S the nomological possibility space for NCCs. For a given conscious experience, the NNCC will then be defined by the nomological possibility space of NCCs minus the NCC of the given experience itself. Pairing up the NCC with a corresponding NNCC enables us to make sure that the neural correlate we are searching for is truly sufficient for the corresponding phenomenal state. This conceptual modification may bring us a considerable step closer to predicting conscious experience from brain data.

## THE NNCC IS CONTENT-SPECIFIC AND SHOULD NOT BE SUBSUMED UNDER CONDITIONS C

A different solution to the two problems outlined above might be to include the absence of neural events S ¬ Ni in the definition of conditions C under which $N_i$ is the neural correlate of $P_i$. However, we think that this is clearly not satisfactory because conditions C are not supposed to comprise components that are related to the specific content of a phenomenal experience. Instead, conditions C ought to be content-invariant background processes. Therefore, a better solution is to amend our concept of the neural correlate of $P_i$. Accordingly, the true neural correlate of $P_i$ is the pair of the positive correlate $P_i$ (as defined so far) and the negative correlate S ¬ $N_i$. If and only if both the positive correlate Ni occurs and the negative correlate S ¬ $N_i$ does not occur, under conditions C, does this lead to the phenomenal experience $P_i$. Thus, S ¬ $N_i$ cannot be ignored in defining the neural correlate of the phenomenal state $P_i$. Therefore, negative neural correlates should not be disregarded in the search for a neural correlates of consciousness.

## REINTERPRETING EMPIRICAL RESULTS – A CONCRETE EXAMPLE OF THE NNCC FRAMEWORK

Admittedly, given the current limitations of neuroimaging, especially in humans, it will not be possible in the near future, if ever, to map out the nomological possibility space for NCCs. Thus, empirical scientists might turn away disappointedly from our all too theoretical speculations. Yet we think that even for those scientists the NNCC concept offers a new framework of how to think about the results of research. This point can be illustrated by the example of past research on perceiving stationary and moving stimuli.

Several investigators (Beckers & Hoemberg, 1992; Sack, Kohler, Linden, Goebel, & Muckli, 2006; Silvanto, Lavie, & Walsh, 2005) used transcranial magnetic stimulation (TMS) over human brain area V5 to induce transient periods of akinetopsia. Participants were presented with moving random dot patterns and had to identify the direction of movement. During particular time windows, TMS over V5 disrupted motion perception. The time course of this effect (Sack et al., 2006; Silvanto et al., 2005) together with the results from a different TMS paradigm (Pascual-Leone & Walsh, 2001) suggests that in order to perceive the movement of a stimulus, this stimulus first needs to be processed in early visual cortex, followed by activity in V5, and subsequent recurrent activation of early visual cortex. These experiments suggest that the effect of disrupting area V5 is not that perception of a stimulus is obliterated in general, but that the percept loses a certain phenomenal quality—namely that of movement. Hence, neural events in area V5 positively

correlate with the perception of movement. Therefore, neural events in area V5 may be part of a negative correlate for the perception of a stationary stimulus. In the following, we are going to further strengthen this claim.

The motion aftereffect is a perceptual illusion that occurs after prolonged exposure to a moving stimulus. For instance, imagine you look at a waterfall for about a minute, without changing your gaze. When you afterwards fixate a different scene without movement, it seems as if part of this new scene is moving. This effect is specific to the part of your visual field where you previously saw the waterfall. This motion aftereffect has been studied with fMRI (Tootell et al., 1995; Culham et al., 1999; He, Cohen, & Hu, 1998), and it was shown that the illusionary movement of stationary stimuli after movement adaptation correlates with activity in area V5. Furthermore, area V5 is not simply active for a particular period of time after adaptation to a moving stimulus. Rather, it only activates when a stimulus is presented in the adapted region of the visual field and the motion aftereffect is actually experienced (Culham et al., 1999; He, Cohen, & Hu, 1998). If a period of darkness—i.e. total absence of visual stimulation—is included after adaptation, no movement is experienced and area V5 is not activated. When a stationary stimulus is subsequently presented, activity in area V5 and illusionary movement perception resume.

Additional evidence comes from an animal study in which electrical microstimulation was applied to direction-sensitive neurons in monkey area V5, also known as area MT (Salzman, Britten, & Newsome, 1990). Monkeys were trained to report the direction of movement of visual stimuli. When V5 neurons that had a particular movement direction preference were stimulated, the monkeys' reports were biased towards this direction. Although no introspective verbal report can be obtained in an animal study, the monkeys' behaviour suggests that the microstimulation probably induced an illusory percept of movement into a particular direction.

The experiments on the motion aftereffect in humans and microstimulation in area V5 in monkeys can plausibly be interpreted in terms of the NNCC framework. It appears that in order to perceive a visual stimulus as stationary, certain neural events in area V5 must *not* occur. Otherwise, the stimulus is perceived as moving—even if in fact it is stationary. If, for instance, after having looked at a waterfall for a minute or so one directs their gaze at a rock face next to the waterfall, a stripe of rock appears to be moving upwards. Hence, we expect the neural substrate of consciously perceiving the same rock face without movement to include a negative correlate—namely the absence of particular neural events in area V5.

## POTENTIAL OBJECTIONS TO THE NNCC AMENDMENT

We would like to respond to several anticipated objections to our NNCC framework. First, it could be argued that the NNCC framework is not backed up by empirical observations. Secondly, one could object that if we took the NNCC framework seriously, we would have to include the whole brain as a content NNCC for any given

conscious experience. Thirdly, the NNCC framework might be considered irrelevant for human-to-human comparisons. In the following, we will deal with each of these objections in turn.

## THE NNCC FRAMEWORK IS CONCEPTUAL, NOT EMPIRICAL

The nature of our argumentation is conceptual, not empirical. As things currently stand, we do not know the exact neural events that cause a particular phenomenal state, although many empirical candidates for an NCC have been proposed, such as 40 Hz oscillations (Crick & Koch, 1990; Engel & Singer, 2001), fast recurrent cortical feedback (Lamme, 2010), and many others. Therefore, we want our framework to be broad enough to leave room for different concrete neuronal correlates, and we refer to these as 'neural events'. In this context, it is important to note that the positive and negative neural correlates of a phenomenal experience can probably not simply be equated with two neural populations that ought to be active and silent, respectively, to cause a particular phenomenal experience. It is an open empirical question to find out what the exact neural correlates of consciousness are, but we would like to consider one example NNC in order to elucidate why the NNCC cannot necessarily be equated with a drop in firing rate. Baars (1988) put forward the theory that content becomes phenomenally conscious if it has access to the 'global workspace'. On the neural level, access to the global workspace could be mediated by a change in the synchronisation of neural populations (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Engel & Singer, 2001). Importantly, in this case the neural correlate of a phenomenal state may include absolutely no change in the overall firing rate of the relevant neural populations, but only a change in the timing (i.e. the phase) of spikes. This point illustrates why we prefer to use the term 'neural events' instead of for example 'neural activity'.

## THE NNCC IS GLOBAL IN AN ANATOMICAL SENSE, BUT SPECIFIC IN A FUNCTIONAL SENSE

Another objection to our proposal could be that the NNCC framework suggests including the whole brain as a content NNCC for any given conscious experience. Then, it could be contended that nothing would be gained by doing so. We would like to respond in two ways.

First, let us come back to the above example of experiencing a stationary visual stimulus. Again, the NNCC does not predict a total absence of activity in neural population. Even if a person is experiencing a stationary visual stimulus, motion sensitive cortical areas such as V5 do not necessarily go into hibernation and cease all metabolic and neural activity. The NNCC states that precisely those neural events that would give rise to the conscious experience of motion are not present. For instance, let us assume that fast recurrent cortical backward projections are

necessary for any conscious experience. Then we would argue that in order to perceive a given stimulus as stationary, no fast recurrent cortical feedback projections from area V5 to area V1 must occur. Thus, the NNCC does not subsume every kind of neural activity in a relevant brain area or cortical module or between these. Rather, it selectively excludes precisely those neural events that would give rise to conscious experience. Therefore, the NNCC is global in an anatomical sense, since the neural events that would act as a content disrupter for the respective phenomenal state must not occur in a whole lot of brain areas. In contrast, the NNCC is specific in a functional sense, because it only excludes precisely those neural events that are relevant for bringing about consciousness.

Having acknowledged the anatomically global character of the NNCC framework, we would like to voice a second response to the criticism that our proposal will result in too inclusive definitions. Namely, brain systems outside the cortical complex are unlikely to be included in our search. Neural events in the cerebellum, for instance, may neither qualify as a content NCC nor as a NNCC, for neither their presence nor absence contributes to our phenomenal experience. According to all the clinical and experimental evidence that has been gathered so far, the cerebellum does not contribute to our phenomenal experience (Tononi, 2012). This is accounted for by Tononi's (2004, 2008) theory, which assumes that although the cerebellum performs very sophisticated calculations, it is incapable of integrating information and thus does never correspond to conscious experience. Similarly, the processes in the brainstem and other subcortical systems do not need to be included in an NNCC because they are already accounted for as non-content-specific background conditions C in the definition of the neural correlate of consciousness.

A good guideline for deciding whether a neuronal event is an NNCC is to look whether there is any (nomologically) possible situation or case in which this neuronal event could contribute to our phenomenology—independently of whether it contributes at the very moment we measure it. If there is the nomological possibility, then the neuronal event should be considered as an NNCC. If there is no such possible case, like for the cerebellum, then it should not be considered as an NNCC. From all we know at the moment, the thalamocortical system might be a good starting point to look for content NNCCs.

## THE NNCC FRAMEWORK ALLOWS ACCOUNTING FOR HUMAN-TO-HUMAN VARIABILITY

Finally, another objection in the vicinity may be that the notion of an NNCC is not all too relevant for human-to-human comparisons. Critics might say that it is reasonable to expect that the nomological possibility space is roughly the same across humans. The NNCCs thus could be kept constant and would not matter too much for human-to-human comparisons. However, making this simplifying assumption would only address the problem resulting from the IITC (second reason) but not the problem of sufficiency (first reason). Furthermore, we think that we ought to be prepared to face some considerable human-to-human variability in the content

of phenomenal experiences; maybe we could simply ignore it so far because of the limitations in our current methods of comparison (e.g. verbal reports).

## DIRECTIONS FOR FUTURE RESEARCH

A particularly interesting direction for future research would be to investigate the predictions made by the NNCC framework at a microscopic level. Could it for example be that the neural correlate of perceiving the colour red at a given location in the visual field comprises particular neural event in colour-sensitive cells of the cortical module with the corresponding receptive field as a positive correlate, and the absence of the same neural events in other colour-sensitive cells in the same module? A similar logic may apply to the conscious perception of orientation. Another interesting prediction of the NNCC framework concerns the effects of lesions. If for example area V5 is lesioned, does this 'reduce' the total size of the content NNCC of perceiving a stationary stimulus? Does it reduce the overall capacity of visual consciousness? The NNCC framework predicts that the answer to these questions is yes. So what are the consequences of extreme lesions, such as for example severing the two cortical hemispheres like in split-brain patients, for the neural correlates of consciousness? We hope that the NNCC framework will inspire an interesting debate and further empirical investigations.

## CONCLUDING REMARKS

We introduced the concept of a negative neural correlate of consciousness (NNCC). An NNCC can be understood as a neural event that contributes to the content of phenomenal experience via its absence. Our framework is motivated by the problem of sufficiency. Furthermore, the framework is inspired by Tononi's (2004, 2008) information integration theory of consciousness, according to which "consciousness corresponds to the capacity of a system to integrate information" (Tononi, 2004, p. 1). In this theory, the unity of phenomenal experience is reflected in the fact that conscious systems *integrate* information, and the complexity of conscious experience is dependent on the ability of the system to *differentiate* between many alternative states. If consciousness is characterised by the integration of information and differentiation of alternative states, we cannot ignore those states that are excluded in our search for the neural correlate of consciousness. Hence, for the definition of a neural correlate of consciousness it may not only be important which neural events are present, but also which ones are absent. After all, the quality and content of phenomenal experiences is not only determined by the presence, but also by the absence of neural events. Therefore, the definition of a neural event that is minimally sufficient to produce a particular phenomenal experience would not only have to include a certain set of neural events that are present, but also such that are absent.

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NIENKE VAN ALPHEN

# Steps towards sustainable student support: Stressors among international high school students living in a boarding house

ORIGINAL PAPER

High school is a stressful time for any adolescent. But what about teenagers at an international boarding school? This study aimed to discover what stressors boarding students at an international school experience through a literature research and 15 semi-structured interviews with current students and recent graduates. The findings indicate that the boarders experience a wide variety of boarding-, peer-, and school-related stressors. Interventions are suggested to address the mentioned stressors and to help the school design effective programs to promote student wellbeing.
**Keywords**: adolescence, stressors, boarding school students.

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## INTRODUCTION

Adolescence is a critical time in child development. It is a time where one starts to make one's choices independently (Reyna, Chapman, Dougherty, & Confrey, 2012). Bandura's (1977) observational learning theory explains that people imitate behaviours of others, if they have a good reason to do so, such as fitting in. During adolescence, these social role models tend to be one's peers, especially one's friends (McWhirter, McWhirter, McWhirter, & McWhirter, 2013). Thus,

living with one's peers rather than one's parents is likely to have large impact on adolescent development.

Attending an international boarding school during high school can be a life-defining experience. It can allow students to grow, but it is not an environment free of challenges. Mead's (1928) sociocultural theory of adolescence that one's environment determines the type of stressors adolescents experience more than the genetic processes that take place during puberty. Mead's theory illustrates that 'typical' stressors in adolescence can take on a new meaning in a boarding school. By illustration, falling in love, developing intimate friendships, and exploring one's identity are common during adolescence (Bauminger, Finzi-Dottan, Chason, & Har-Even, 2008; Kerpelman et al., 2012). The intensity of these experiences is likely to be amplified when living with one's peers. The same increased intensity may be true for other adolescent experiences, such as bullying, depression, or loneliness (Newman, Holden, & Delville, 2005; Vanhalst et al., 2012). Various mental disorders are prevalent during adolescence, such as anxiety and mood disorders, eating disorders and adjustment disorder (Mann et al., 2011; Swanson, Crow, Le Grange, Swendsen, & Merikangas, 2011; Pelkonen, Marttunen, Henriksson, & Lönnqvist, 2007). These disorders can all be explained by the diathesis-stress model, which states that a particular genetic predisposition may only result in the disorder if one is exposed to environmental stressors (Wilmshurst, 2011). Living at a boarding school may increase the prevalence of disorders by affecting the intensity, amount or type of stressors.

A boarding school also adds context-specific variables. Leaving home as a high school student results in several potentially stressful changes (Wannebo & Wichstrøm, 2010). Wannebo and Wichstrøm found that these stressful changes lead to internalizing problems among girls. In a comparison of day and residential students, boarding students are at an increased risk for psychological problems (Niknami, Zamani-Alavijeh, Shafiee, & Seifi, 2011). High school students immigrating to foreign countries without their parents often experience culture shock and homesickness (Tartatovsky, 2007). A study with American college students about roommate living shows that both roommate conflict and close roommate friendships can cause significant stress (Dusselier, Dunn, Wang, Shelley, & Whalen, 2005). Acculturative stress, homesickness, and roommate living are likely to affect boarding students.

Unfortunately, not all boarding schools recognize the importance of understanding what stressors their students face and many rely on student resiliency as well as empathy of their residential and teaching staff to help students cope. This study aims to investigate what stressors are experienced by adolescents at an international boarding school. It is based on semi-structured interviews with three recent graduates and twelve current students, as well as literature research.

Findings about the stressors experienced by residential students at this particular school may be generalizable to those of boarders at other (international)

boarding schools. This study encourages other schools to consider the stressors experienced by their students and design health interventions.

Academically, this study will fill a gap in current scientific literature. To the author's knowledge, there are no published studies on psychological wellbeing of adolescents who were selected to go to an international boarding school. The findings will offer insight in the stressors these students experience and will extend the overall scientific knowledge of fields such as Health Psychology, Developmental Psychology, and Pedagogy.

## METHODS

### Pilot Needs Assessment

A needs assessment is a study of what is happening and what should be happening, with regards to a target population and situation (Gilmore & Campbell, 2005). It is important to be aware of a community's strengths and weaknesses, as this can help health educators design interventions that will maximize the community's unique resources (Bartholomew et al., 2011). This study will function as a pilot for a larger quantitative needs assessment.

### Data Collection

A qualitative research methodology is opted for, as no prior research has been conducted on stressors in this specific context. Therefore, it is important to understand the mental health situation from the view of the boarders, as main stakeholders. Qualitative methods are ideal for exploring their needs from an unbiased perspective.

Explorative interviews were conducted with three recent graduates to investigate relevant topics. The pilot interviews raised awareness of stressors such as the competitive environment, misunderstandings with teachers, roommate issues, and cultural differences. These topics formed the starting point for a literature research, which provided guidelines for the development of the interview guidelines for individual, semi-structured interviews with twelve current students. Individual interviews were used so that the students would feel comfortable enough to freely share their thoughts, as psychological wellbeing can be a sensitive topic. To recruit participants, the headmaster to posted a recruitment message on the students' Facebook group. The first to respond were included in the study, resulting in convenience sampling. The final sample consisted of twelve participants: five first years and seven second years, five boys and seven girls. Together, the boarders represented eleven nationalities: six from the Americas (Latin America, North America, and the Caribbean), four from Europe (both Western/Eastern), and two from the Middle East. The age of the participants ranged from 16-19.

The interviews were conducted in a room at the boarding school. Interviews were recorded. No one withdrew participation or refused to answer certain

questions. Students were compensated for their time with a local snack. Each interview lasted 20-30 minutes.

**Ethical Considerations**

To ensure student anonymity, all names were changed into gender-neutral ones and any other identifiers (gender; country) have been altered on the transcripts. The full transcripts are not accessible to staff or students at the school, to further protect confidentiality. The school's anonymity is also protected. Prior to the interviews, informed consent was given (in the case of minors by the headmaster). This study is part of a research line approved by the Research Ethics Board of the Faculty of Psychology and Neuroscience, Maastricht University, nr. ECP -04-09-2012.

**Data Analysis**

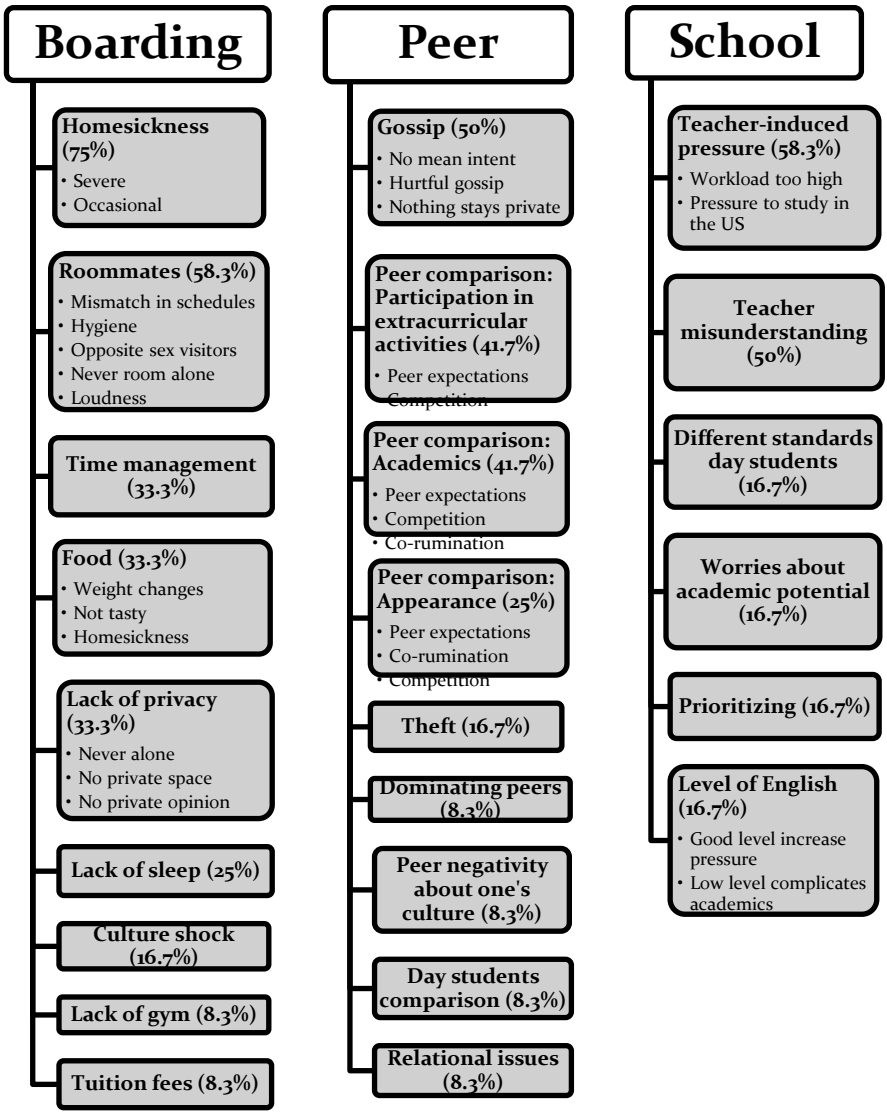
For data analysis, the grounded theory approach was been taken. This approach creates theory based on generated data and thereby reverses the conventional scientific approach, whereby data is collected only after a hypothesis has been formulated based on existing theory (Henwood & Pidgeon, 2003). According to this approach, the first step is to create inductive categories for coding. The key categories created were boarding-related stressors, peer-related stressors, and school-related stressors. Based on these categories, the interview data was coded and memos were created. Lastly, a written and pictorial analysis of the emerged themes was done.

## RESULTS

**Overview of Stressors**

These interviews aimed to discover what stresses boarding students at the school. Table 1 on the next page represents a pictorial overview of these stressors. This model is simplistic, as it does not represent the interactions between the various stressors, but it indicates preliminarily what topics in what domains should be addressed for a health promotion intervention at the school.

**Table 1.** Overview of Stressors. The percentages show what percentage of the participants brings a specific topic up as a stressor, regardless of whether it was mentioned as a personal stressor or one that they see other boarders experience.




*(n = 12 participants)*

**Boarding-Related Stressors**

The most-mentioned boarding-related stressor is homesickness. Many students have experienced homesickness. This seems inevitable, given that for the vast

majority of boarding students, coming to this school is the first time they are separated from their family. Homesickness also includes missing one's culture or home country, such as food or the weather. Overall, homesickness does not appear to cause significant stress in all students. Some students say that there is too much going on to be homesick. Others characterize it as occasionally missing home, for example around the holidays. However, a third group says that there are definitely boarders who struggle with severe homesickness. Riley actually claims homesickness as a major reason that one of his/her friends chose to leave the school. Simone explains that in the beginning it was very hard to be so far away from his/her family, but that in the second year (s)he somehow got used to this and that it was no longer such shock not to be able to go home often.

Seven participants say they have (had) issues because of living with roommates. These issues are very diverse and can be experienced as extremely intense. It can be the occasional argument, but also a yearlong struggle to live together. A major issue seems to be a mismatch in day-wake schedules. Different levels of cleanliness can also be a source of conflict among roommates or stress for an individual. Two participants say that it can also be problematic if there are frequently visitors of the opposite sex in the room. For instance, if one roommate has a serious relationship and spends a lot of time with his/her partner, others may feel uncomfortable in their own room as a result. On the other hand, many participants say how much they value their roommate relationships, as they have become even better friends by living together. It appears that roommates are mostly viewed as stressful when the students are only roommates and not friends. In a typical environment, students would be able to avoid those who they do not connect with and stay away from arguments. However, by sharing a room, conflict and the accompanying distress seem almost inevitable.

Four participants say that it can be quite stressful to manage time. It is a challenge to learn how to decide what to focus on. To illustrate, Riley's experience:

> "I was just not sleeping at all and having a lot of social life and a lot of study time and just no sleep at all and that was pretty bad."

Food is seen as a major stressor by four participants. They say that a lot of boarders find the food in their canteen disgusting. More importantly, it seems that the food is linked to weight changes that upset the students. Some are gaining a lot of weight. Riley thinks these gains may be due to students have comfort food either to compensate for the canteen food or because they are stressed about something else. Another reason could be that the food is usually fried and very oily, despite it being steamed in the canteen. On the other hand, Chris feels unable to eat this food and says the food lacks nutritional value, which results in weight losses. Both types of weight changes are perceived as stressful.

When students live together in shared rooms, feelings of a lack of privacy are not surprising. However, the experiences differ. Three students occasionally struggle that they are never alone. According to Spencer, the lack of privacy is experienced as omnipresent and quite intense:

> "Your space is not private, your opinion is not private, everything is out for show and that also has an affect on people and on confidence levels."

Lack of sleep also has an impact on the boarders' lives. Prolonged sleep deprivation in adolescence leads to difficulties in cognitive functioning and impairs performance (Orzeł-Gryglewska, 2010). Furthermore, sleep deprivation increase the subjective experience of stress; it mostly makes minor stressors seem very large (Minkel et al., 2012). Three participants speak about long-term sleeping difficulties. For some, such as Beau, it is upsetting to not get the amount of sleep (s)he wants. In Beau's case, sleep deprivation can be seen as a stressor in itself. For others, it seems that a lack of sleep reduces students' abilities to deal with the demands of the school and to intensify other stressors. For all, sleep deprivation appears to negatively impact their daily life.

Only two participants spoke about acculturative stress. Nevertheless, both claim that many students experience culture shock. This culture shock can be due to the mix of cultures or the host culture. Furthermore, the boarding school culture, such as the way older students interact, can also be a shock to some at first. The reason that culture shock is only highlighted by two participants could be due to similarities between the home culture and the host culture. Being motivated to attend an international boarding school may also reduce experiences of acculturative stress.

**Peer-Related Stressors**

With a small community of teenagers living together, gossip appears inevitable. Therefore, it is not surprising that six participants say that gossip is commonplace in the boarding school. Nevertheless, the majority says that the gossip is not intended to hurt anyone. People talk about each other, as they live in a "bubble", and very little stays private. Only two participants say that hurtful gossip is spread at times.

Peer comparison appears to be a major stressor. According to Riley:

> "Everyone who came to the boarding house was chosen by a group of people who wanted to choose the most competitive person. … You're special in some way. And not only are you special, you are not okay with being one in the bunch."

This quote illustrates the school's competitive environment. The three main domains impacted by social comparison are: participation in extracurricular activities, academics, and appearance. Within these domains, the comparisons are driven by the expectations the students have of each other, the (indirectly) competitive environment, and occasionally by co-rumination. Co-rumination is the *excessive* discussion of personal problems with a friend (Landphair & Preddy, 2012). In adolescent friendships, co-rumination increases the risk of internalizing symptoms (Rose, Carlson, & Waller, 2007). It seems that discussing problems triggers students to compare their experiences to their friends', which causes significant distress.

In comparing preparedness to participate in extracurricular activities, students seem to impose a pressure on one another to fit their ideas of the perfect student. The students come with different expectations of what the other students will be like and all are exposed to each other's expectations. This creates a pressure to live up to the social norms dictating the perfect student.

Academically, social comparison and observational learning set the standard for how much to study, what grades to get, and where to go for university. The students say that they feel that they should study, when they see others do so. Spencer says that if one student worries about not studying enough, he/she will talk about this concern to his/her friends and roommates, who will start to worry about their own studying. Alex notes that many boarders were among the top students at their old school, which makes people want, and expect, to succeed academically. This illustrates how co-rumination can amplify academic pressure, even if it was not there initially. Spencer ended up taking the SATs and writing many essays to go study in the United States, but that once (s)he got accepted, (s)he realized (s)he never wanted to study there in the first place and that the social expectancy to study in the US got to him/her.

In the section on boarding-related stressors, food's relation to weight changes has been discussed. Living together, boarders also observe these weight changes in each other. Riley says that it is sort of accepted to gain weight in the boarding school, because so many people do. At the same time, Alex points out that the peer competition also makes students strive to look the best, and perhaps gain the least weight. Spencer's answer exemplifies co-rumination in relation to appearance:

> "There are many girls constantly talking about their weight. They are just doing it between them, but started to make each other anxious, as a ripple effect."

Spencer's quote shows how the social comparison of each other's appearance, especially weight, can be severely stressful to some boarders.

Both Taylor and Michele refer to an incidence of theft in the boarding school this year. In itself, missing money can be stressful, especially for those boarders

who already do not have much money. However, both seem to worry more about the impact the theft had on the boarding school. It created a lack of trust in the community, which makes it harder to live together.

**School-Related Stressors**

The main school-related stressors have to do with the teachers. Seven participants experience the teacher-induced pressure about the amount of studying and homework that need to get done as extremely intense. In the students' eyes, most teachers only care about the academic curriculum, specifically their own subjects, and nothing else seems to matter. Jordan says the teachers even scare the students by telling lies. For instance, teachers say all homework count for the final grade, which is not true at all. Taylor agrees and finds the teachers quite aggressive, especially towards boarding students. Taylor says teachers would say things like "you are going to fail" to students, who can get extremely upset about this. Taylor even suggests that the teacher-induced pressure is possibly why some students start to self-mutilate. Riley also finds teacher pressure too intense and claims this was another main reason why his/her friend left.

Another problem with the teachers appears to be that some students feel that teachers do not understand they come to the school multiple reasons, rather than only academics. The students say the teachers do not understand it when at times life in the boarding school is so intense that a student may need a mental health day or struggles to meet a certain deadline once. Taylor notes that the teachers then just think the boarders are being irresponsible. Sam says most teachers have never even been to the boarding school and that therefore they cannot imagine what the boarders are going through. Simone says that the teachers hold the fact that some boarders receive funding over their head.

The expectations teachers have of the boarders are influenced by the presence of day students. Two students feel that this increased academic pressure for boarders. The teachers expect the students to only study and work for school once school is out, as the day students do so. The teachers do not seem to understand that it is harder to focus on academics after school due to all the other activities in the boarding school.

Students also have individual worries about achieving their full academic potential, which can increase the stress they put on themselves. Alex observes that quite some boarders study all the time and that it is very frustrating for them to not get the grades they want. In Beau's words,

> "I stressed about school so much. … People would say that it would be fine, but inside that just wasn't the case. It was internal hell."

Beau's quote illustrates the extreme pressure (s)he was putting on him/herself to succeed academically. Beau uses 'internal hell', as (s)he expresses that it pained

to be this stressed, which exemplifies the intensive experiences of academic pressure.

For Spencer and Simone it was a struggle to decide what to prioritize: social life or academics. Partially this has to do with time management, but it also comes down to one's goals. Simone says that one can either want amazing grades and not be social or have relatively good grades and be a part of the boarding community. Spencer found it hard to justify sacrificing academics for social things in the beginning, as (s)he constantly had to justify to others why (s)he would not study all night, but only one hour and spend the rest of the evening socializing.

## DISCUSSION

### Limitations

Firstly, there are limitations due to the sample. The sample size of twelve is rather large for a qualitative study and comprises a substantial percentage of the total population of boarders at the school. However, the underrepresentation of certain cultural groups underlines that the sample is of a non-random nature, which limits its ecological validity and suggests a possible response bias. It may be that the sensitive nature of this topic made it difficult for some boarders to come forward and discuss this face-to-face with a researcher. Furthermore, some participants mentioned that they had a specific reason why they wanted to do the interview, such as personally having struggled with the current counsellor services at the school. Such motives could further reduce the sample representativeness. The nature of this sample should therefore be kept in mind while interpreting the results.

Secondly, the short amount of time taken for the interviews is a limitation. To be able to delve into certain topics into more depth, more than 30 minutes would have been required. However, longer interviews were not possible, because of the limited time in which this study was conducted.

Finally, a limitation is that the collected data can be interpreted in multiple ways, which is a disadvantage of the grounded theory approach. To increase objectivity, the data has been interpret in light of available literature and the memos explaining how each quote has been interpret can be made available upon request.

### Important Findings

Despite these limitations, this study had several important findings. Firstly, it becomes clear that students struggle with boarding-related issues such as those linked to sharing rooms, time management, and a lack of privacy. Secondly, the major influence that the boarders have on each other through behavioural

modelling is revealed. Thirdly, a mismatch of expectations between teachers and boarders came to light.

**Suggested Interventions**

These findings lead to several suggested interventions to promote student wellbeing. One way would be to develop a class curriculum for boarding students, which addresses the typical stressors the boarders face and offers advice on how to effectively cope with these stressors. Such curriculum in the boarding school division could teach residential students how to deal with struggles in roommate living, time management, lack of privacy, as well as how to maintain healthy eating patterns. More generally, the course could address stress management skills. Such school-based stress management courses aiming at universal prevention that address students have been found effective with adolescents (Hampel, Meier, & Kummel, 2008; Kraag et al., 2006). If this course manages to result in one student coping more effectively, positive effects are likely to be amplified through the effects of behavioural modelling among boarding students.

Another intervention can specifically address the problems related to food and weight changes. The canteen could attempt to supply healthier food. A school ensuring that students have access to healthy food and reducing their opportunities to buy unhealthy food has been shown to positively influence students' eating patterns in schools (Cacavas et al., 2011; Traill et al., 2010). Moreover, a meta-analysis of community-based interventions to promote healthy eating found that multifaceted interventions delivering their message through media (e.g. Internet, videos) are especially successful (Barton & Whitehead, 2008). The impact of modelling can multiply the effect of such healthy eating intervention, because if one student starts to become concerned with healthy eating, it is expected that others will follow.

Specific interventions should be used to address the problems between students and teachers. Improvements in teacher-student relations can significantly increase student compliance with rules, enhance their wellbeing, and improve their academic achievements (Murray & Pianta, 2007; Jennings & Greenberg, 2009; Hughes, Luo, Kwok, & Loyd, 2008).

To summarize, it is highly recommended that a trained psychologist is hired to help students deal with individual stressors and to include the above stated interventions in the curriculum.

## CONCLUSION

In conclusion, these boarding students face many additional stressors as a result of the environment they are living in, which can negatively impact their wellbeing. This confirms findings of previous studies conducted on high school boarding students (Wannebo & Wichstrøm, 2010; Niknami et al., 2011; Tartatovsky, 2007). Under boarding-related stressors, homesickness and

problems due to sharing rooms are perceived as the most problematic. Additional boarding-related issues include, but are not limited to, the food and time management. Concerning peer-related stressors, the expectations the students have of each other, the competitive environment created, and their perceived inability to help each other seem to be perceived as the most stressful. Co-rumination, though intended as social support, can actually stress and anxiety (Rose et al., 2007). With respect to school-related stressors, the relations between boarding students and teachers are the most problematic, due to differing expectations. Health interventions such as a class curriculum and individual counselling are proposed to prevent the negative impact stress could have on boarders. In conclusion, this study has provided an overview of stressors of the boarders and suggestions on how to improve student wellbeing.

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LEONIE BANNING

# Lacking control, Pattern Perception, and Symptom Overendorsement

Original Paper

Whitson and Galinksy (2008) claimed to have shown that a state of chaos – i.e. uncontrollability – promotes pattern perception and spurious beliefs. In this lab report, we discuss an attempt to replicate Whitson and Galinsky's (2008) results. Furthermore, we tried to go one step further by exploring the possibility that uncontrollability and fantasy proneness promotes symptom overendorsement as an internal strategy to create order. In a within-subjects design, we asked 28 individuals to think about an uncontrollable situation or a situation in which they had been in full control. Next, participants were given a Snowy Picture Task (VPT), a Superstitious Beliefs Test (SBT), and a test tapping into symptom overendorsement (SIMS). We found that whether being in control or lacking control does not influence symptom overendorsement. Furthermore, we were not able to replicate Whitson and Galinsky's (2008) results. Limitations and implications are discussed.
**Keywords**: Lacking control, pattern perception, symptom overendorsement

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## INTRODUCTION

According to Pittman and Heller (1987), human beings have preferred internal conditions such as consistency, perceptions of freedom, or perceptions of being in control. These preferred internal conditions can be considered as a sort of cognitive homeostasis, or as an equilibrium. If any of these conditions produces cognitive dissonance by deviating from the preferred conditions, then the individual will act upon them to restore the cognitive homeostasis (p. 467-468).

The attribution theory (Jones, 1985) focuses on why and what attributions would be made given different sets of information. Initially it was assumed that attributions would make sure that the social world is predictable and controllable, for us human beings (Pittman et al., 1987). By linking the homeostatic approach to the attribution theory, some authors formulated the hypothesis that lacking control will lead to an increase in control-directed behavior, by creating attributional explanations for events. In 1980, Pittman and Pittman conducted an experiment in which they exposed participants to varying degrees of control deprivation. Next, they measured to what extent subjects' attributions were affected by variations of how much information was available to them. The authors found that the attributions of subjects who had lacked control were significantly more affected by variations in the available stimulus information, in comparison with subjects who did not experience a lack-of-control (Pittman & Pittman, 1980). In 1983, this experiment was replicated by McCaul, who also confirmed this hypothesis.

Symptom endorsement can also be seen as a form of attribution. In line with the literature (Wood, 2004), we contend that a diagnostic label and the symptoms it implies might provide the individual with a causal attribution for the anxiety caused by chaos. In other words, after being diagnosed, some individuals feel like they are not in control over their behaviors and cognitions, resulting in attributional processes.

In 2008, Whitson and Galinsky conducted six experiments that demonstrated that lacking control motivates pattern perception. They concluded that "the need to be and feel in control is so strong that individuals will produce a pattern from noise to return the world to a predictable state" (p. 117). By perceiving illusory patterns, it feels like the world functions as an organized system. People assume that one incident influences another and that there are patterns in how things evolve. These relationships, also perceived at a perceptual level, make people believe that they can predict and affect future events (Kay, Whitson, Gaucher & Galinksy, 2009). In turn, this restores feelings of being in control. For example, in one of their experiments, Whitson and Galinsky (2008) asked their participants to think of uncontrollable events and then gave them a Superstitious Belief Task (SBT) and a Snowy Pictures Task (SPT). Scoring high on SBT and identifying images in snowy pictures is a manifestation of illusory pattern perception. The authors found that subjects in experimental uncontrollability scored higher on these tasks than controls.

In light of the previous research, we explored whether uncontrollability induces symptom overendorsement compared to situations of controllability. We also evaluated whether a trait known as fantasy proneness might play a role in the connection between uncontrollability and symptom overendorsement, the basic idea being that people high on this trait are better able to imagine a scenario in which symptom overendorsement provides an explanation for feelings of uncontrollability. Note in this context that, for example, students high in fantasy proneness more often suffer from the Medical Student Syndrome (Candel & Merckelbach, 2003). Knowledge or believes about illnesses that people have will influence their interpretation of bodily sensations. According to Mittenberg, Digiulioo, and Perrin (1992), the interaction between selective attention and expectation can produce symptoms mimicking any disease. For example, when medical students learn about

symptoms of a disease, this will heighten their illness perceptions (i.e. making attribution errors), which in turn will lead to more self-appraisal.

To sum up, then, in this study, we tried to replicate Whitson and Galinsky's (2008) findings. Next, following their line of reasoning, we evaluated whether besides illusory pattern perception another phenomenon may occur to reduce feelings of lacking control: namely, symptom overendorsement.

## METHODS

### Participants

In total, 28 Psychology students (24 female) with a mean age of 22 years (*SD* = 2.77; range: 18 to 27 years) participated in the study. They were contacted by sending emails and by posting advertisements for the study on social media. The participants received a financial bonus of €15 after completing the study.

### Measures

#### *Creative Experiences Questionnaire (CEQ)*

This is a 25-item self-administered questionnaire to measure fantasy proneness. Participants are presented with 25 items and answer them with yes/no. A sample item is: "Many of my fantasies have a realistic intensity". To obtain a total CEQ score, yes-answers are summed. This results in a score ranging from 0-25, with higher scores indicating higher levels of fantasy proneness. The scale takes about 5 minutes to complete. Merckelbach, Horselenberg, and Muris (2001) examined the psychometric properties of the Dutch version of the CEQ. They found a test-retest reliability of .95 (with the second measurement conducted 6 weeks after the first measurement), and sufficient internal consistency (Cronbach's $\alpha = .72$).

#### *Structured Inventory of Malingered Symptomatology (SIMS)*

This is a 75-item self-administered questionnaire to detect symptom over-endorsement. Its items pertain to rare and atypical symptoms and statements. Participants indicate whether the item is true or false. The SIMS contains five subscales: low intelligence (LI), affective disorders (AF), neurological impairment (N), psychosis (P), and amnestic disorders (AM). Each subscale contains 15 items. Merckelbach and Smith (2003) examined the psychometric properties of the Dutch version of the SIMS. They found a test-retest reliability of .72, and an acceptable consistency (Cronbach's $\alpha = .72$) for the SIMS total scale. However, internal consistency for the subscales was low and varied between .24 (LI) and .59 (AF). Furthermore, they found a modest but significant correlation ($r = .33$, $p < .01$) between fantasy proneness, as measured by the CEQ, and the SIMS. This correlation makes sense if one assumes that fantasy proneness is accompanied by a positive response bias when answering odd items.

*Superstitious Beliefs Task (SBT)*

Based on the superstition task of Whitson and Galinsky (2008), we made our own version of this task, the Superstitious Beliefs Task (SBT) (see appendix A). Participants were presented with five scenarios. In each scenario an event was preceded by an action that was not necessarily objectively connected to it. For example, "Imagine you are a student and you have an important exam today. Normally, your mother lights a candle. It is her way to think of you and help you through your exam. You have a bad feeling about the exam, it did not go very well. Afterwards, when you are on the phone with your mother, it turns out that she forgot to light a candle. To what extent do you feel that not lighting the candle was of influence on your performance on the exam?" The participants were asked to read the scenarios carefully. It was stressed that there were no right or wrong answers. They were asked about the extent to which they felt one event was connected to the other, by indicating their answer on a Likert-scale. The scale ranged from 0 ("These things have nothing to do with each other.") to 10 ("These things have everything to do with each other."). The total SBT score on this test was computed by averaging all scores.

*Visual Perception Task (VPT)*

Based on the 'Snowy Pictures task' of Whitson and Galinsky (2008), we made our own version of this task (see appendix B). This task consisted of a series of 10 pictures of scattered dots. Eight pictures consisted of random scatters of black dots or small stripes on a white background and any identification of an object in the pictures is evidence for illusory pattern perception. To increase the credibility of the task, two pictures depicted a real image (one of a house and one of a horse), but they were degraded so that it was difficult to discern a meaningful image. These pictures were presented in the second and sixth position. When computing a total score, the score for the two pictures with real images were omitted, since their contribution does not tell us anything about the illusory perception of images.

Participants were told that it is important in daily life to see and recognize objects, even if they are not entirely visible. This can happen if objects are degraded by snow, rain, haze, darkness, or other visual obstructions. Next, they were told they would be presented with ten ambiguous images on the computer screen. Every image would be visible for 3 seconds each. Images had a size of 15 by 16 cm. The participants were asked about the extent to which they thought there was a figure, object, or pattern in the image, by indicating their answer on a Likert-scale. This scale ranged from 0 ("I do not see anything at all".) to 10 ("I clearly see a pattern."). If their answer was positive, they were also asked to write down what it was they had seen. The participants could decide for themselves how long they would take to answer this question, since they had to push a button to go to the next image. The total score on this test was computed by summing all scores (except for image 2 and 6, since these depicted real images) and then averaging them.

**Procedure**

Upon arrival, participants were told they were going to complete five unrelated tasks. Participants were asked to report some basis demographic details, such as

gender, age, and education level/profession. The study consisted of five tasks (the two autobiographical recall tasks were considered as one task). All participants started with a CEQ. Next, in the autobiographical recall task, half of the participants were asked to report an event in which they were completely in control, and the other half was asked to report an event in which they lacked control. The third task was the SIMS, the fourth again an autobiographical recall task. The participants who previously reported the being-in-control event now reported a lack-of-control event, and vice-versa. The two last tasks were a VPT and a SBT. Participants were randomly assigned to one of the two condition sequences (control-lacking control; lacking control-control).

The instruction for the lack-of-control event was: "You are asked to describe a recent incident that has happened to you, in which you were not in control. Think of something like: failing your driving test, or being in the chair at the dentist. Describe the situation in which you felt lack of control as specific as possible – what happened, how you felt, how it ended, and so on." The instruction for the being-in-control event was: "You are asked to describe a recent incident that has happened to you, in which you were in total control. Think of something like: playing a game and having total superiority over the opponent, or giving a speech which goes exactly as you planned it. Describe the situation in which you were in control as specific as possible – what happened, how you felt, how it ended, and so on."

**Statistical analyses**

Statistical analyses were performed using SPSS 21.0 software.
At group level, *t*–tests were computed to compare the control and lack-of-control conditions on SIMS, SBT, and VPT. The SIMS was further analyzed, first by only taking the first 10 responses on this test, and secondly by taking only the mood disorder subscale. These scores were also compared between control and lack-of-control condition. In addition, effect sizes (Cohens's *d*) were computed. Correlations (Pearson: product-moment) were computed both between CEQ, SIMS, SBT, and VPT, and between CEQ and the other variables (SIM, SBT, and VPT) per condition for each test. A *P*-value of ≤ .05 was considered statistically significant. No correction for multiple comparison was performed.
One participant skipped a question on the CEQ, and two participants skipped a question on the SIMS. In both cases, these missing values were dealt with by mean substitution; taking the average response on these items from all other participants (Anderson, Basilevsky & Hum, 1983).

## RESULTS

Table 1 shows mean scores and standard deviations of the two conditions on the CEQ, SIMS, VPT, and SBT. We carried out a series of *t*-tests to compare the two conditions.

**Table 1**. Summary of results in control and lack of control condition (N = 28)

| | Condition | Mean | *SD* | Chronbach's alpha | *t* | *p* | Cohen's *d* |
|---|---|---|---|---|---|---|---|
| SIMS | Control | 14.00 | 3.44 | .66 | .81 | .43 | .30 |
| | Lacking control | 12.86 | 4.04 | | | | |
| SBT | Control | 26.60 | 27.56 | .89 | -.09 | .93 | .04 |
| | Lacking control | 25.83 | 14.06 | | | | |
| VPT | Control | 16.19 | 16.60 | .91 | .41 | .68 | -.16 |
| | Lacking control | 19.08 | 20.25 | | | | |

As can be seen in table 1, there is no significant difference between the two conditions (control vs. lack-of-control) with regard to the various tests. Thus, it is not the case that lack of control enhances superstitious beliefs (SBT), illusory pattern perception (VPT), or symptomatology (SIMS).

With regard to symptomatology, we carried out two further tests. First, effects of lack of control might be short-lived, while the SIMS is a lengthy test. Therefore, we compared control and lack-of-control group with regard to their first 10 responses. Means were 2.79 (*SD* = 1.25) and 2.78 (*SD* = 1.05), respectively, and this group difference was not significant: $t(26) = 0.02$, $p > .05$. Second, the SIMS contains extreme (e.g., psychotic, amnestic) and less extreme subscales (mood disorders). One might argue that the effects of lack of control are subtle and do only occur with regard to more plausible symptoms. Therefore, we compared the control and lack-of-control group with regard to their mood disorder subscale score. Means were 3.79 (*SD* = 2.08) and 3.07 (*SD* = 1.21), respectively, and this group difference also failed to reach significance: $t(26) = 1.11, p < .28$.

Table 2 shows the Pearson product-moment correlations between CEQ, SIMS, VPT, and SBT. As can be seen, the correlation between SIMS and CEQ was significant, while that between CEQ and SBT reached borderline significance ($p = .08$).

Table 2. Pearson correlations between variables.

| | CEQ | SIMS | SBT | VPT |
|---|---|---|---|---|
| CEQ | ____ | | | |
| SIMS | .45* | ____ | | |
| SBT | .33 | 0.07 | ____ | |
| VPT | -.07 | 0.02 | 0.20 | ____ |

*$p < 0.05$ level

Table 3 shows the Pearson product-moment correlations between CEQ (M = 8.96; min = 2, max = 18; *SD* = 3.90) and other variables within the two conditions (control and lack-of-control). As can be seen, only the correlation between the CEQ and the lack-of-control condition of the SIMS was significant. Participants scoring high on the CEQ also scored high on the SIMS, but only when not being in control, $r = .60$, $p < .05$. The correlation between CEQ and SBT within the lacking-control condition ($r = .43$) reached borderline significance ($p = .13$)

**Table 3**. Pearson correlations of CEQ with other variables within conditions.

| | Condition | *p* |
|---|---|---|
| SIMS | Control | .28 |
| | Lacking control | .60* |
| SBT | Control | .30 |
| | Lacking control | .43 |
| VPT | Control | -.07 |
| | Lacking control | -.06 |

*$p < 0.05$ level

## DISCUSSION

The main results of the current study can be summarized as follows. First, we could not replicate Whitson and Galinsky's (2008) finding that lacking control leads to increased pattern perception and superstition. Second, we could neither confirm our own hypothesis, namely that lacking control promotes symptom overendorsement. We did find a borderline significance between the two conditions on the SIMS. However, the findings indicated that being *in* control led to a higher score on the SIMS. This is in contrast to our hypothesis, that *lack* of control would lead to higher scores on the SIMS. Finally, we found that participants scoring high on the CEQ, also scored high on the SIMS within the lack-of-control condition. These findings are in line with the literature (Merckelbach et al., 2003) in that individuals high on fantasy proneness are more inclined to symptom overendorsement.

A limitation of this study is the small sample size ($N = 28$), with the majority of the subjects being female and all being in the same age range. However, Whitson and Galinsky's (2008) employed in their studies samples of 36 and 41, with the majority of the subjects also being female undergraduates. Thus, this should be no reason for the different results found. With this small sample, the authors found no significant results, but they found medium to large effect sizes ($d = .60$ and $d = .65$ for the VPT and SBT respectively). In contrast, we found only small effect sizes ($d = -.16$ and $d = .04$).

It is possible that our lack of findings is a result of our measurement instruments. Some small factors differed regarding our VPT with the Snowy Pictures Task of

Whitson and Galinsky (2008). Whereas they showed 12 pictures with and 12 pictures without an image, we only showed 2 pictures with and 8 without. In addition, they asked their subjects only to identify whether an image or not existed in the picture. To obtain more precise data, we asked the subjects to indicate the extent to which they thought there was an image in the picture. This scale difference might explain the small effect sizes found. However, if these small differences in task variables are the reason for our failure to replicate their findings, it is questionable to what extent this phenomenon can be generalized.

A more fundamental problem in our set-up is the cross-over in our manipulation. People who first were in control later were asked to think of an uncontrollable situation and vice versa. This provided us with direct controls of the subjects, thus increasing the power. However, this may have attenuated the second manipulation. That is, people who first think of a situation in which they had perfect control might be reluctant to imagine a lack of control scene.

Relatedly, we did not check whether subjects adhered to their instructions and really thought about controllable or uncontrollable situations. Follow-up research is necessary in which controllability is directly manipulated.

Another factor that might explain the obtained results is the difference between the expectations of Whitson and Galinsky (2008) and our own. As shown by Doyen, Kelin, Pichon, and Cleeremans (2012), the beliefs of the experimenter may subtly be communicated to the participants, hereby affecting the behavior of the participant. It may be the case that participants were unconsciously influenced to conform their behavior to the expectations of the experimenters, for example whilst communicating with the participants. In order to have a controlled replication, the experimenters' expectations should be manipulated.

Although we did not find any effects of lacking control on symptom overendorsement, we did find that individuals high on fantasy proneness, experience more symptom overendorsement when not being in control. This tells us that maybe controllability affects symptom overendorsment, but in a subtle way. Thus, before rejecting the idea of symptom overendorsement as a way to regain control, a stronger experiment – with more *N*, no carry-over, a direct manipulation of control, and a manipulation of the experimenter's expectations– is required.

**Acknowledgements**

I want to express my gratitude to my supervisor Prof. Harald Merckelbach, who not only has given me the opportunity to conduct this research, but who has also taught me a lot during the process.

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## APPENDIX A – SBT

You will get to read five different scenarios. After reading each scenario carefully we want you to indicate your answer by marking the line. Give the answer that best reflects your impression. Note that no answer is right or wrong.

Scenario 1.

Imagine you are working in the market department of a large company. Your marketing ideas are almost always accepted in meetings. Usually, before a meeting starts, you stomp your feet three times on the ground before entering the meeting room. Unfortunately, today you were in a hurry and you forgot to stomp your feet. In the meeting all your ideas were completely ignored. To what extent do you feel that not stamping your feet on the ground is related to the ignoring of your ideas?

Please answer by putting a mark on the following scale (0 = these events have

nothing to do with each other; 10 = these events have everything to do with each other). Select the position on the line that best reflects your impression.

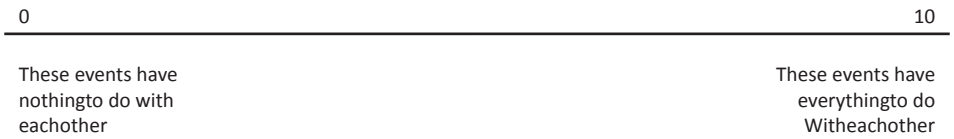

Scenario 2.

Imagine you are a student who lives at campus. During the weekend you would like to visit your parents. These suggest that you travel by train, however, you would like to travel using the car in order to practice your driving skills. The discussion which transportation you will take ends in an argument. Against your parent's wishes you still take the car. Along the way you get a flat tire, and you are forced to wait for help. To what extent do you feel that your rebellious behavior is related to the car troubles? Please answer by putting a mark on the following scale (0 = these events have nothing to do with each other; 10 = these events have everything to do with each other). Select the position on the line that best reflects your impression.


Scenario 3.

Imagine that you play soccer at a high competition level. You and your teammates have the habit to sing a motivating song before the start of the game. The new coach thought this was nonsense and made you start the game without singing the team song. You lost 3-0. To what extent do you feel that not singing the song is related to losing the game?

Please answer by putting a mark on the following scale (0 = these events have nothing to do with each other; 10 = these events have everything to do with each other). Select the position on the line that best reflects your impression.




Scenario 4.

Imagine that you have to pay the dentist a visit. Before every visit, you have the habit to knock three times on the wooden table in the waiting room. So far, you have never had any problems with your teeth. Today you had such a nice conversation with another patient, that you totally forgot to knock on the table. The dentist finds a mark in your teeth. To what extent do you feel that not knocking on the table is related to finding the mark in your teeth?

Please answer by putting a mark on the following scale (0 = these events have nothing to do with each other; 10 = these events have everything to do with each other). Select the position on the line that best reflects your impression.

0 10

These events have nothingto do with eachother

These events have everythingto do witheachother

Scenario 5.

Imagine that you are a student. Today you have an important exam. Normally your mother always lights a candle, to think of you and to help you. You have a bad feeling about the exam. Afterwards, you speak with your mother and she tells you that she has forgotten to light the candle. To what extent do you feel that not lighting the candle is related to your exam results?

Please answer by putting a mark on the following scale (0 = these events have nothing to do with each other; 10 = these events have everything to do with each other). Select the position on the line that best reflects your impression.

0 10

These events have nothingto do with eachother

These events have everythingto do witheachother

## APPENDIX B – VPT

In daily life it is important to see and recognize objects, even if they are degraded by snow, rain, haze, darkness, or other visual obstructions. You are presented with 10 ambiguous images on the computer screen. Every image is visible for 3 seconds each. After inspection of the image, you are asked about the extent to which you have seen a figure, object or pattern in the image. Indicate your answer by marking the scale (ranging from 0 = 'I do not see anything at all' to 10 = 'I clearly see a pattern'). If you answer positively, also write down what it is that you have seen. Note that no answer is right or wrong.

Image 1

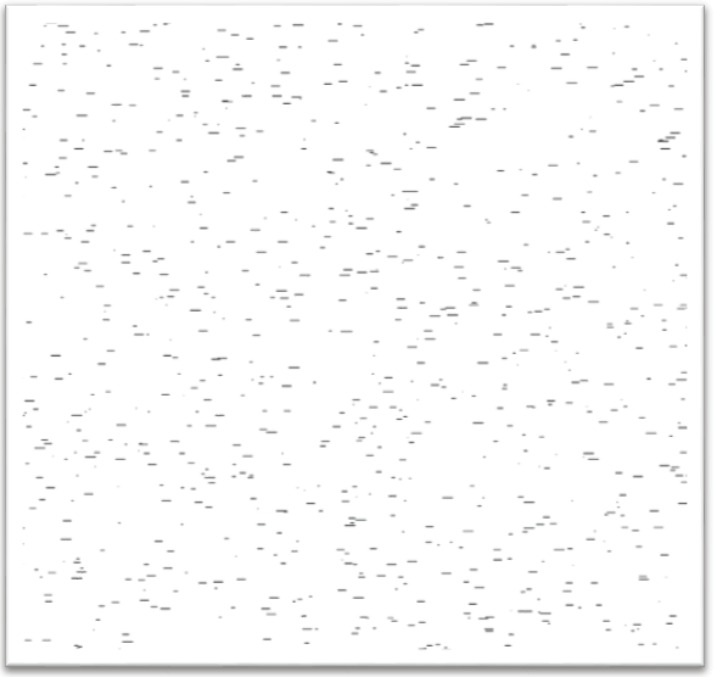
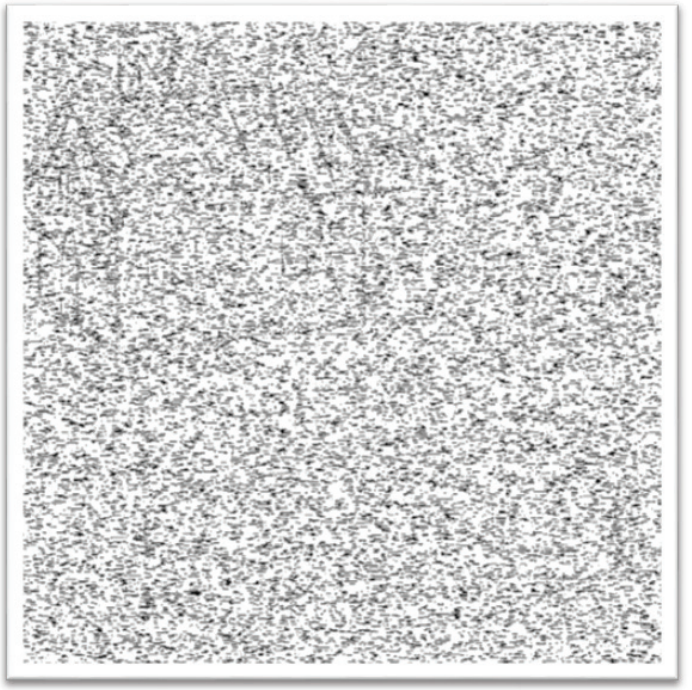
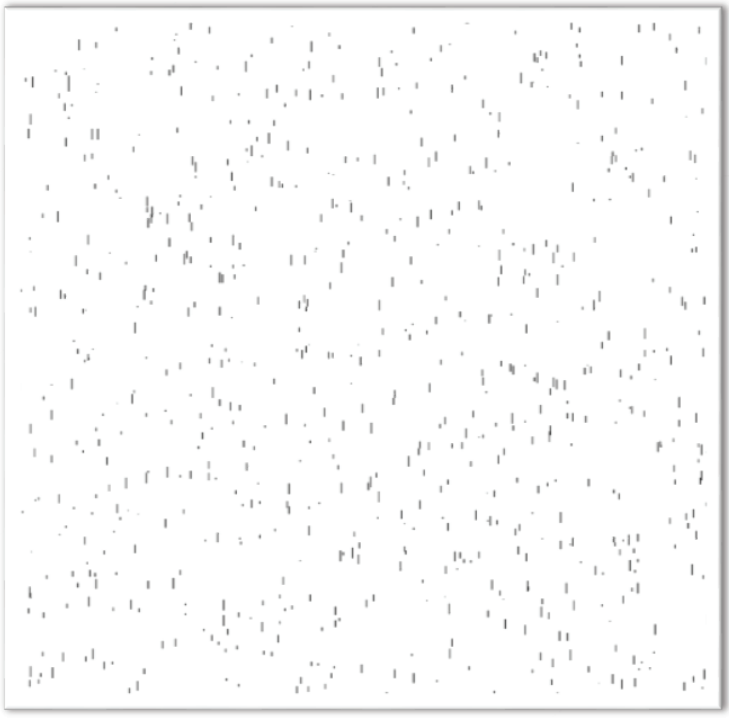


Image 2





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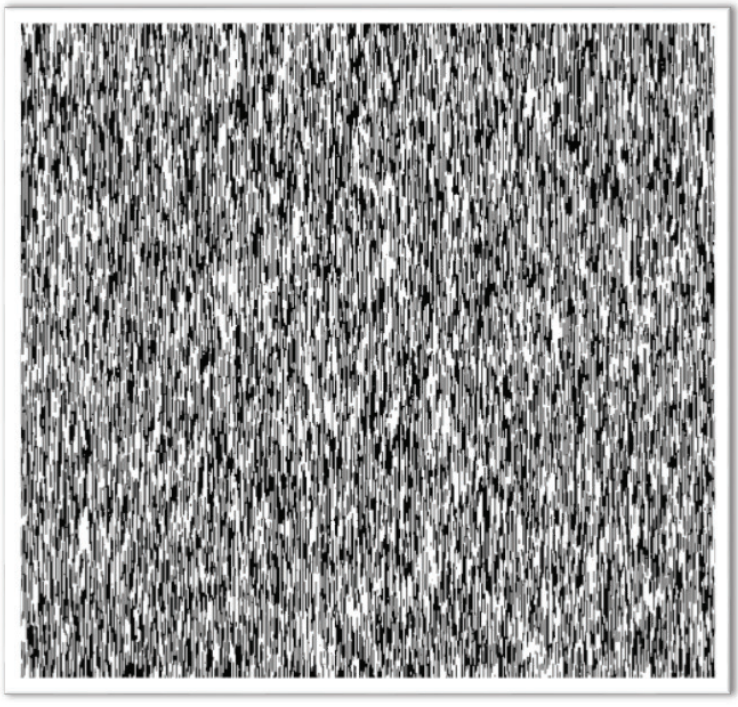

Image 3

Image 5



Image 6

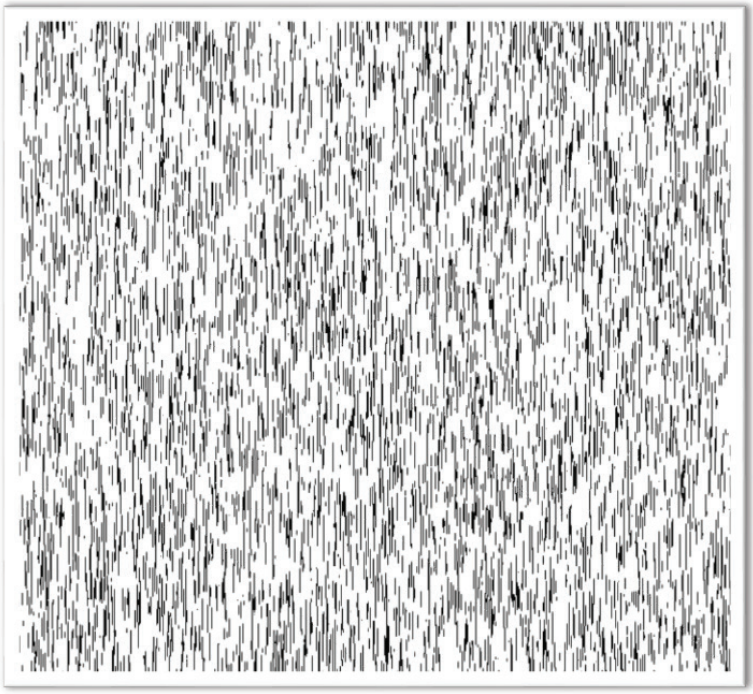

Image 8

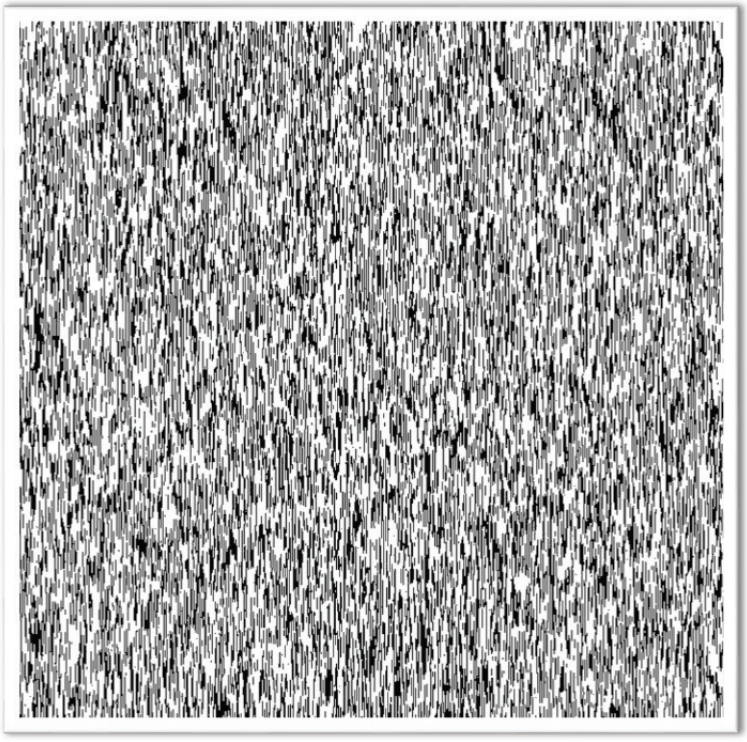

Image 7

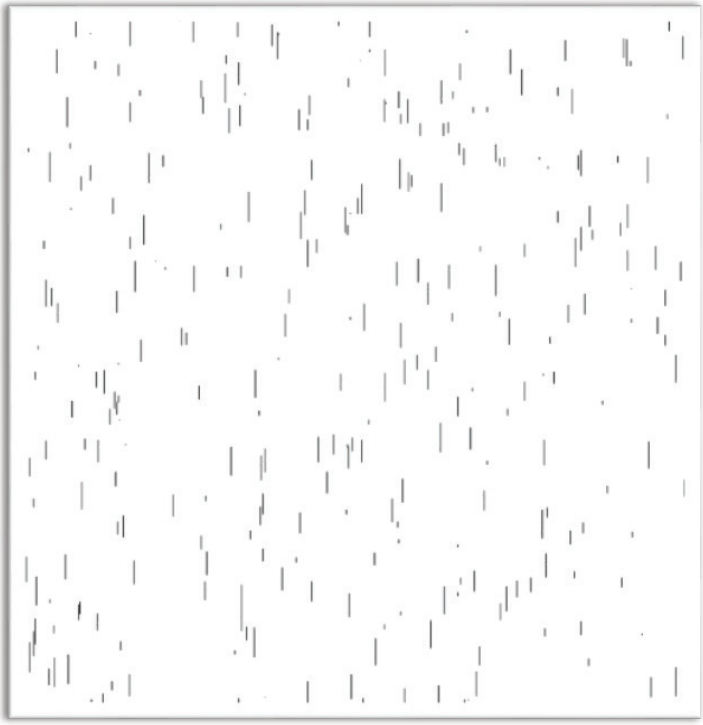

Image 9

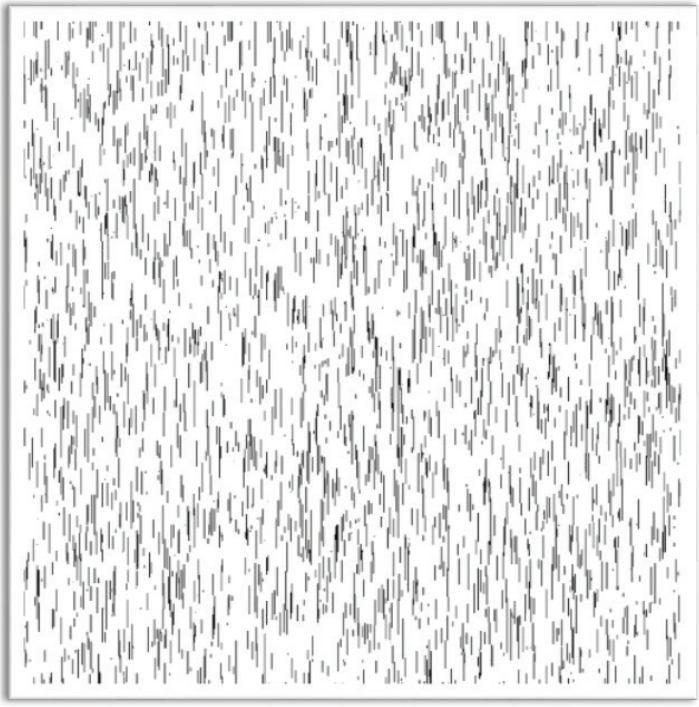

Image 10

CARMEN FEHRMANN & FRANZISKA DEPENBROCK

# Recovery from Work-Related Stress: A literature review

Review

Occupational stress adversely affects both the individual and the organization. Because of its economical and health relevance, much research has been devoted to employee recovery from work stress. Defined as a process of replenishing resources, recovery has been suggested to be important in reducing work-related fatigue, thereby making individuals feeling ready again to meet the demands at work. This literature review systematically summarizes findings from research on recovery. The literature search was conducted based on the PsychInfo database. Forty-eight journal articles were included in the review. Overall, studies consistently implicate that daily recovery is especially important to avoid long-term strain reactions. Moreover, research has found specific off-job activities as well as experiences attached to these activities to promote recovery, thereby improving performance, health, and well-being. Taken together, results imply that both individuals and organizations should be concerned about employee recovery and possibilities to support it during work and non-work time.

**Keywords:** fatigue; recovery experiences; recovery settings; well-being; work-related stress.

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## FATIGUE AND RECOVERY AFTER WORK

Today´s work force is confronted with deteriorating working conditions due to the economic crisis, the increasing globalization, the establishment of a free market, and demographic shifts (e.g., raising tendency of the retirement age)(Eurofound, 2012; European Commission, 2010). As a result, job stressors such as extended working days, blurred boundaries between work and family, and persistent in-work poverty are accelerating (Eurofound, 2012). Leka and Cox (2008) highlighted that the huge competitive pressure governing the labor market urges employees to meet the job requirements no matter which effort must be rendered. According to the authors, these developments take their toll on employees´ well-being; more than 40 million workers in the European Union suffer from work-related stress. Due to this, organizational costs are heightened by elevating rates of fluctuation and absenteeism (Leka & Cox, 2008).

When employees invest effort in order to meet the demands made on them at work, personal resources are depleted resulting in an exhausted state called fatigue (Åkerstedt et al., 2004). This state is identified as a core component of several diseases, such as the burnout syndrome which can be defined as a multi-dimensional work-related mental health complaint characterized by mental fatigue (emotional exhaustion), negative perceptions about other people (depersonalization), and a crisis in professional competence (reduced personal accomplishment)(Åkerstedt et al., 2004; Hakanen & Schaufeli, 2012).

Efficient recovery can lead to the rebuilding of the resources depleted during work (Geurts & Sonnentag, 2006), thereby promoting employee health. This process of replenishing resources is, however, easily impeded (e.g., Sonnentag & Bayer, 2005). Thus, to fully understand the concept of recovery, it is not only important to understand when, how, and why employees recover, but also to gather information on factors impeding the recovery process.

A systematic literature search was conducted using the the PsychInfo database to gather the knowledge on recovery that has been generated. The keywords being used were: burnout, chronic fatigue, chronic strain reactions, fatigue, job stressors, job demands, occupational health and well-being, recovery, recovery effects, recovery outcomes, work demands, and work performance. From the 129 initially identified articles 48 articles from peer-reviewed journals were included in the review. All articles used were considered thematically relevant on the basis of titles and abstracts. That is they addressed either when, how, or why employees recover from work-related stress or investigated factors that hinder or promote recovery. With the exception of three classic articles, which were published in the late eighties and nineties, all articles were published in the period from 2000 to 2012. To systematically summarize the findings from these articles, theories dealing with recovery will be discussed first. Next, information on perspectives from which recovery can be approached will be provided, namely: a) recovery settings, b) recovery as a process, and c) recovery as an outcome. Finally, implications and future research directions are discussed in conclusion.

## THEORETICAL FRAMEWORK

It is well-proven that work-related stress negatively impacts employees' health and well-being (see Nieuwenhuijsen, Bruinvels, & Frings-Dresen, 2010 for review). McEwen's (2006) allostatic load theory provides a framework which describes how this might happen. In the face of potential stressors, allostatic systems, such as the autonomic nervous system and the immune system, promote adaptation. For example, in case of threat, the sympathetic nervous system releases epinephrine and norepinephrine. In response, heart rate and blood pressure increase, pupils dilate and muscles get tensed – the organism is ready to fight or flight. When the threat ceases, the parasympathetic nervous system is activated. It inhibits the sympathetic adaptive responses, thereby maintaining balance (homeostasis). This process of achieving homeostasis is called *allostasis* (McEwen, 2006). However, as a result of repeated or prolonged stress this balance in systems promoting adaptation can be disrupted. McEwen uses the term *allostatic load* to describe the condition wherein allostatic systems do not perform normally. For example, the immune system may be hyperactive which can cause allergic responses. Geurts and Sonnentag (2006) suggested that recovery may help to explain the relation between acute stress reactions in response to stressful work characteristics and chronic health impairment in the long run. They argued that recovery may intervene in this strain process.

According to Siltaloppi, Kinnunen, Feldt and Tolvanen (2012) need for recovery is an indicator of the long-term stress effects(i.e. allostatic load). However, there are only few theories that deal with the role of recovery from occupational stress (Demerouti, Bakker, Nachreiner, & Schaufeli, 2001). According to Meijman and Mulder's (1998) effort-recovery model, effort expenditure at work inevitably causes acute load reactions such as fatigue. Fatigue relates to the impairment of mood, motivation, psychomotor, and cognitive functions such as decreased reaction times, memory, and information processing (Querstret & Cropley, 2012). Normally, fatigue and other acute load reactions are released during after-work hours resulting in recovery and reconstruction of the baseline levels. However, the model suggests that recovery occurs only if the systems that are taxed during work are not used after work. Thus, when individuals are exposed to work during after-work hours or to demands similar to those of work, stress-related load reactions are prolonged and recovery is impeded. Consequently, the employee will start the subsequent workday in a suboptimal state and work will cost extra effort. As a result acute load reactions may accumulate and become chronic, causing impaired well-being (Meijman & Mulder, 1998).

According to Hobfoll's (1989) conservation of resources theory people have a certain amount of resources which they strive to obtain, retain and protect. Resources can be objects or conditions, such as housing situation or marriage; personal characteristics, such as self-esteem; and energies, such as money or time. Environmental circumstances exhaust or threaten people's resources, thereby producing psychological stress. To recover from stress, people have to restore those resources or invest in new resources. For example, an employee's self-esteem might be affected by negative feedback. Consequently, he or she feels stressed and needs

to recover from it. Recovery can be realized, for example, by engaging in leisure activities that positively contribute to the employee's self-esteem. If the resources cannot be restored sufficiently, resulting in prolonged stress and an increasing lack of recovery, this may ultimately harm health and well-being.

Thus both the effort-recovery model and the conversation of resources theory emphasize the importance of recovery for health and well-being and they complement each other. According to the former theory it is important to withdraw from the demands of work and to avoid exposure to similar demands, so that resources required at work are not depleted after work either. According to the latter theory, restoring threatened resources or gaining new internal resources will help to recover (Siltaloppi, Kinnunen, & Feldt, 2009).

**The concept of recovery and its importance**

Recovery can be defined as the process during which an individual replenishes and repairs the energy resources depleted during work, thereby reconstructing the pre-stressor homeostasis of physiological and psychological systems (Sonnentag & Fritz, 2007). Thus, recovery represents a process opposite to the strain reactions occurring during stressful work (Geurts & Sonnentag, 2006; Sonnentag & Geurts, 2009). Due to the fact that time is a crucial variable in the recovery process (Meijman & Mulder, 1998), it seems obvious that longer periods of respites are accompanied by better and more efficient recovery. However, the measurement of recovery indicators such as fatigue, sleep quality, and health complaints illustrate that vacation effects fade within the first few weeks after resuming work (de Bloom et al., 2009, 2011). Research findings emphasize the importance of daily recovery processes after each work day (Demerouti, Bakker, Geurts, & Taris, 2009). During leisure time an individual engages in different activities (e.g. social activities sleep) that might reduce fatigue while improving mood and recharging one´s battery (Sonnentag & Fritz, 2007). In case of inadequate recovery and a consistent exposure to job stressors, chronic fatigue can occur (Querstret & Cropley, 2012).

The need for recovery is a conscious emotional state which can be characterized as an inherent need that provides for the rebuilding of personal resources (Sonnentag & Zijlstra, 2006). Study findings reveal that the need for recovery is negatively related to individual well-being (Sonnentag & Zijlstra, 2006). Furthermore, after stressful working days, when workload and cognitive demands are high, the organism needs more time to unwind and to down-regulate the aroused psycho-physiological system. This is shown for example in having difficulties to relax during off-work time or to concentrate on non-work related tasks (Sluiter, Frings-Dresen, Meijman, & Van der Beek, 2000; Sonnentag & Zijlstra, 2006). The need for recovery refers to an early phase of long-term load reactions which can result in prolonged fatigue (Demerouti, et al., 2009). This incomplete recovery spills over to the energy level in the next working day, resulting in heightened levels of need for recovery. If the spillover effects accumulate in the long run, a vicious cycle results which causes chronic fatigue. In turn, other health problems such as high blood pressure will emerge (Sluiter et al., 2000).

*Settings in which recovery may occur*

Recovery can occur during both work and leisure time (Geurts & Sonnentag, 2006). The former is referred to as internal recovery, the latter is referred to as external recovery (Taris, et al., 2006; Van der Hulst & Geurts, 2001). Internal recovery includes, for example, lunch and coffee breaks (Tucker, 2003). External recovery is assumed to occur in various temporal settings, including after-work hours, weekends, and longer periods of respite (e.g., holidays) (Demerouti et al., 2009; Geurts & Sonnentag, 2006). Breaks during work are most effective when taken during periods of experienced fatigue (Tucker, 2003). Within such rest breaks, food, caffeine and naps are identified as fatigue countermeasures (Horn & Reyner, 1996). According to Tucker (2003) the effective timing of these breaks is often difficult to manage, especially for employees with less autonomous work schedules, as they have to adhere to the fixed timing of breaks. Consequently, they may have to take a break even when they are not exhausted or cannot pause when desired and needed. With regard to the optimal duration of intra-shift breaks, there are no consistent recommendations given (e.g., suggestions include having three bigger breaks a day versus having a 15 minute break every two hours). This may be due to a lack of systematic investigations, but may also depend on the work load the employee has to fulfill, such that higher work load requires shorter time intervals between each rest break (Tucker, 2003).

In addition to investigating the beneficial effects of rest breaks during work, research has also focused on the effects of recovery occurring after work (i.e. external recovery) (Demerouti et al., 2009), and has provided support for the notion that off-job time also promotes recovery (e.g., Fritz & Sonnentag, 2005; Sonnentag, 2001; Westman & Etzion, 2001). Vacation studies have demonstrated that vacation from work has a positive effect on health and well-being (de Bloom et al., 2011). Among others, employees' perceived stress, experienced burnout, and rate of absenteeism for non-health reasonssuch as personal matters, have been found to decline after vacation (Westman & Etzion, 2001). However, vacation is not always beneficial; negative incidents, such as illness or conflicts, can undermine the recovery process (de Bloom et al., 2011). Conversely, absence from work that is not intended to serve as a respite, such as military reserve service, can promote recovery if experienced positively (Etzion, Eden, & Lapidot, 1998). However, as mentioned before, the salutary effects of vacations do not last long (de Bloom et al., 2011; Westman & Etzion, 2001) and daily off-job time or weekends may be more important for the employees' recovery process.

Effective weekend recovery has been found to predict weekly job performance and better well-being on Mondays (Fritz & Sonnentag, 2005). In addition, research has shown that employees perceive the accomplishment of their tasks as less effortful and straining when recovered at the weekend (Binnewies, Sonnentag, & Mojza, 2010).Employees also have been found to experience less disengagement and exhaustion when recovered adequately (Fritz & Sonnentag, 2005). At the day level, those who recover after work have been found to report better well-being before going to sleep (Sonnentag, 2001), and less fatigue and negative affect in the morning

(Sonnentag, Binnewies, & Mojza, 2008). Also, employees that feel physically and mentally refreshed in the morning showed better work performance and work engagement (Binnewies et al., 2010; Demerouti, Bakker, Sonnentag, & Fullagar, 2012; Sonnentag, 2003).

*Off-job activities*

According to Sonnentag and Geurts (2009), researchers approaching recovery as a process focus on the mechanisms underlying recovery. These mechanisms refer to off-job activities employees engage in after work as well as to attributes associated with these activities. It has been claimed that it is not important what one does to recover but how one feels while doing it (Sonnentag & Fritz, 2007). Thus, individuals engaging in different off-job activities might recover equally, due to similar psychological experiences attached to these activities.

Individuals cannot however spend all their off-job time on activities that promote recovery (Sonnentag, 2001). Besides fulfilling basic needs, such as eating, or sleeping, employees are confronted with activities with an obligatory nature, such as additional work-related and domestic activities. If these additional duties have been carried out, off-job time can be considered as synonymous with leisure time, which individuals can spend on activities, such as watching television, meeting with friends, or doing sports (Geurts & Sonnentag, 2006). Sonnentag (2001) examined the contribution of various off-job activities to recovery. Work-related activities, task-related activities (such as making one's tax declaration), and household and child-care activities were predicted to be negatively related to recovery, assuming that they draw on the same resources depleted during work, or are demanding themselves. On the other hand, leisure time activities with a potential for recovery were hypothesized to be positively related to recovery, since they put no additional demands on the individual's resources needed during work, or they help to gain new resources. Low-effort activities, such as watching a movie, social activities, and physical activities, were considered as such leisure activities with a potential for recovery.

Almost all of Sonnentag's (2001) hypotheses were supported by research, only time spent on household and child-care activities appeared to have not the predicted effects. However, these findings on low-effort and social activities have not always been replicated (Rook & Zijlstra, 2006; Sonnentag & Zijlstra, 2006; Sonnentag, 2001). For example, a study on flight attendants' daily recovery from work, found time spent on social activities to be positively related to depression (Sonnentag & Natter, 2004). The researchers argued that this might be due to the fact that flight attendants are confronted with high emotional demands during work and therefore prefer to withdraw from social activities after work. However, flight attendants may spend time with others (especially with colleagues between shifts) despite their need for social withdrawal, resulting in rather impaired recovery processes. Generally, individuals have been found to show an increased tendency to socially withdraw after stressful working days (Repetti & Wood, 1997).

*Recovery Experiences*

It has been argued that not specific activities but the psychological experiences attached to off-job activities help employees to recover (Sonnentag & Fritz, 2007). These experiences are labeled recovery experiences and they consist of psychological detachment from work, relaxation, mastery, and control. Psychological detachment and relaxation may help to recover, because they imply that no additional demands are made on resources exhausted during work. The experience of mastery and control should promote recovery by building up new resources, such as self-confidence (Sonnentag & Fritz, 2007).

Studies indicate that the experience of mastery, control, and relaxation plays a significant role in maintaining well-being at work (Siltaloppi et al., 2009; Sonnentag et al., 2008; Sonnentag & Fritz, 2007). Relaxation can result from deliberately practicing relaxation techniques, such as meditation, and from activities of everyday life, such as taking a bath (Pennonen, 2011). It is characterized by decreases in heart rate and muscle tension, thereby contributing to recovery by reducing prolonged activation. Among others, it has been found to be negatively related to emotional exhaustion and sleep problems, and positively related to affect (Sonnentag et al., 2008; Sonnentag & Fritz, 2007). Mastery experiences refer to off-job activities that offer opportunities to acquire new skills, such as learning a foreign language, and sport. These experiences must not overtax an individual's capabilities, so that finally the benefits exceed possible negative consequences. That is, mastery experiences act as external resources by increasing self-efficacy and feelings of competence, thereby promoting recovery (Sonnentag & Fritz, 2007). This applies also to the experience of control during leisure time. Control describes the degree to which an individual is able to choose which activity to engage in after work (Siltaloppi et al., 2009). Just as relaxation, mastery experiences and control experiences have been found to be negatively related to emotional exhaustion and need for recovery (Sonnentag & Fritz, 2007). Moreover, mastery experiences during the evening hours were positively associated with positive affect in the morning (Sonnentag et al., 2008). Control, on the other hand, was associated with higher life satisfaction and less depressive symptoms and health complaints (Sonnentag & Fritz, 2007).

So far, psychological detachment has received most research attention. First introduced by Etzion and colleagues (1998), psychological detachment is defined as an individual's feeling of being away from work. However, psychological detachment implies not only being physically away from the work situation during non-work time, but also to disengage mentally (Sonnentag & Fritz, 2007). Thus, for psychological detachment to occur, one needs to stop job-related tasks and to stop thinking about job-related issues. For example, it is impossible to reach a detached state of mind when ruminating about an argument with the supervisor or when answering work-related emails during off-job time (Sonnentag & Bayer, 2005). Congruently, research indicates that employees who spend much time on work-related activities, frequently use communication technologies, and have low work-home boundaries, detach less from work (Park, Fritz, & Jex, 2011; Sonnentag & Bayer, 2005; Sonnentag, Kuttler, & Fritz, 2010). It is suggested that psychological detachment is one of the

major factors that contributes to recovery from work-related stress (e.g., Etzion et al., 1998; Siltaloppi, et al., 2009). Studies indicate that it is negatively related to need for recovery and emotional exhaustion, and particularly important after high time pressure work days (Sonnentag & Bayer, 2005; Sonnentag & Fritz, 2007). Especially when work demands are high, individuals are less successful to detach (Sonnentag & Kruel, 2006). Thus when needed the most, recovery is impeded, which in turn impairs well-being (Sonnentag, 2012). Poor psychological detachment has been found to result in increased fatigue and less positive mood at bedtime and in the morning prior to work (Sonnentag & Bayer, 2005; Sonnentag et al., 2008).

Research has shown that individuals who expect that they can adequately recover after work, are more likely to psychologically detach during off-job time (Sonnentag & Kruel, 2006). However, this so-called recovery-related self-efficacy does not moderate the relationship between work demands and psychological detachment. Other individual-difference variables found to have an impact on psychological detachment are job involvement and negative affectivity (Sonnentag, 2012). Both individuals highly involved in their jobs (i.e. people who show high identification with their job), and individuals who tend to experience negative emotions more frequently have been found to psychologically detach less from work (Kühnel, Sonnentag, & Westman, 2009; Sonnentag & Fritz, 2007; Sonnentag & Kruel, 2006). It is argued that these individuals have difficulty to stop thinking about past and subsequent workdays (Sonnentag, 2012). It is suggested that psychological detachment is particularly important for those individuals (Sonnentag, Mojza, Binnewies, & Scholl, 2008). Also, employees who are consciously more willing to separate their workplace from their homes are better able to detach psychologically during off-job time (Park, Fritz, & Jex, 2011).Thinking about work during leisure time does however not only have detrimental effects. Positive reflection about work has also been found to benefit work performance (Binnewies, Sonnentag, & Mojza, 2009; Querstret & Cropley, 2012).

*Recovery as an outcome*

Recovery can also be approached as an outcome, that is, as a state of being recovered (Pennonen, 2011; Sonnentag & Geurts, 2009). Whereas feeling recovered and high sleep quality are positive indicators of recovery, need for recovery and fatigue indicate insufficient recovery (Binnewies et al., 2009; Querstret & Cropley, 2012; Siltaloppi et al., 2009). In addition, psychological outcomes considered to result from long-term incomplete recovery, such as job burnout, and behavior outcomes, such as work performance, can be used to assess recovery (Binnewies et al., 2010; Demerouti et al., 2012; Sonnentag & Geurts, 2009; Sonnentag, 2003). These outcome variables are interrelated. During work, fatigue builds up resulting in an urgent need to take a break to recover (Demerouti et al., 2009). If this need is not met after work, this may impair sleep quality (Sonnentag & Geurts, 2009), which in turn predicts fatigue (Åkerstedt et al., 2004; Querstret & Cropley, 2012). Fatigue, on the other hand, impedes work performance and may ultimately, if chronic, lead to long-term strain reaction, such as burnout (Querstret & Cropley, 2012).

## CONCLUSION

The goal of this paper was to provide a structured review of recovery from work-related stress during leisure time. Firstly, theories that help to understand recovery were summarized. Secondly, results from research on different recovery settings were reported. It became evident that intra-shift breaks, daily recovery after work and recovery at weekends are important to maintain health and well-being, especially since the salutary effects of longer respite periods have been found to fade out quickly. However, most findings derived from diary studies that have been conducted over short periods of time only. In order to better evaluate the effects of different periods of recovery time, future research should examine the effects of recovery over an extended period of time (Binnewies et al., 2010). Similarly, more studies approaching recovery as a process are needed to establish a better understanding of underlying factors.

Whereas work-related and task-related activities can be considered to impede the recovery process, physical activities have been found to be beneficial. In contrast, findings on low-effort and social activities are less clear; further research is needed to examine their contribution to recovery. It cannot be assumed that employees benefit from any off-job activity that is enjoyable and not related to work. For example, time spent watching a football game in a bar cannot be equivalent to time spent in the nature; being in busy environments requires voluntary attention whereas being in the nature demands effortless attention and helps with stress recovery (Aspinall, Mavros, Coyne, & Roe, 2013). In addition to this, more green spaces have been found to lessen brain fatigue and to be related to lower stress levels as indicated by decreased salivary cortisol levels (Thompson, Roe, Aspinall, Mitchell, & Miller, 2012). Even sounds from nature are enough to facilitate recovery (Alvarsson, Wiens, & Nilsson, 2010). Future studies should aim to extend these findings by addressing potential beneficial effects of providing green spaces or nature sounds at work on employee recovery.

Findings from research on off-job activities can be considered to be highly valuable as they can be used by both the individual and the organization to promote recovery. For example, organizations could facilitate sport activities in order to stimulate employees to engage in activities that foster recovery. Findings from research on recovery experiences are equally promising. Psychological detachment seems to be one of major factors that contribute to recovery from work-related stress. Consequently, future research should examine techniques that help enhance psychological detachment. For example, mindfulness, a psychological quality that has its roots in Buddhist meditation, has repeatedly been found to decrease rumination and might therefore have beneficial effects on detachment (e.g., Labelle, Campbell, & Carlson, 2010).

In addition to future studies focusing on facilitating effects, more research on factors impeding recovery experiences such as psychological detachment is needed.

For example, the impact of low work-home boundaries on recovery is especially interesting, as more and more employees work from their homes (Sonnentag, 2012). How these employees can detach from work is only one of the questions that remain to be answered. Another area of interest that should be further pursued is the influence of personality on recovery processes and work behavior. For example, employees with high work engagement tend to be stronger involved in work related demands resulting in a reduced ability to psychologically detach.

Taken together, based on the reviewed literature it can be concluded that daily recovery, promoted by off-job activities and recovery experiences, is indispensable in order to maintain employee health, well-being and job performance.

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KARLIJN HERMANS

# Memories in public speaking performance anxiety reconstructed: a qualitative exploration using a cognitive and etiological model

Original Paper

Prior research on social anxiety disorder (SAD) demonstrated the importance of anxiety provoking images, which can be related to memories. The present study examines how imagery plays a role in young adults' public speaking anxiety. The experiential intervention imagery rescripting (ImRs), conducted in fourteen participants with public speaking anxiety, resulted in reconstructing memories from adolescence. In order to explore which themes contribute to anxiety provoking images, the study of reconstructed memories focused on the cognitive anxiety process and etiological factors. Qualitative theory-driven analysis of these memories demonstrates that the anxiety process fits the cognitive model on SAD. With regard to etiology, expected influences of negative peer behaviour and parents were small or not found whereas influence of negative teacher behaviour was found. The present results therefore suggest that ImRs could be effective for the specific anxiety group which should be directed on negative teacher behaviour as contributor to their anxiety.
**Keywords**: public speaking anxiety, social anxiety disorder, cognitive model, etiological model, imagery rescripting

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## INTRODUCTION

The concept anxiety in general concerns symptoms at a physiological, cognitive-emotional and behavioural level (Lang, 1993). With regard to performance anxiety, physiological or somatic symptoms include trembling, sweating and blushing which could resemble panic symptoms (Bögels et al., 2010). Furthermore, anxious cognitions include fear of a bad outcome like doing or saying something embarrassing, one's mind going blank, saying foolish things, being unable to continue talking and showing somatic anxiety symptoms (Stein, Walker & Forde., 1996). This anxiety of exposure to others and fear of a critical evaluation is expressed in avoidance behaviour or suffering the situation (APA, 2013). Bögels et al. (2010) define performance anxiety as the fear concerning performing for an audience, including giving a public speech, a music performance or presentations in classes or meetings. It is a subtype of social anxiety disorder (SAD) which constitutes anxiety for general social situations (APA, 2000). Although performance anxiety concerns non-general situations, it shares the same core cognitive concern about being scrutinised and judged negatively (Bögels et al., 2010).

Among other changes from DSM-IV-TR to DSM-V, the subtype performance anxiety became a specifier of SAD (APA, 2000, 2013). This change advanced the differences between non-general and general anxiety in order to better distinguish these types. In comparison to SAD, performance anxiety shows a lower genetic component and a stronger psychophysiological panic-like response to performance situations (Blöte, Kint, Miers & Westenberg, 2009). Moreover, Bögels et al. (2010) argue that performance anxiety has a later onset, can be relieved by β-blockers and has no correlation with personality characteristics such as shyness and behavioural inhibition. Rather, traumatic experiences or panic are important in the development of performance anxiety (Bögels et al., 2010). These findings are not directly related to cognitive and etiological factors underlying performance anxiety. Therefore, it is interesting to look into models and research on SAD concerning these factors, and study whether and how performance anxiety could fit into these models too.

### Cognitive model

With regard to SAD, Clark and Wells (1995) modelled the interaction between anxiety responses and processes and showed how anxiety is maintained. Cognitive theory underlying this model states that anxiety elicits automatic inhibitory behaviours and safety behaviour (Beck, Emery & Greenberg, 2005). Assumptions that become activated when entering a feared social or performance situation are about the performers themselves and their (social) world (Clark, 2001; Clark & Wells, 1995). Safety behaviour is referred to as attempts to conceal the anxiety symptoms. This in turn disrupts social performance and can lead to negative evaluation of others. Furthermore, fears are visualised by viewing themselves in a catastrophic situation from an observer's perspective. Concerns provoked by these visualisations or images enhance and maintain this self-focused attention. That is, absent or ambiguous reactions from others will be interpreted negatively, thereby confirming the negative thoughts (Clark, 2001). In cognitive theory, one of

the discussed characteristics of SAD is the image or visualization of a catastrophic scenario (Clark & Beck, 2010). Hackmann, Clark and McManus (2000) show these images are recurrent and associated with memories of 'traumatic' experiences. There can be all sorts of memories which have a pictorial component and can be related to pathogenic early developed beliefs or schemas (Arntz & Weertman, 1999). Thus, images are associated with memories of 'traumatic' experiences (Hackmann et al., 2000). Furthermore, studies on imagery in SAD demonstrate treatment could better target imagery than verbal cognitions (Holmes & Mathews, 2010).

With regard to imagery in performance anxiety, former research did not study memories whereas there are some results in the study on flashforwards, in which future feared situations are imagined and visualised and could manifest as vivid, detailed and distressing (Engelhard et al., 2012). Imagined future catastrophes experienced as intrusive images may fuel distress and avoidance behaviour and are therefore considered to both decrease performance by distraction as well as maintain anxiety symptoms. Combined with the importance of the adolescent age stage, concerning the onset of public speaking situations (Gullone & King, 1993; Stein et al., 1996), it would be interesting to study whether memories also occur in this anxiety and how they contribute to current public speaking performance anxiety.

**Imagery rescripting**

Based on the results concerning the role of imagery, research focussed on changing the frequency and/or content of images rather than changing verbal cognitions (Arntz & Weertman, 1999; Hackmann, Surawy & Clark, 1998; Holmes & Mathews, 2010). These are referred to as experiential methods in which a change of images is induced by using emotional experience rather than controlled thinking or behaviour (Arntz & Weertman, 1999). One of these methods is Imagery Rescripting (ImRs). The aim of ImRs is to adapt traumatic or anxiety provoking experiences by focusing on new adaptive meanings and by reducing the scope of the old experiences. In order to achieve this, different perspectives and related feelings and needs are experienced in the reconstructed 'traumatic' situation. Ultimately, it is important the client develops the belief that the early experience was an exception rather than the rule, thus changing dysfunctional anxious beliefs (Arntz & Weertman, 1999; Hackmann, 2011).

**Etiological model**

With regard to memories of socially anxious individuals, external factors could influence the likelihood of developing an anxiety when unpleasant or traumatic events have occurred. Rapee and Spence (2004) address these factors in their etiological model of SAD. They include parent influences, peer influences and actual aversive social outcomes and negative life events. From their point of view, individuals have their own, mostly genetically mediated set point which reflects an individual's level of social anxiety. This epigenetic set point could be altered by the aforementioned environmental influences in a degree dependent of their timing, impact or chronicity. Aversive social outcomes and negative life events themselves

contribute to an increase of the level of social anxiety (Rapee & Spence, 2004).

Peer influence as defined by Rapee and Spence (2004) encompasses negative behaviour of peers in the classroom in the form of rejection and teasing. Studies show that highly socially anxious adolescents are treated more negatively by their peers than non-anxious or low anxious adolescents (Blöte, Kint & Westenberg, 2007; Blöte & Westenberg, 2007). Blöte and Westenberg (2007) examined this by measuring the perception of classmates that functioned as independent observers. Their results show negative class behaviour is based both on the speaker's performance and on the pattern of social interactions that developed in the classroom. The latter constitutes for instance making fun of the speaker, not showing interest and being noisy (Blöte, Duvekot, Schalk, Tuinenburg & Westenburg, 2010; Blöte & Westenberg, 2007). Blöte et al. (2007) replicated the findings with measurements from an independent observer on negative classroom behaviour, in addition to the measurements from the students themselves and the teacher.

With regard to rejection based on the performance of high socially anxious adolescents, Blöte, Bokhorst, Miers and Westenberg (2011) demonstrate this took place within two minutes, even without actual social interaction taking place. That is, only an overall impression in which peers noticed negative features was enough to provoke a negative evaluation. Miers, Blöte and Westenberg (2010) suggest that negative features on which performers are rejected are related to content of speech, facial expressions, posture and body movement and way of speaking. Furthermore, Blöte et al. (2010) studied the role of social skills and overt nervousness of socially anxious students on class behaviour. They found that only social performance predicts negative social responses. That is, peers show negative behaviour towards poor social performance, whereas they do not respond that way at overt nervousness. This is interesting since individuals with speaking anxiety report the (perception of the) visibility of their overt nervousness as a primary factor in their anxiety (Bögels et al., 2010) Taken together, the studies on perception of negative peer/class behaviour suggest a highly socially anxious individual's perception is not distorted. Further, it is related to longer lasting social interactions in the classroom rather than to specific state anxiety characteristics as expected by the anxious individual.

The present study aims to address the question of the extent to which performance anxiety is similar to SAD concerning mental imagery, and the occurrence of 'traumatic' memories. Confirming results might lead to beneficial effects of ImRs for this specific anxiety too. When hypothesizing that individuals with performance anxiety could also link their anxiety provoking images to memories, the next question would be which factors are important and are considered to contribute to the current anxiety. The present study has an explorative character, in which it is assumed that individuals' current public speaking performance anxiety is associated with their reconstructed memories. From the data obtained by imagery rescripting on fourteen young adults with public speaking anxiety, results of the imagery interview adapted from Hackmann et al. (2000) contains the reconstructed 'traumatic' memory and will therefore be used for qualitative analysis. The qualitative analysis will be driven by the cognitive model(Clark & Wells, 1995) and the etiological model (Rapee & Spence, 2004). Overarching themes found across the data will be discussed on their contribution to the current anxiety. This paper

will conclude with a discussion in which findings are translated into directions for altering the existing models and treatment on SAD for a group with public speaking performance anxiety.

The present study addresses the following research questions concerning the expected obtained memories: 1) How can memories fit into the cognitive model of Clark and Wells (1995)? Since performance anxiety shares characteristics with SAD (APA, 2013), it is expected that the cognitive model on SAD is able to explain the process of public speaking performance anxiety as well. 2) What external factors contribute to the negative appraisal of an anxiety provoking experience? Based on the etiological model of SAD (Rapee & Spence, 2004) parents and peers are expected to play a major anxiety contributing role in the memories.

## METHODS

### Participants

After a screening for inclusion criteria, mentioned later in the current section, fourteen participants were enrolled in this study. This number is regarded as sufficient to achieve a complete and broad overview of the studied topic (Guest, Bunce & Johnson, 2006). They ranged in age from 18 to 31 (M = 22.64 years, SD = 4.22 years). Only one participant was male although both sexes could have signed up for the study. The majority of the participants were students of whom two had recently graduated. They were recruited by announcements at different information channels connected with Maastricht University, for instance via flyers at the faculty of Health, Medicine and Life Sciences, via the digital learning environment EleUM and advertisements on social media. In the recruitment text they were asked to participate in a pilot studying a new intervention for public speaking anxiety. It was well communicated that no actual speech was expected from them, which could have lowered the threshold to participate. All individuals that signed up for the study received the screening questionnaire Personal Report of Confidence as a Speaker via e-mail to confirm public speaking anxiety (Paul, 1966). Those with a score of 16 or higher were invited to actually participate in the study. This cut-off score was adapted from Paul (1966) and caused several individuals to be excluded from participating.

Before starting the session, participants filled in the PRCS again. Scores here varied from 13 to 29 (M = 23.07, SD = 4.22). Although one participant scored below the cut-off score, this did not lead to exclusion. This was decided because the score on the first screening was above the cut-off score. Next to the PRCS, participants were interviewed with the SCID-I (Structured Clinical Interview for DSM-IV Axis 1 disorders; Groenestijn, Akkerhuis, Kupka, Schneider & Nolen, 1997). Scores on this test indicated two participants met criteria for SAD. Finally, participants would be excluded when they met criteria on posttraumatic stress disorder (PTSD) and had prior knowledge of Imagery Rescripting (ImRs). A demographic questionnaire including these topics showed no participants had to be excluded based on these exclusion criteria. Fourteen participants in the end met the inclusion criteria.

Table 1 provides an overview of the relevant characteristics of the participants. Participation was rewarded by offering a 12.50 euro voucher or 2.5 credits for psychology students. All participants signed for informed consent. The Ethical Committee of the Faculty of Psychology and Neuroscience, Maastricht University, approved the study design.

**Table 1**. Characteristics participants linked to their age, gender, education, score on the PRCS and diagnosis of SAD.

| Participant | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 20 | 31 | 18 | 20 | 26 | 20 | 21 | 18 | 19 | 20 | 28 | 25 | 23 | 28 |
| Gender | M | F | F | F | F | F | F | F | F | F | F | F | F | F |
| Education | b | c | a | a | d | b | a | a | a | ? | d | e | c | c |
| PRCS | 25 | 20 | 26 | 29 | 27 | 25 | 23 | 23 | 23 | 25 | 17 | 26 | 21 | 13 |
| SAD* | yes | no | no | no | no | no | yes | no | no | no | no | no | no | no |

a = 1st year student, b = 2nd year student, c = 3rd year student, d = 4th year student, e = graduated
? = missing
* Social Anxiety Disorder as diagnosed by SCID-I

**Materials**

The present study will primarily focus on the data on the flashback, the memory, retrieved from the Imagery interview adapted from Hackmann et al. (2000). The entire data collection comprised a complete intervention with the imagery rescripting technique. Due to restrictions in time and the goal of the present study, these data will not be discussed in this article.

*Personal Report of Confidence as a speaker*

The Personal Report of Confidence as a speaker (PRCS: Paul, 1966) is a self-report scale. It pretends to measure affective and behavioural responses in public speaking situations. The questionnaire is arranged in a true/false format consisting of 30 questions with possible scores ranging from 0 to 30. The score is higher when the degree of anxiety is greater. Half of the items are reversed scored. Daly (1978) found that the PCRS has a high internal consistency (Cronbach's alpha = 0.91).

*Structured Clinical Interview for DSM-IV Axis 1 disorders*

The Structured Clinical Interview for DSM-IV Axis 1 disorders (Groenestijn et al., 1997) is an individual pen and paper test for diagnosing psychiatric disorders based on the DSM-IV. The interview addresses only axis 1 disorders, e.g. mood disorders, anxiety disorders and eating disorders. Regarding the final diagnosis, the clinical judgement of the researcher is decisive. The scores are both categorical as well as dimensional. Basco et al. (2000) reported a superior validity of the SCID-I over standard clinical interviews concerning the intake. Lobbestael, Leurgans and Arntz (2011) demonstrated a good inter-rater reliability concerning SAD (Cronbach's alpha = 0.83).

*Imagery interview*

The imagery interview is used to obtain descriptions and meaning of recurrent images that emerge during public speaking situations. This semi-structured interview is adapted from Hackmann et al. (2000) by translating it into Dutch and adjusting some questions to improve the applicability in the present study. That is, some items were deleted and therefore only questions focusing on public speaking anxiety remained. These questions are standardised and asked in a fixed order.

**Procedure**

The interviews were held in a laboratory at Maastricht University. Participants were first asked to fill in the questionnaires related to the exclusion criteria. The imagery interview (adapted from Hackmann et al., 2000) took approximately 45 minutes in which the therapist obtained a detailed description of this flashback by asking questions like 'what do you see?', 'who is there with you?', 'what do you hear?', 'what do you feel, both in your mind and body?', 'what do you think?' and 'what has led to this situation?'. The participant was instructed to describe this scenario like it happened again in the present. Finally, the participants were asked to rate the memory on vividness and experience of distress. This was executed on a scale from 0 (absolutely not vivid/distressing) to 100 (absolutely vivid/distressing), according to Hackmann et al. (2000).

Detailed information was obtained including mainly the responses of both the participants and other people present in the memory. After the description of the flashback, it was asked to describe how the memorised experience could influence the participant as a person. The same question was asked concerning other people, their relationships and the world in general. Responses on these questions are analysed in the result section in a qualitative regard since they are considered relevant for studying the flashback.

The complete interview sessions had a duration of approximately 2,5 hours. They were recorded on an MP3 player after consent was given and anonymity was stressed. The interview stopped when the entire imagery rescripting session was completed. The duration could vary between participants. This was due to the characteristic of ImRs which states the participant can continue intervening until he or she is satisfied with the rescripted scenario (Arntz & Weertman, 1999).

**Data abstraction**

All recorded interviews were transcribed by typing them out verbatim. The data set was analysed by thematic analysis as described by Braun and Clarke (2006). It was decided to conduct an analysis that would lead to a thematic description of the entire data set used in this study; the memory described in the imagery interview. Furthermore, Braun and Clarke (2006) define inductive or data-driven versus theoretical or analyst-driven thematic analysis. Initially, this study started coding with an inductive approach. This involved repeated and active reading of the transcripts aimed at looking for patterns of meaning and issues of potential interest in the data. These patterns were listed and given codes for the subsequent coding

phase. Care was taken to search across the dataset and to prevent it being exclusively led by the questions in the interview.

During the coding phase, the data were organised into meaningful groups based on the coding list. Data extracts from all interviews were categorised within codes, preserving a minimal context and a label of which interview it was extracted. This was done because the surrounding data were relevant for interpretation of the core data extract.

After all relevant data extracts were coded, the analysis phase started. In this phase, codes were combined to form overarching themes. These are described in the result section. Finally, it was important to go beyond the semantic surface level and interpret the data. This was done by linking qualitative data organised in themes with existing literature and theory. In this phase the analysis became more analyst-driven since literature search contributed to the interpretation of the data. In particular, themes found across the data were linked to the cognitive model of SAD (Clark & Wells, 1995) and the etiological model of SAD (Rapee & Spence, 2004).

## RESULTS

The analysis across the data resulted in specific themes concerning the relevant topics formulated in the hypotheses. These are listed in table 2. These are structured by using factors of general models on SAD; the cognitive model (Clark & Wells, 1995) and the etiological model of SAD (Rapee & Spence, 2004).

### Cognitive model of social phobia

The cognitive model of Clark and Wells (1995) describes several factors that are relevant in the process and maintenance of SAD. Reported anxiety responses and behaviour will be structured by their considered position within this common model.

#### *Memorised (social) situation*

The majority of the provoked memories resembled each other. As shown in table 2, most described memories occurred at the age of late adolescence. The age of adolescence as defined in several studies ranges between 13 and 18 years (Blöte et al., 2011; Blöte et al., 2007; Blöte & Westenberg, 2007). Three described memories occurred at the next age stage (young adulthood) and two were experienced in their late childhood. When the performance was a public speaking situation, this is specifically indicated. The other performance situations included for instance singing or playing an instrument in front of an audience. A couple of memories were about experiences of being bullied and one memory describes receiving criticism. The similarities between all cases are the overall somatic, cognitive and behavioural anxiety responses that were similar to recent anxiety provoking public speaking situations.

Table 2. Characteristics memorised situations, participants linked to their current age, their age during the memory, gender and the situation type.

| Participant | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current | 20 | 31 | 18 | 20 | 26 | 20 | 21 | 18 | 19 | 20 | 28 | 25 | 23 | 28 |
| Memory | 14 | 19 | 14 | 9 | 22 | 15 | 15 | 15 | 18 | 17 | 22 | 17 | 7 | 12 |
| Gender | M | F | F | F | F | F | F | F | F | F | F | F | F | F |
| Situation | S | S | P | B | S | S | S | P | S | P | C | S | P | B |

S = speech, P = performance, B = bullying, C = criticism

The performance situations ranged from a scenario in which everybody watched the speaker (actually standing in front of people) to being in the spotlights (literally by performing on stage) to being watched sitting in the classroom and expected to answer a question. The two bullying experiences described the participant to be the target of bullying. Further, the criticism memory described a situation during an internship in which the assessor only provided negative feedback in conversations with the student.

### *Assumptions and negative automatic thoughts*

Participants reported about how they think their audience, peers or teacher have high expectations about their performance. Conditional beliefs about consequences that emerged frequently from the data are in terms of 'If my performance fails, other people think I'm incompetent'. Unconditional negative beliefs that were reported reflect low self efficacy. The majority of the participants thought they could not perform properly.

Participants furthermore reported ambiguous behaviour, for instance silence, gazing and asking questions. They tended to appraise absent or ambiguous behaviour negatively.

### *Processing of self as a social object*

While the data collection was conducted by using an imagery interview, the focus was on processing of the self as a social object. That is, participants were encouraged to visualise themselves in the early experience and looking at themselves from the observer's perspective, accessing the emotional cognition. According to the cognitive model, the focus on internal information generated a negative self-impression (Clark, 2001). Related internal sensations were explicitly mentioned.

### *Somatic and cognitive symptoms*

The participants' responses could be divided into expressions at the somatic, cognitive and behavioural level. Somatic responses that emerged from the data were mostly flushing, chilliness, sweating, head full of thoughts, trembling, elevated heart rate, strange feeling in the stomach, restlessness and nervousness. These responses were explicitly described by most participants.

Some participants related panic-like symptoms to actual panic. Among these symptoms was the feeling of losing control about their anxiety responses. This

perceived loss of control was reported by almost all participants. One case reported a floating feeling which is considered to resemble the panic symptom light-headedness.

One participant additionally reported fear of the internal physical sensations itself. In concordance with literature, this is common for symptoms related to the hyperarousal associated with performance anxiety (Bögels et al., 2010). Cognitive anxiety symptoms typically related to performance anxiety were reported as getting a black out.

### *Anxiety symptom or safety behaviour?*

Some reported behaviour was difficult to categorise as either anxiety symptom or safety behaviour. For instance, thoughts that expressed the urge to escape could be viewed as an anxiety symptom when it is not functionally used. Since it is however also a kind of avoidance, it has characteristics of safety behaviour.
Additional behaviours that were difficult to categorise were exaggerated laughter and fast talking. These behaviours are similar to typical safety behaviour (Clark, 2001). However, it could be questioned to what extent this behaviour is performed to reduce anxiety. Rather it could be an expression of anxious or nervous feelings.

### *Safety behaviours*

When describing the somatic responses, participants also described their attempts to hide these responses in order to prevent other people from seeing them. Further safety behaviour that was reported concerned behaviour which might have provoked negative evaluation, despite it being performed to avoid this.

Taken together, the data concerning anxiety responses are in concordance with symptoms as described by the DSM-V criteria (APA, 2013) and as modelled by the cognitive model of SAD (Clark, 2001; Clark & Wells, 1995).

## Etiological model of social phobia

The present study's data revealed themes that can be related to factors described in the etiological model of SAD of Rapee and Spence (2004). Themes will be structured as considered relation to the etiological factors.

### *High set point*

'Could you describe what happened in your life in the period of the flashback?', 'How did you feel about yourself?' These questions were asked after describing the memory and confused most of the interviewees. After the question was clarified, responses were very similar. Almost all participants reported they were insecure and had a low self esteem at the time of the flashback. When asked to extend these feelings, also fear of critical evaluation by others was mentioned. Some viewed the low self esteem as a normal characteristic of puberty, whereas most viewed this characteristic as a contributing factor to their anxiety in that period. In addition, a substantial part of the responses reflected the feeling of being an outsider.

Although negative feelings seemed to dominate, some reported compensating thoughts, for instance 'Nevertheless, I'm not stupid' when obtaining high grades.

*Parent influences*

Some cases explicitly mentioned the negative influence of their parents, indicating either a lack of support or overprotection.

*Peer influences*

Except for one, all cases described a situation where there was an audience of peers present. This group varied in size from twenty to 40 peers in performance situations and four to five in bullying situations. While reliving the memory, participants were asked to describe in detail what happened, including peer behaviour.

The most frequently reported response of peers was laughing. This laughing could be divided into laughing at the speaker and laughing with each other. Both were viewed as disturbing and negative behaviour. Other peer or more general classroom behaviour that was described was an uneasy silence and talking to each other. Additionally, imitating behaviour was reported. This resembled the bullying behaviour, with typical features like pushing, laughing and yelling mean things. Although some participants experienced extremely negative peer behaviour, for instance bullying, most reported peer responses can be considered as reflecting normal behaviour. Participants also reported they understood their peers' reactions and did not blame their peers for their anxiety.

*Aversive social outcomes*

Most participants could not remember the exact onset of their anxiety. They appraised the described memory as contributing to their anxiety that was already present. There were two cases who did not experience anxiety before the described memory.

*Additional influence teacher*

In addition to parental influence, explicitly negative descriptions of deviant normative behaviour emerged frequently from the data. These held behaviour performed by the teacher or another authority figure. This is contrary to the behaviour that participants reported to expect from them, for instance creating a safe environment, providing constructive feedback and giving support.

Summarizing, the themes revealed from the flashback interviews offer qualitative insights on different aspects of performance anxiety. Overall, the anxiety responses fit into the cognitive model of Clark and Wells (1995). Furthermore, with regard to the etiological factors to SAD as described in the model of Rapee and Spence (2004), peer influence as modelled was found. The expected important role of parents was not demonstrated. Rather, negative influence of teacher behaviour was reported.

## DISCUSSION AND CONCLUSION

The present study examined memories of young adults with public speaking anxiety which mostly refer to performance experiences in their late adolescence. It was aimed to study whether young adults with public speaking performance anxiety could, like socially anxious individuals, provoke memories in which their anxiety was similar to their current anxiety. The present results show these memories could be obtained by conducting imagery rescripting. The goal related to the analysis of these data was to reveal relevant factors that influence the appraisal of the memorised situation and therefore contribute to the anxiety. This was facilitated by using models based on general SAD; the cognitive model of Clark and Wells (1995) and the etiological model of social phobia of Rapee and Spence (2004).

### Cognitive model

The present data provide confirming evidence regarding the first research question. The obtained memories fit into the cognitive model of SAD (Clark & Wells, 1995). That is, all factors described in the cognitive model(Clark & Beck, 2010) could be supported by data extracts and are therefore shown to be prominent in public speaking anxiety too. These factors included a memorised (social) situation, assumptions and negative automatic thoughts, processing of self as a social object, somatic and cognitive symptoms and safety behaviours.

Furthermore, some data extracts were difficult to categorise while there was too little information to confirm their exact function. Although the relation between performance anxiety and SAD is confirmed, aspects on which the qualitative differences between the specific and general anxiety are based were not examined in this study (APA, 2013; Bögels et al., 2010).

According to the cognitive model of Clark and Wells (1995), safety behaviour is performed in an attempt to conceal anxiety symptoms. Since the goal is to avoid negative social outcomes (the presumed negative evaluation of others), it is viewed as subtle avoidance behaviour (Clark, 2001; Clark & Wells, 1995). In the present data, this behaviour is indicated by speakers that for instance hold their hands beneath the table to conceal their trembling. However, as Clark (2001) also suggests in his theory, performing safety behaviour itself could lead to a negative outcome and therefore work in contrary to the intended outcome. That is, peers could notice this safety behaviour before the actual trembling of the hands. Consequently, they could perceive this deviant behaviour in terms of negative features which in turn leads to rejection (Miers et al., 2010). Furthermore, characteristics like avoiding eye contact and talking fast could be interpreted as inappropriate social behaviour, although the function of these behaviours is not clear. As shown by Blöte et al. (2007) and Blöte and Westenberg (2007), high anxious performers can provoke negative evaluation among peers. Although paradoxical, safety behaviour could contribute to this too. This is in concordance with the description of safety behaviour in the model of Clark

and Wells (1995) by Clark (2001). The present results therefore suggest a vicious cycle in which safety behaviour is perceived as a social skill deficit that influences global judgements about social competence, which leads to rejection.

**Etiological model**

Regarding the second question concerning which external factors contribute to the negative appraisal of the actual memorised experience, the model of Rapee and Spence (2004) was used. According to this model, similar to SAD it was expected that parents and peers would play a major role in the provoked memories. However, parents' influence was minimally reported and peers did play a role but were not blamed in playing the most important contributing role to anxiety. What is more, teacher influence was found relevant in performance experiences regarding their behaviour towards the performer. Therefore, in order to describe relevant external factors contributing to performance anxiety, teacher influence is suggested to be added to the etiological model of SAD according to Rapee and Spence (2004).

*Parental influence*

Only few participants reported a negative influence of their parents during the described period. Consequently, this influence's importance in setting the set point level of SAD according to Rapee and Spence (2004) is not confirmed by the present data. The reason for this could be related to the age at which the memories in the present data occurred. That is, the present data address late adolescence instead of late childhood and early adolescence on which Rapee and Spence's (2004) findings are based. Furthermore, it could be that the parents did not play a major role in the descriptions of the participants because in the present intervention it was not specifically asked to extend the performance related memory to their home situation. Another plausible explanation is that parental influence is more subtle than other influences and less powerfully linked to unpleasant memories.

*Peer influence*

Although peers would be expected to play an important contributing role to anxiety, the results show most peer behaviour was normal or appraised normal by the participants themselves. The effect of peer behaviour on anxiety will therefore be small. An explanation for this finding could be their behaviour was appraised less negative compared to the behaviour of the participant's teacher. Furthermore, it is possible participants could identify themselves more with their peers than with their teacher, which could explain there was no blame directed at their peers' behaviour.

*Additional teacher influence*

Almost all participants reported a negative influence of the teacher or assessor in the memory. This factor is not described in Rapee and Spence's model (2004). This might be due to the focus of the model on the etiology of SAD and not on specific performance anxiety. However, in particular concerning performance related experiences, the role of the teacher or assessor could be of more relevance than for the more generalised SAD subtype. Although this teacher role was expected to

be related to fear of critical evaluation, in terms of a bad assessment for instance, the present data show participants report negative behaviour of the teacher as contributing to their anxiety. With regard to teacher behaviour, participants expected teachers to provide constructive feedback and create a safe environment. These expectations of teachers or assessors are in line with research on this topic of Kunter et al. (2013) and Wentzel (1997) who indicate caring behaviour is important in addition to knowledge transmission. It seems they feel teachers or assessors are supposed to perform professional behaviour which could be set as an example for students.

The present study's results showed negative teacher behaviour towards the performer to be associated with an increase in level of anxiety. However, to what extent the teacher behaviour is perceived rather than objectively present could not be measured since data only comprise of the performer's memories. Prior research that did examine student's perceptions of teacher treatment was more objectively conducted by Babad (1990) and later extended and replicated by Blöte (1995). These studies conclude that low-achieving peers were treated differently by their teachers from high-achieving peers. Although the low-achieving students received more help and support, well performing students were more often praised than poorly performing students. These study results are based on general achievement instead of specific achievements, like speaking performance in the present study. Furthermore, these studies' validity of student perceptions still require more attention. Taken together, despite this limitation and the lack of prior research on specific achievements, this study suggests an important role of teachers regarding the development of this anxiety.

**Limitations and recommendations**

There are a number of limitations related to the interpretation of the data and to the study's design. A first limitation of this study can link to the comparability of the memories used as data. That is, the timing of the memory and its characteristics was not particularly looked into. Although a variation in memories was expected from the imagery interview (Arntz & Weertman, 1999), bullying experiences and performance experiences were not easily comparable. These provoked similar anxiety responses but varied, among other things, on their impact, the degree of emotions provoked, the number of peers involved and the role of the teacher. For the majority of participants, the memory itself did not function as an onset point for the speaking anxiety but rather functioned as an important contribution to the anxiety. Furthermore, the extent of this contribution could have varied between the participants. Nevertheless, it was decided to use all data together in the analysis because this study is an explorative pilot study that focused on the anxiety responses more than on the situation itself. The heterogeneous etiology of memories is in this respect considered interesting.

Another limitation of the present study is the validity of others' behaviour. That is, perceived peer, parent or teacher behaviour could be influenced by the anxiety and by the beliefs or assumptions anxious individuals have. This is for instance illustrated by the negative interpretation of ambiguous behaviour, as reported by

Clark (2001) and as shown by the present results. Since the present study did not involve independent observers of the memory to compare their observations to the observations of the participants themselves, it is not possible to make conclusions about the actual behaviour. This holds for both teacher and peer behaviour that was reported.

Finally, common shortcomings related to the design of qualitative research as discussed in literature and relevant to this study are purposive sampling, grounded theory, multiple coding and respondent validation (Barbour, 2001).

Based on the discussion and limitations, several recommendations on future research could be made. In this respect, the age on which participants retrieved the intervention could be discussed. Rapee and Spence (2004) suggest age is important in the transition from a high level of social anxiety to a formal diagnosis of SAD. They argue early to mid adolescence is the age at which symptoms result in impairment to the individual's life. They further suggest this is due to increasing importance of social interactions. During the age stage described by Rapee and Spence (2004), there are still many parental influences, which are followed by an increasingly important role for peers. The present study however examined most memories in late adolescence, except for two cases in late childhood and three in young adulthood. Data that emerged from these memories indicated the teacher becomes increasingly important. In order to obtain an overview of which factors become more relevant in contributing to anxiety at each age stage for performance anxiety, it is suggested to study memories from different age stages of young adults with performance anxiety.

Based on the present study results, it is suggested to focus more on peer and especially teacher behaviour when conducting ImRs on young adults with performance anxiety. Participants indicate a preference for more positive, supporting behaviour from their peers, although it seems they do not expect this from them. This is in contrast to the blame they place on authority figures like teachers and assessors which are expected to set an example. It could be interesting to study the perception of both influencing factors further in depth. For instance, what are specific expectations on teacher behaviour based on and how did these develop? In educating on the interpretation of the exemplary role of the teacher, parents might be important. When studying this topic on actual behaviour, it is further suggested to increase the validity by including objective observers, as in prior research on peer behaviour (Blöte & Westenberg, 2007) and teacher treatment (Babad, 1990; Blöte, 1995).

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IRENE TRILLA

# Involvement of the FKBP5 gene in the pathogenesis of stress-related disorders and antidepressant response: An update

Review

The FKBP5 gene has been shown to modulate stress responses by regulating glucocorticoid receptor sensitivity. Because stressful events are increasingly recognized as important environmental risk factors of psychiatric disorders, FKBP5 has recently become a candidate gene in research on stress-related conditions. This review aims to provide a concise overview of current knowledge about the FKBP5 gene and its clinical implications and suggest directions for future research. Firstly, the functional role of the gene will be described. Associations with affective and post-traumatic stress disorders will then be discussed in the context of gene-by-environment interactions. Finally, the usefulness of FKBP5 genotype as predictor of antidepressant drug response will be outlined.
**Keywords**: FKBP5, stress, affective disorders, PTSD, antidepressant response

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## INTRODUCTION

Psychiatric disorders are the result of an interplay between genetic and environmental influences. Identifying those genetic factors could improve knowledge of pathophysiological mechanisms, as well as development of new treatment approaches. FK506 binding protein 51 (FKBP5) has been proposed as a candidate gene for stress-related conditions due to its role in the regulation of neurobiological stress responses. Initial evidence of pathophysiological implications of the FKBP5 gene dates back to the early 2000's (Binder, Salyakina, & Lichtner, 2004; Fallin et al., 2005; Koenen et al., 2005), but it was not until the publication of a seminal

review paper (Binder, 2009) that interest in this gene has started to grow. Since then, several lines of research have provided new evidence on the involvement of the FKBP5 gene in stress-related conditions and drug response, shifting the focus from direct genetic effects to gene-by-environment (G x E) interactions. To understand the scope and the implications of this change of paradigms, an updated overview of the latest research on the FKBP5 gene is required.

This paper integrates recent findings on the FKBP5 gene with the aim of updating the existing knowledge about its involvement in stress-related disorders. Firstly, an overview on the functional role of FKBP5 in glucocorticoid-signaling will be provided. Secondly, focus will be placed on associations between the FKBP5 gene and affective disorders, suicidal behavior and post-traumatic stress disorder (PTSD). Even though such stress-related conditions share underlying pathophysiology, genetic influences will be discussed individually for the sake of comprehension. Finally, reports of the FKBP5 gene as a biomarker of antidepressant treatment response will be reviewed.

## METHODS

Scientific databases (PubMed, PsycInfo) were searched for published reports on the FKBP5 gene (August 2013). Search terms included: FKBP5, FK506 binding protein 5. Only human studies were included in the review. Table 1 provides an overview of the key studies investigating the link between the FKBP5 gene and stress-related conditions. Table 2 includes reports examining the associations between FKBP5 polymorphisms and response to antidepressant drug treatment.

**Table 1**. Studies examining associations between FKBP5 polymorphisms and stress-related disorders.

| Study | n | Ethnic background | G x E | SNP | Risk allele | Main finding |
|---|---|---|---|---|---|---|
| *Depression* | | | | | | |
| Appel et al. (2011) | 2157 | Caucasian | Yes | rs1360780 | T | TT genotype interacted with childhood physical, sexual and abuse to increase adult depression. |
| Dackis, Rogosch, Oshri and Cicchetti (2012) | 236 | African-American (53.8)<br>Caucasian (33.9)<br>Hispanic (8.5)<br>Other (3.8) | Yes | rs3800373<br>rs9296158<br>rs1360870<br>rs9470080 | C<br>A<br>T<br>T | A haplotype formed by the risk alleles interacted with child maltreatment to increase limbic irritability. This interaction moderated the indirect effect of maltreatment on depression and dissociative experiences via limbic irritability. |
| Fani et al.(2013) | 103 | African-American | No | rs1360780 | T | T-allele was associated with higher attention bias for threat, increased hippocampal activation to threat and differences in hippocampal morphology. |
| Kang et al. (2012) | 130 | Korean | Yes | rs1360780<br>rs9296158<br>rs9470080 | T<br>A<br>T | Minor alleles predicted higher anxiety and depression after prolonged stress exposure in cancer patients. |
| Lavebratt, Aberg, Sjöholm and Forsell (2010) | 2743 | Caucasian | Yes | rs1360780 | T | T-allele and TT genotype were overrepresented in men with depression. No interaction was found between FKBP5 genotype and childhood problems or negative life events. |
| Lewis, Collishaw, Harold, Rice and Thapar (2012) | 436 | Caucasian | Yes | rs1260780<br>rs4713916<br>rs2800373 | --<br>--<br>-- | Recurrent maternal depression did not interact with FKBP5 genotype to predict child and adolescent depression symptoms. |
| Shinozaki et al. (2011) | 131 | Non-Hispanic Caucasian | Yes | rs1360780<br>rs3800373<br>rs9296258<br>rs9470080 | T<br>--<br>A<br>T | Minor alleles were associated with higher depression scores in kidney transplant recipients. |
| Tatro et al. (2010) | 57 | ??? | No | rs3800373<br>rs1360780 | G<br>T | Change in severity of depressive mood correlated with FKBP5 gene expression in carriers of risk alleles homozygous. |
| Velders et al. (2011) | 2928 | ??? | No | rs9470080<br>rs9394309<br>rs7748266<br>rs1360780 | G<br>--<br>--<br>-- | G-allele was associated with higher rate of depressive symptoms. |

Table 1. *Continued*

| Study | n | Ethnic background | G x E | SNP | Risk allele | Main finding |
|---|---|---|---|---|---|---|
| White et al. (2012) | 139 | Caucasian | Yes | rs7748266 | T | Risk alleles and haplotypes interacted with childhood emotional neglect to predict increased threat-related amygdala reactivity. |
| | | | | rs1360780 | T | |
| | | | | rs9296158 | A | |
| | | | | rs3800373 | G | |
| | | | | rs9470080 | T | |
| | | | | rs9394309 | G | |
| Zimmermann et al. (2011) | 884 | Caucasian | Yes | rs3800373 | C | Homozygozity for the minor alleles interacted with prior trauma exposure to increase the risk of development of major depressive episodes. |
| | | | | rs1360780 | T | |
| | | | | rs4713916 | A | |
| | | | | rs9296158 | A | |
| | | | | rs9470080 | T | |
| *Bipolar disorder* | | | | | | |
| Ceulemans et al. (2011) | 673 | Caucasian | No | rs9296157 | -- | None of the FKBP5 SNPs studied were associated with bipolar disorder. |
| | | | | rs3800374 | -- | |
| | | | | rs7757037 | -- | |
| | | | | rs755658 | -- | |
| | | | | rs2294807 | -- | |
| | | | | rs992105 | -- | |
| | | | | rs3798346 | -- | |
| | | | | rs9366890 | -- | |
| | | | | rs9296158 | -- | |
| | | | | rs4713899 | -- | |
| | | | | rs737054 | -- | |
| | | | | rs3777747 | -- | |
| | | | | rs9380524 | -- | |
| | | | | rs1360780 | -- | |
| | | | | rs2143404 | -- | |
| | | | | rs4713902 | -- | |
| | | | | rs17542466 | -- | |
| | | | | rs1334894 | -- | |
| | | | | rs6912833 | -- | |

**Table 1.** *Continued*

| Study | n | Ethnic background | G x E | SNP | Risk allele | Main finding |
|---|---|---|---|---|---|---|
| | | | | rs9470080 | -- | |
| | | | | rs13192954 | -- | |
| | | | | rs17614642 | -- | |
| Roy, Hodgkinson, Deluca, Goldman and Enoch (2012) | 474 | African-American | Yes | rs3800373 | A | AA-genotype interacted with childhood abuse to increase risk for suicidal behavior. |
| Supriyanto et al. (2011) | 447 | Japanese | No | rs2800373 | T | None of the FKBP5 polymorphisms were associated with completed suicide, but a haplotype formed by the minor alleles of rs2800373 and rs1360780 was overrepresented in suicide victims. |
| | | | | rs1360780 | C | |
| | | | | rs2395635 | -- | |
| *PTSD* | | | | | | |
| Binder et al. (2008) | 762 | African-American (95.2) | Yes | rs3800373 | C | Four polymorphisms interacted with childhood abuse to predict increased adult PTSD symptoms. |
| | | | | rs992105 | -- | |
| | | Caucasian (2.2) | | rs9296158 | A | |
| | | Hispanic (0.6) | | rs737054 | -- | |
| | | Asian (0.1) | | rs2360780 | T | |
| | | Mixed (0.9) | | rs1334894 | -- | |
| | | Other (0.1) | | rs9470080 | T | |
| | | | | rs4713916 | -- | |
| Koenen et al. (2005) | 46 | African-American (52.0) | No | rs3800373 | C | Minor alleles were associated with increased risk of peritraumatic dissociation in children with medical injury. |
| | | | | rs1360780 | T | |
| | | Caucasian (48.0) | | | | |
| Klengel et al. (2013) | 1963 | African-American | Yes | rs1360780 | T | T-allele interacted with early trauma to predict recurrent and lifetime PTSD. |
| Xie et al. (2010) | 2427 | Caucasian (47.2) | Yes | rs3800373 | -- | TT genotype (rs9470080) interacted with childhood abuse to increase the risk of PTSD only in African-Americans. |
| | | African-American (52.9) | | rs9296158 | -- | |
| | | | | rs1360780 | -- | |
| | | | | rs9470080 | T | |
| *Psychosis* | | | | | | |
| Collip et al. (2013) | 401 | Caucasian | Yes | rs9296158 | A | Risk alleles interacted with childhood trauma to increase psychotic symptoms. |
| | | | | rs1043805 | A | |
| | | | | rs1360780 | T | |
| | | | | rs4713916 | A | |

Only alleles that showed significant associations ($p \leq 0.05$) are included in the table. Dashes (--) indicate polymorphisms that did not show any significant association. Question marks (???) indicate that information about the sample's ethnic backround was not reported in the respective studies. SNP: Single-nucleotide polymorphism.

**Table 2**. Studies examining associations between FKBP5 polymorphisms and response to antidepressant drug treatment.

| Study | n | Ethnic background | Patient group | Antidepressant drug | Outcome measure | Predictive FKBP5 SNPs | Main finding |
|---|---|---|---|---|---|---|---|
| Binder et al. (2004) | 633 | Caucasian | MDD (86.6)<br>Bipolar disorder (12.0)<br>Dysthymic disorders (1.4) | Doctor´s choice.<br>Concomitant treatment:<br>Mood stabilizers (21.6)<br>Antipsychotics (7.7)<br>Benzodiazepines (48.7) | HAM-D | rs1360780<br>rs1334894<br>rs755658<br>rs4713916<br>rs3800373 | Minor alleles predicted response to antidepressant drug treatment. TT genotype (r1360780) was associated with more lifetime depressive episodes. |
| Ellsworth et al. (2013) | 529 | White non-Hispanic | MDD | Citalopram Escitalopram | QIDS<br>HAM-D | None | None of the 127 FKBP5 SNPs examined predicted response to antidepressant drug treatment. |
| Horstmann et al. (2010) | 387 | Caucasians | MDD (90.7)<br>Bipolar disorder (9.3)<br>Psychotic depression (14.3) | Doctor´s choice.<br>Concomitant treatment:<br>Mood stabilizers (18.0)<br>Antipsychotics (21.0)<br>Benzodiazepines (35.0) | HAM-D | rs1360780 | TT genotype was associated with response to antidepressant drug treatment (4.3% of the variance). Gene-by-gene interactions between FKBP5 rs1360780 and GRIK4 and HTR2A SNPs predicted 13.1% of the variance for remission. |
| Lekman et al. (2008) | 2562 | White non-Hispanic (83.6)<br>African-American (16.4) | MDD | Citalopram | QIDS | rs1360780<br>rs4713916 | T-allele (rs1360780) was overrepresented in non-Hispanic White patients with depression. Rs4713916 genotype predicted remission of depressive symptoms after antidepressant drug treatment. |
| Sarginson, Lazzeroni, Ryan, Schatzberg and Murphy (2010) | 246 | Caucasian (91.9)<br>Other (8.1) | MDD | Paroxetine (50.4)<br>Mirtazapine (49.6) | HAM-D | None | None of the FKBP5 SNPs examined (rs1360780, rs3800373) predicted response to antidepressant drug treatment. |
| Tsai, Hong, Chen and Yu (2007) | 125 | Chinese | MDD (95.2)<br>Dysthymic disorders (4.8) | Fluoxetine | HAM-D | None | FKBP5 rs1360780 did not predict response to antidepressant drug treatment. |
| Zobel et al. (2010) | 552 | Caucasian | MDD | Citalopram | HAM-D<br>Dex/CRH test<br>Hippocampal volume | rs3800373<br>rs4713916 | Major homozygous genotypes were associated with higher risk of developing depression, and predicted hippocampal volume and HPA response to antidepressant drug treatment. |

Only polymorphisms that significantly predicted response to antidepressant treatment ($p \leq 0.05$) are included in the table. Dex/CRH test: dexamethasone/corticotrophin-releasin hormone test; HAM-D: Hamilton Depression Rating Scale; MDD: Major depressive disorder; QIDS: Quick Inventory of Depressive Symptomatology; SNP: Single nucleoid polymorphism.

## GLUCOCORTICOID-SIGNALING AND FKBP5 FUNCTION

A combined effect of (epi-)genetic predispositions and environmental factors determines an individual's susceptibility to psychiatric disorders (Mehta & Binder, 2012). The physiological stress response plays a central role in coping with negative life events. Individual differences in neuroendocrine response systems, such as the hypothalamic-pituitary-adrenal (HPA) axis, are therefore of particular interest in the detection of risk factors for stress-related conditions (Spijker & van Rossum, 2012).

Stress induces the release of corticotropin releasing hormone from the paraventricular nucleus in the hypothalamus, which stimulates pituitary adrenocorticotrophine hormone synthesis, in turn increasing the release of glucocorticoids from the adrenal cortex (Mehta & Binder, 2012). Glucocorticoids participate in the termination of stress response via the activation of glucocorticoid receptors (GR), a ligand-activated transcription factor that promotes negative feedback inhibition of the HPA-axis. Upon cortisol-binding, GR translocates from the cytosol to the cell nucleus, where it exhibits its transcription and translation actions. GR function is modulated by a molecular hetero-complex that comprises hsp90/hsp70 chaperones and a number of co-chaperones, including FKBP5. When FKBP5 is bound to the GR complex, the receptor has lower affinity for cortisol, leading to a reduction of the amount of activated GR translocation and cellular glucocorticoid resistance (i.e. reduced glucocorticoid sensitivity) (Hartmann et al., 2012). Glucocorticoids induce FKBP5 expression as a part of an intracellular ultra-short negative feedback loop for GR activity (Binder, 2009; Hartmann et al., 2012).

Proper termination of physiological stress responses after stressor exposure is necessary for a healthy regulation, and prolonged or excessive activation of the HPA-axis has been implicated in the pathogenesis of stress-related disorders (Binder, 2009; Mehta & Binder, 2012). For example, impaired GR signaling results in an attenuation of the negative feedback inhibition. This can lead to glucocorticoid resistance and HPA-axis hyperactivity, two alterations commonly observed in mood disorders (Binder, 2009; Menke et al., 2012; Spijker & van Rossum, 2012). On the other hand, an increase in GR sensitivity due to enhanced negative feedback is observed in anxiety disorders such as PTSD (Mehta et al., 2011; Sarapas et al., 2011; van Zuiden et al., 2012; Yehuda et al., 2009).

## FKBP5 POLYMORPHISMS AND THEIR FUNCTIONAL ROLE IN GR SIGNALING

Individual differences in HPA-axis regulation are due to genetic factors and/or the combined effect with environmental exposures (e.g., early stressful life events, trauma exposure) that alter the baseline response to this system (Mehta & Binder, 2012). Indeed, GR-related genes have been shown to shape the physiological stress responsiveness (Mahon, Zandi, Potash, Nestadt, & Wand, 2013; Menke et al., 2012). In humans, several polymorphisms in the gene that codes for FKBP5, located on

the chromosome 6p21, seem to define distinct GR functioning (Binder, 2009). For example, common single-nucleotide polymorphisms (SNPs) of the FKBP5 gene have been associated with higher FKBP5 protein/mRNA expression and increased GR resistance, leading to impaired negative feedback inhibition of the HPA-axis after exposure to psychosocial stressors (Binder, Bradley, & Liu, 2008; Ising et al., 2008; Lekman et al., 2008; Mahon et al., 2013; Touma et al., 2011).

Importantly, this genetic association with GR function appears to be state-dependent, in other words specific alleles might lead to different GR function depending on the disease-status of the individual. For example, the minor allele of polymorphisms initially associated with high FKBP5 induction in healthy individuals (e.g., rs1360780) have been linked to lower FKBP5 gene expression and GR hypersensitivity in patients with depression (Menke et al., 2013) or PTSD (Mehta et al., 2011; Sarapas et al., 2011). Mehta et al. (2011) hypothesized that this state-dependence could be mediated by changes in the expression of other GR chaperones and systems influencing the HPA-axis. In a recent study, the same group also identified a long-term epigenetic mechanism (i.e. alterations in gene activity not caused by changes in the DNA sequence) that mediates the combined effects of early life stress exposure and FKBP5 SNPs on the risk of developing stress-related psychiatric disorders (Klengel et al., 2013). Allele-specific changes in FKBP5 DNA methylation in response to childhood abuse were shown to alter the responsiveness of FKBP5 to GR activation, leading to long-term dysregulation of the stress hormone system and a global effect on the immune system and brain regions associated with stress regulation.

Sex-specific effects have been reported in the association between the FKBP5 gene and GR function. In a study by Mahon et al. (2013) only male participants showed a positive genetic association with high cortisol levels in response to acute psychosocial stress. This male-specific effect could be related to the influence of sex hormones on FKBP5 and other GR-related genes (Binder, 2009). Nevertheless, sex-specific effects of the FKBP5 gene were not observed in other similar studies (Binder et al., 2008; Ising et al., 2008; Luijk et al., 2010).

## FKBP5 AND RISK FOR STRESS-RELATED PSYCHIATRIC CONDITIONS

### Mood disorders

Consistent with abnormalities in the HPA-axis feedback regulation and GR signaling in affective disorders, GR-related genes, including FKBP5, have been implicated in their pathogenesis (Binder, 2009; Spijker & van Rossum, 2012). In fact, FKBP5 genotype-dependent differences in GR sensitivity have been detected in patients with major depression, suggesting that the FKBP5 gene might delineate neuroendocrinologically distinct subtypes of depression (Menke et al., 2013).

High risk of developing depressive symptoms has been associated with FKBP5 polymorphisms (Lavebratt, Aberg, Sjöholm, & Forsell, 2010; Lekman et al., 2008; Velders et al., 2011; Zobel et al., 2010). However, there are some inconsistencies regarding the concrete genotypes that increase the vulnerability to depression. While some studies support a model in which carriers of the minor alleles are at higher

risk of depression (Lavebratt et al., 2010; Velders et al., 2011), others identified an over-representation of major alleles in patients with depression (Zobel et al., 2010). In the same direction, a correlation between change in the severity of depressive symptoms and FKBP5 gene expression was observed in HIV-infected individuals, but only in those homozygous for the major allele (i.e. carriers of two copies of the major allele) of the FKBP5 SNP examined (Tatro et al., 2010).

Results of these early reports in which direct genetic effects on disease status were detected have not been replicated in several other studies (Appel et al., 2011; Binder et al., 2004; Kang et al., 2012; Lewis, Collishaw, Harold, Rice, & Thapar, 2012; Shinozaki et al., 2011; Zimmermann et al., 2011). For example, Binder et al. (2004) found an association between FKBP5 genotype and lifetime depressive episodes, but failed to detect differences in SNPs frequencies between patients with depression and controls. Furthermore, a comprehensive meta-analysis that evaluated the relationship between FKBP5 polymorphisms and mood disorders yielded only one positive association (Feng et al., 2011). As an explanation of lack of consistent replication, the importance of FKBP5 gene-by-environment interactions in depression has been highlighted (Appel et al., 2011; Kang et al., 2012; Shinozaki et al., 2011; Zimmermann et al., 2011).

Early stressful events have been shown to increase the susceptibility to mood disorders in adulthood (Zimmermann et al., 2011), and FKBP5 gene seems to moderate this relationship. Appel et al. (2011) found a significant interaction between childhood abuse and FKBP5 genotype on the severity of adult depressive symptoms and lifetime major depression. More specifically, childhood abuse increased the vulnerability to depression only in homozygous for the minor allele of the SNP examined. This interaction effect, however, was not observed with childhood neglect, suggesting that FKBP5 moderates particularly the effect of abuse-related stress (Appel et al., 2011).

An interaction between adverse life events and FKBP5 polymorphisms was also observed in a prospective longitudinal community study (Zimmermann et al., 2011). Homozygosity for the minor allele of five FKBP5 SNPs increased the risk of developing a major depressive episode in individuals with prior trauma exposure. Interestingly, this relationship was dose-dependent, with stronger interaction effect with increasing trauma severity. These results were replicated in one of the two additional independent samples analyzed in this study.

The moderating role of FKBP5 gene in the risk effect of long-lasting stress is further supported by studies that examine the influence of FKBP5 polymorphisms on the development of depression after relatively uniform stressful experiences, such as diagnosis and treatment of severe medical conditions. Shinozaki et al. (2011) and Kang et al. (2012) found that FKBP5 polymorphisms predicted the development of depressive symptoms after kidney transplant or two cycles of chemotherapy. Nonetheless, results reported in the study by Shinozaki et al. (2011) should be interpreted carefully since no correction for multiple comparisons was applied and there were no data about the pre-transplant depression status.

While most evidence points to significant G x E interactions, some studies have failed to provide support to this relationship. A common FKBP5 polymorphism did not modulate the risk for depression in individuals exposed to childhood problems

or negative life events during the previous year (Lavebratt et al., 2010). Similarly, FKBP5 genotype did not interact with recurrent maternal depression to increase the vulnerability to child and adolescent depression (Lewis et al., 2012). Besides the possibility that significant G x E interactions were not detected due to low statistical power, or that they might not be applicable to the FKBP5 SNPs studied, it is likely that FKBP5 is only sensitive to certain types of severe psychosocial stressors (Appel et al., 2011) and during sensitive periods in early development (Klengel et al., 2013). Given the cumulative evidence of a combined effect of FKBP5 and childhood trauma on depression, the main genetic effects detected in some of the previously discussed reports might be due to the presence of high rates of trauma in the study samples, as most of those studies were based on clinical samples (e.g., Lavebratt et al., 2010; Lekman et al., 2008; Tatro et al., 2010; Zobel et al., 2010) in which early stressful events tend to be high (Appel et al., 2011; Zimmermann et al., 2011).

Evidence for an association between the FKBP5 gene and bipolar disorder is less conclusive. While Willour et al. (2009) reported an over-transmission of several FKBP5 alleles in families with bipolar disorder, these findings were not replicated in three other independent studies in which none of the SNPs tested yielded significant associations (Ceulemans et al., 2011; Fallin et al., 2005; Gawlik et al., 2006).

**Suicidal behavior**

FKBP5 seems to be also involved in the pathophysiology of suicidal behavior. Haplotypes of the FKBP5 gene have been associated with completed suicide in a Japanese sample (Supriyanto et al., 2011), although due to the lack of the psychiatric history of the victims it cannot be excluded that the identified relationship is mediated by the effects of the FKBP5 gene on mood disorders or other psychiatric pathologies associated with suicide. To disentangle this issue, Pérez-Ortiz, Garía-Gutiérrez, Navarrete, Giner, & Manzanarez (2013) examined FKBP5 expression in the amygdala of suicide victims without any underlying psychiatric disorder and found significant reductions of both FKBP5 gene and protein expression compared to controls, thus implicating FKBP5 in the neurobiological mechanisms of suicidal behavior.

G x E studies suggest a moderating role of FKBP5 genotype in the association between childhood trauma and suicide (Roy, Gorodetsky, Yuan, Goldman, & Enoch, 2010; Roy, Hodgkinson, Deluca, Goldman, & Enoch, 2012). In other words, childhood trauma exposure increased the risk of attempting suicide only in carriers of certain FKBP5 allelic-variants or haplotypes.

**Post-traumatic stress disorder**

Both stressful life events (e.g., childhood trauma) and GR-related genes have been shown to affect HPA-axis activity, and as described above, alterations in stress regulation are present in PTSD (Mehta & Binder, 2012). In addition, PTSD is the only psychiatric disorder in the Diagnostic and Statistical Manual of Mental Disorders (Fourth Edition) (DSM-IV) that requires the exposure to a traumatic event. It is therefore not surprising that G x E interactions contribute significantly to shaping the individual differences in the susceptibility to PTSD (for a review on

G x E vulnerability factors for PTSD, see Mehta & Binder, 2012).

To date only a handful of studies have examined the effect of FKBP5 polymorphisms on the risk to develop PTSD after early trauma exposure. Binder et al. (2008) detected four FKBP5 SNPs that interacted with child abuse to predict PTSD symptomatology in adulthood in a population of mostly African-Americans. In this sample, the non-risk alleles exerted a protective action against the development of adult PTSD after severe child abuse in a gene dose-dependent manner, that is, carriers of two non-risk alleles reported lower PTSD symptoms than carriers of only one non-risk allele. The moderating effect of FKBP5 on the relationship between childhood trauma and PTSD has been replicated in African Americans (Mehta et al., 2011; Xie et al., 2010) but not in European Americans (Xie et al., 2010). The lack of associations observed in the European American cohort might be due to ethnic-specific genetic linkage disequilibrium (i.e. shared inheritance of two or more allelic variants), or to differences in the severity of trauma exposure between the two samples (Mehta & Binder, 2012; Xie et al., 2010). As already observed in several studies on depression, genetic main effects on PTSD symptoms were non-significant in these studies (Binder et al., 2008; Xie et al., 2010), thus further highlighting the importance of G x E interactions in stress-related conditions.

FKBP5 polymorphisms have also been associated with peritraumatic dissociation (i.e. dissociative experiences such as depersonalization and derealization at the time of a traumatic event), a risk factor for PTSD, in children that suffered an acute medical injury (Koenen et al., 2005). Moreover, FKBP5 variants might define biologically distinct subtypes of PTSD, since different GR sensitivity, baseline cortisol levels and whole-blood gene expression pattern were associated with FKBP5 genotype in a sample of patients with PTSD (Mehta et al., 2011).

Reduced FKBP5 gene expression has been proposed as a state marker of PTSD (Sarapas et al., 2011; Yehuda et al., 2009) and it predicted high levels of PTSD symptoms in response to military deployment in a prospective study (van Zuiden et al., 2012). Interestingly, clinical response to cognitive behavioral therapy has been associated with normalization of the FKBP5 gene expression levels in patients with PTSD (Levy-Gigi, Szabó, Kelemen, & Kéri, 2013).

## ANTIDEPRESSANT DRUG RESPONSE

Since the first report in 2004 in which common FKBP5 polymorphisms predicted the response to antidepressant drug treatment (Binder et al., 2004), several replication pharmacogenetic studies have found both positive and negative associations between FKBP5 markers and antidepressant response across independent samples (Ellsworth et al., 2013; Horstmann et al., 2010; Lekman et al., 2008; Niitsu, Fabbri, Bentini, & Serretti, 2013; Sarginson, Lazzeroni, Ryan, Schatzberg, & Murphy, 2010; Tsai, Hong, Chen, & Yu, 2007; Zobel et al., 2010). Associations between FKBP5 SNPs and remission of depressive symptoms and response to treatment with selective serotonin reuptake inhibitors (SSRIs) have been found in both the STAR*D cohort and the Mayo study (Horstmann et al., 2010; Lekman et al., 2008). Positive FKBP5

genetic associations with antidepressants response were also reported in a recent comprehensive meta-analysis on pharmacogenetics in major depression (Niitsu et al., 2013). Furthermore, FKBP5 allelic-variants predicted smaller hippocampal volume and lack of reduction of HPA-axis hyperactivity after SSRI treatment (Zobel et al., 2010), two indicators of clinical non-response. However, none of the FKBP5 SNPs tested in this study predicted change in the severity of depression (Zobel et al., 2010).

Data challenging the strong genetic associations initially reported comes from studies by Tsai et al., (2007) and Sarginson et al. (2010), in which no FKBP5 gene effect on antidepressant efficacy was detected. Moreover, the FKBP5 polymorphisms most commonly found to be associated with clinical improvements after antidepressant treatment (i.e. rs1360780, rs3800373 and rs4713916) were not predictive of SSRI response in a recent report (Ellsworth et al., 2013).

Several factors might explain the discrepancies between the described findings. First, study samples might differ in terms of age distribution and severity or subtypes of patients. For instance, Binder et al. (2004) included inpatients with major depression, bipolar and dysthymic disorders in the sample, whereas the study group in Sarginson et al. (2010) consisted of elderly outpatients diagnosed with major depression. The ethnic origin of the study sample is another factor that might account for the divergent results, since certain genetic associations have been found in Caucasians and White non-Hispanics but not in African-American population nor in other ethnic subgroups (e.g., Lekman et al., 2008; Niitsu et al., 2013; Tsai et al., 2007). Finally, some of the studies have followed a naturalistic approach in which patients were treated according to doctors' choice (e.g., Binder et al., 2004; Horstmann et al., 2010), while in others a standardized routine treatment with a defined antidepressant was applied (e.g., Ellsworth et al., 2013; Lekman et al., 2008; Sarginson et al., 2010; Tsai et al., 2007; Zobel et al., 2010), which could result in significant differences in the response rates among studies (Tsai et al., 2007).

Perhaps genes x gene (G x G) interactions, rather than direct genetic effects, have a more important role in the pharmacogenetics of antidepressant drugs. For example, Horstmann et al. (2010) reported a significant interaction between FKBP5 and another GR-related gene (i.e. GRIK4) genotypes on the prediction of the antidepressant treatment. Furthermore, when different multi-marker models were tested, those that included G x G effects accounted for a higher percentage of the variance of treatment response than models considering only genetic main effects. Finally, antidepressant drugs have been shown to reduce the abnormally high FKBP5 gene expression levels in patients with depression that successfully responded to the treatment, although there was no association between baseline FKBP5 mRNA levels and treatment response (Cattaneo et al., 2013).

## CONCLUSIONS AND FUTURE DIRECTIONS

In the last years, several lines of research have implicated the FKBP5 gene in the etiology of stress-related phenomena. Consistent evidence supports associations between the FKBP5 polymorphisms and depression, suicidal behavior and PTSD. However, additional replication studies are warranted to provide conclusive data on the role of this gene in bipolar disorder and other conditions. For example, a recent report suggests that FKBP5 polymorphisms might also confer risk for psychotic experiences (Collip et al., 2013). The use of endophenotype-based approaches in addition to the classic genetic association studies will aid attempts to further link the FKBP5 gene to psychiatric disorders. In fact, some studies have already implicated the FKBP5 gene in endophenotypes associated with stress-related psychopathology, such as increased amygdala reactivity (White et al., 2012) and limbic system irritability after childhood trauma (Dackis, Rogosch, Oshri, & Cicchetti, 2012), as well as attention bias for threat and hippocampal alterations (Fani et al., 2013).

Increasing evidence highlights the importance of G x E studies for the detection of risk factors of stress-related psychopathology. Indeed, interaction between FKBP5 polymorphisms and early life stress exposure, rather than direct genetic effects, seems to better predict the development of PTSD, adult depression and suicide behavior. Importantly, the modulatory role of FKBP5 gene might not apply to all types of early stressors, as it seems to be specific for the effects of severe trauma-related stress. Upcoming epigenetic studies will contribute to elucidating mechanisms by which the interaction of FKBP5 gene and childhood trauma increases the susceptibility to mood disorders and PTSD.

Inconsistent findings with regard to the concrete FKBP5 polymorphisms and allelic-variants that increase the vulnerability to stress-related disorders are commonly reported. It is possible that, due to the high linkage disequilibrium in the FKBP5 gene and variations in allele frequencies by ethnicity (Binder, 2009), some of the SNPs tested might reflect the action of other functional variants in linkage disequilibrium, thus limiting the detection of significant associations. In addition, little is known about the functional impact of the FKBP5 polymorphisms on GR signaling. Future studies should therefore address these issues to better identify genetic and environmental conditions that render individuals from different ethnic backgrounds vulnerable to stress-related disorders. Moreover, detailed knowledge about the functional properties of FKBP5 polymorphisms might facilitate the identification of biologically distinct subtypes of depression and PTSD, which could lead to advances in the diagnosis and treatment of these disorders.

Finally, FKBP5 polymorphisms have also been demonstrated to play a promising role in pharmacogenetics of antidepressant drugs. For instance, FKBP5 genotype could potentially be harnessed as biomarker of SSRI response. However, more research is needed to fully resolve the involvement of the FKBP5 gene in the response to antidepressant treatment, with special focus on G x G interactions.

To sum up, gaining further knowledge of the FKBP5 gene could improve understanding and treatment of stress-related disorders that might be useful for future interventions. To this end, it might be advantageous not just to consider the FKBP5 gene alone, but in concert with the environment and other genes.

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STELLA VERENA FANGAUF

# Spirituality and Resilience: New Insights Into Their Relation With Life Satisfaction and Depression

Original Paper

Spirituality is not only commonly under debate as part of peoples' quest for meaning, but has also been subject to many studies concerning its influence on people with severe illnesses. The current research aims at investigating its influence on mental health. For this purpose a four-scale questionnaire was used to test peoples' spirituality and resilience as well as their life satisfaction and current symptoms of depression. To diversify the sample the survey was conducted in three languages, namely English, German and Dutch. Spirituality was found to correlate positively with life satisfaction and negatively with depression. Furthermore, resilience was identified as a mediator of the effect of spirituality on depression and as a partial mediator for the effect on life satisfaction. This study therefore suggests spirituality and resilience could be valuable factors in promoting peoples' mental health.
**Keywords:** spirituality; life satisfaction; depression; resilience; mediation

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## INTRODUCTION

A lot is known about the positive influence of spirituality on chronic pain (Büssing et al., 2009) and on cancer patients. Research showed positive associations of spirituality with hope and quality of life and negative correlations with depression and anxiety in those patients (Berg, Garssen, de Jager Meezenbroek, & Visser, 2005;

Visser, Garssen, & Vingerhoets, 2009). In addition, Doster, Harvey, Riley, Goven, and Moorefield (2002) found that spiritual people displayed less cardio-vascular risk factors, such as high levels of cholesterol or high blood pressure (Doster et al., 2002). Spirituality can be seen as a particular way of perceiving and interpreting the world (Lindeman, Blomqvist, & Takada, 2012), independent of religion and as shown, it affects people's health.

However, very little is known about the influence of spirituality on mental health in a healthy population. Mental Health is generally not only defined by the absence of mental disorders (The World Health Organization (WHO), 2001), but in the field of positive psychology also includes the acquisition of new resources (Seligman, Steen, Park, & Peterson, 2005). Nowadays people in the European Union work on average 41.4 hours per week under increasing time pressure (Eurofound, 2010) and weekend shifts have increased about 4.7% over the past 10 years (Wisdorff, 2013). Although work generally has a positive and meaningful effect, it can also become a strain when it is immoderate (Lohmann-Haislah, 2012). The workload then results in stress, which in turn can lead to a depressed immune system, fatigue and high blood pressure (Lohmann-Haislah, 2012). Automatic stress responses of the body include emotional and psychological arousal, impulsive action, intrusive thoughts, and some form of escape behavior (Lee, Cheung, & Kwong, 2012). This response can lead to depression or burnout, which are now widespread hardships that people face, evident from 53 million sick days taken in Germany in 2012 due to mental illnesses (Lohmann-Haislah, 2012). Given all this data, there is an imperative to find resources that can make people stronger in times of stress.

While everybody faces stress and adversities in life, some people seem to "bounce back" to or maintain a healthy mental status more easily than others. The American Psychological Association (APA) defines this "bouncing back" from challenging experiences as resilience, which is "the process of adapting well in the face of adversity, trauma, tragedy, threats, or even significant sources of stress - such as family and relationship problems, serious health problems, or workplace and financial stressors" (Comas-Diaz et al., n.d.). The APA acknowledges that there can be various burdening factors that people have to deal with in life. These factors include unexpected events, such as accidents, severe illnesses, or the loss of a loved one. Furthermore hardships can result from troublesome family or work situations. Additionally monetary issues can put a great strain on people. Resilient people have the capacity to accommodate to these kinds of problems.

This capacity has been defined by Block and Kremen (1996) as ego-resiliency, a dynamic reaction to the "demand characteristics of the environmental context, so as to preserve or enhance system equilibration" (p.351). This suggests that everybody has a characteristic level of self-control, and ego-resiliency is the ability to return to this level after being under a stressful influence.

Similarly to ego-resiliency, Reich, Zentra and Hall (2010) differentiate between two aspects of resilience: a recovery aspect and a sustainability aspect. While recovery refers to the duration and quality of readjustment after a specific experience or period of stress, sustainability refers to the ability to stay healthy or even improve one's own mental health as a sound reaction to stress. These authors propose resilience is actually an active decision to stay healthy (Reich et al., 2010)

similar to the APA's characterization of resilience as an active process and not a trait that people either have or do not have. Resilience can thus be learned and trained, even when the circumstances in childhood have not been ideal to build effective strategies against stress and adversities. However, apart from trainable factors there are further indicators that contribute to resilience and are very reliable markers in predicting peoples functioning and mental health through adversities. Three factors should be emphasized. First of all, various personal characteristics are contributors to resilience, including an agreeable temperament and the ability to regulate oneself. Secondly, close relationships with family and capable friends can predict a good outcome when struggling through hardships. These relationships include a warm and trusting relationship with one's parents. Finally, external structures that are supportive play an important role in peoples' functioning under adverse conditions. Structures such as an affluent neighborhood, good quality schools, and contact to prosocial organizations are linked to such positive effects (Garmezy, 1987). These multidimensional characteristics of resilience make it a key variable in predicting positive outcomes in the face of adversities (Lee et al., 2012). A decreased chance of becoming depressed and a higher satisfaction with life are likely to be part of these positive outcomes.

Similarly to resilience, life satisfaction can be partly seen as an active decision. It is a personal and subjective assessment of one's situation at a certain point in time and can include people's desire to change their life, their satisfaction with the past and the future as well as the view of significant others on their life (Beutell, 2006). Together with positive and negative affect life satisfaction is one of the three main contributors to well-being (Diener, Emmons, Larsen, & Griffin, 1985). As such it is an active decision to consider one's life as satisfying or not and this decision can be influenced by internal factors (i.e. spirituality) as well as external factors (i.e. relationships). Conversely, people who do not consider their lives to be satisfying have a greatly increased risk for depression (Fisher et al., 2014).

Approximately 18.4 million Europeans suffer from a depression ("European Alliance Against Depression," n.d.), which not only leads to a depressed mood and loss of pleasure in nearly all activities, but can also result in a diminished ability to think or concentrate, insomnia or hypersomnia and fatigue or loss of energy (American Psychiatric Association, 2000, Diagnostic and Statistical Manual of Mental Disorders, 4th ed., text revision). Depression greatly affects peoples' daily routine - due to their loss of energy they struggle even with usually easy tasks, such as getting up in the morning or going to work. Some might lose their hope, while others hold on to their faith.

While 95% of the Americans believe in God, most people in secular societies like Germany and the Netherlands describe themselves as 'spiritual, but not religious' (Shahabi et al., 2002). In 1996, 50% of the Dutch were members in a congregation (Berg et al., 2005). According to Kaski (2013), this number went down to 35,2% in 2011 (Kaski Centrum, Radboud Universiteit Nijmegen, 2013). This has to be taken into account for research asking people about their faith, their religion and their spirituality – and it is important that each are distinguished from the other (Zwingmann, Klein, & Büssing, 2011). On this account, this study asks about spirituality only. While faith and religion necessarily include the belief in God or

gods ("Faith", 2013), spirituality is characterized by individuality and innovation and is not institutional and traditionalistic. Moreover spirituality is open in terms of not being determined by rules and regulations but based on experiences instead of dogmas like traditional religions are. Spiritual people believe in 'some kind of higher power' without necessarily calling this power God. Nowadays spirituality has become more and more of a trend, supporting peoples quest for meaning. The topic can be found on bestseller lists as well as on yoga and meditation schedules and can provide and restore meaning and purpose in life and give hope to people, which makes it easier for them to endure difficult times or face life threatening illnesses (Bucher, 2007). Besides that, prayer or other spiritual traditions can stabilize people in times of uncertainty (Cornah, 2006). A Study of Putnam in 2006/2007 revealed that there was no difference in belief or religious behavior within one year when people joined or left church (Putnam & Campbell, 2012). These results imply that the pure church membership does not have a strong influence on belief but that this is a very personal and intrinsic process. As a result spirituality seems to be the underlying motivation to believe and may operate independently of a church membership.

The previous scientific results imply that resilience and life satisfaction are influenced by many factors and that they can have a positive effect on the mental health of people. Spirituality has been identified as one possible factor to have such effects, as it has been proven valuable in chronic pain and cancer patients. The present research thus investigates the question if spirituality fosters resilience and if it correlates with higher degrees of life satisfaction and less symptoms of depression. I examined whether spiritual people are more resilient and thus more satisfied with their lives, also showing less symptoms of depression. This leads to the following Hypotheses:

Hypothesis 1: Spirituality is positively correlated with life satisfaction.

Hypothesis 2: Spirituality is negatively correlated with depression.

Hypothesis 3: Resilience mediates the positive correlation between spirituality and life satisfaction as well as the negative correlation between spirituality and depression.

A trilingual questionnaire research was used to test these three hypotheses.

## METHODS

### Participants

A total of 344 people participated in this study. One participant was under the age of 18 and thus had to be excluded from the analysis, which lead to a total of 239 female and 104 male participants (N=343). Their mean age was 31.86 (SD= 16.06). 62.1% of the participants were native German speakers (N=213), 13.1% English (N=45) and 24.8% Dutch natives (N=85). The sample included people with different vocational qualifications and different employment situations. 34.3% graduated from high school and 32.4% had a university degree. 8.2% even had a post-graduate degree

and an apprenticeship had been finished by 6.1%. The rest finished 10th grade or less or had taken some other type of education. The majority of the sample consisted of students (56.3%) and people in full- or part-time occupation (33.5%). The rest were pensioners or housewives or had another occupation. Only 1.5% of the sample was unemployed. While most participants (88.8%) were born in a variety of European countries, 7.3% were born in North America and 2.1% in Asia. Only few participants were born in South America (0.3%), Africa (0.3%) or Australia and New Zealand (0.9%). Two participants failed to answer this question.

Potential participants received a link via email inviting them to the study 'My view on life'. Furthermore students from Maastricht University had the possibility to receive the participation link via SONA-Systems and in exchange for their participation they received 0.5 participation points. Further possible participants were reached via snowball sampling. The invitation clearly stated that only English, German and Dutch native speakers were allowed to participate in this study and that participants had four weeks to fill in the questions. Following the email link brought participants to the questionnaire, which was conducted using SurveyGizmo (www.surveygizmo.com). The first page gave them the opportunity to choose their mother tongue (English, German, Dutch or Other) and subsequently participants were redirected to the questionnaire fitting their mother tongue or to a page displaying that they were not eligible to participate in case they chose 'Other'.
The questionnaire consisted of 68 questions including 6 Socio-demographic questions. 26 questions addressed spirituality, 5 asked about life satisfaction, 6 about symptoms of depression and 25 addressed resilience.

**Materials**

All materials were provided in English, German or Dutch depending on the participant's native language. Values for Cronbach's alpha of each scale are reported in Table 1. Cronbach's alpha for each scale per language are reported in Table 2.

*General measures*

Data from the questionnaire were analyzed using SPSS Version 19. To assess socio-demographic information of each participant some general questions were asked in the survey. The answer options for 'highest completed educational level' were adapted to fit the norms of Germany, the Netherlands and English speaking countries respectively. Participants were asked to state their gender, age, marital status, highest completed educational level, country of birth, and their current employment situation.

*Spirituality*

Spirituality was measured using the Spiritual Attitude and Involvement List (SAIL), a 26-Item Scale with answers ranging from 1 ("Statement applies not at all to me") to 6 ("Statement applies to a very high degree to me"). It was originally designed to get more insight into the role of spirituality in dealing with cancer by asking the participant to rate statements like "I approach the world with trust". SAIL has seven subscales (i) Meaningfulness, (ii) Trust, (iii) Acceptance, (iv) Spiritual Activities, (v)

Transcendent Experiences, (vi) Care for others, (vii) Connectedness with Nature. However, in this research the scale was analyzed as a whole. It has been proven valid and reliable in groups of students, healthy participants and cancer patients (Meezenbroek et al., 2012). The scale was originally conceptualized in Dutch and English by de Jager Meezenbroek, Garssen and van den Berg (2008). As part of this research project it was translated into German with the help of bilingual students without a translation-retranslation procedure.
In the analysis phase all scores were summed up per person for the correlation and mediation analysis. Low sum scores reflect low spirituality, whereas high sum scores reflect high spirituality.

*Life Satisfaction*

The Satisfaction with Life Scale (SWLS) was designed to assess global life satisfaction. Life satisfaction is the cognitive aspect of the three contributors to subjective well-being. It requires a judgment about the personal situation (Diener et al., 1985). To measure people's overall judgment of their life Diener et al. (1985) designed a five-item scale. People could agree or disagree on a Likert-scale ranging from 1 ("Strongly disagree") to 7 ("Strongly agree") to questions like "In most ways my life is close to my ideal".

The single scores for every question were summed up per participant. Low sum scores reflect less Satisfaction with Life, whereas people with high sum scores are very satisfied with their life. The English scale of Diener et al. was translated back-to-back into Dutch by van Doorslaer (2007) and into German by Glaesmer, Grande, Braehler, and Roth (2011).

*Depression*

Symptoms of depression were measured using the Four Dimensional Symptom Questionnaire (4-DSQ). This questionnaire covers Symptoms of distress, depression, anxiety and somatisation, however for this research only the six questions concerning depression were used to determine participants' current condition, as the questionnaire focuses on symptoms that were present during the last seven days. The questions asked about the occurrence of specific symptoms, for example "During the past week, did you feel that everything is meaningless?" with answer options ranging from 1 ("No") to 5 ("Very often or constantly"). Answer "No" was scored with zero points, answer 2 ("Sometimes") was scored with one point and all other answers with two points. These scores were summed up separately for every participant. Sum scores of two or lower reflect a normal amount of symptoms of depression. Sums between three and five are considered to be moderately elevated and all scores >6 to be highly elevated (Terluin, 1998).
The scale was designed by Terluin in Dutch (1996) and English (text revision 2010), and translated into German by van den Bussche, Hautus, and Prakke (2008).

*Resilience*

Resilience was tested using the RS-25 (25-item Resilience Scale). This one-dimensional scale with 25 items uses a seven-point rating with 1 equal to "Strongly Disagree" and 7 equal to "Strongly agree". As resilience is not a trait it is measured

as a capacity and willingness to maintain a healthy status. Two studies were able to prove the validity and internal consistency of the scale (Wagnild & Young, 1993; Schumacher, Leppert, Gunzelmann, Strauß, & Brähler, 2005).
The total sum of every participant was used to analyze the person's state of resilience. People who score 25 to 100 are very low in resilience and people who score between 101 and 115 are low. Scores ranging from 116 to 130 are still moderately low, but scores above 130 to 145 are moderately high. People who have a sum score between 146 and 160 have a high resilience score and people between 161 and 175 a very high resilience score (Wagnild & Young, 1993). The scale was translated into German by Schumacher, Leppert, Gunzelmann, Strauß, and Brähler (2005). Due to the fact that the Dutch version of the RS-25 was not available free of charge, it was translated by bilingual students for the purpose of this research.

**Procedure**

The ethical committee of the Faculty of Psychology and Neuroscience at Maastricht University approved the conduction of this research.
The questionnaire started with a description of the survey and participants were provided with an email-address in case they had concerns or questions about the questionnaire. This text also described the requirements to participate in the study. Afterwards they had the choice to confirm that they have read the information and agree with it or not. Participants were first asked to fill in the SAIL followed by SWLS and 4-DSQ. Last they filled in the RS-25. Throughout the questionnaire were explanatory texts that also implied that there were no correct or incorrect answers.
The last page asked the participants to answer some socio-demographic questions and they had the chance to leave their email-address in case they wanted to receive further information. After submitting the data a new screen appeared displaying the debriefing and thanking the participants for their participation. Once again an email-address was provided in case there were any further questions.
The completion of the full questionnaire took about 20 minutes.
<L2> Statistical analysis <L2>
Descriptives were calculated for the socio-demographic questions. Furthermore all raw data of the questionnaires was tested with a Test of Normality (Kolmogorov-Smirnov). Reliability was tested with the internal consistency coefficient Cronbach's alpha and Correlations were calculated with a non-parametric Spearman's rho. To test for mediation, a Linear Regression was applied. Oneway ANOVA was used to check for differences between mean scores of the different language groups. In case of significant findings, post-hoc tests were done using Bonferroni correction.

## RESULTS

### Descriptives

Tests for Normality showed that scores for depression and life satisfaction were not distributed normally (Kolmogorov-Smirnov p<.001 respectively). The majority of the participants were not depressed (78.7% had normal scores and only 12.2% and 9.0% had moderately or strongly elevated scores, respectively). Resilience was also not normally distributed (Kolmogorov-Smirnov p<.001). Analysis of spirituality scores revealed that it was distributed normally (Kolmogorov-Smirnov p<.201). Mean values and standard deviations are reported in Table 1.

**Table 1.** Cronbach´s alphas, Means, Standard Deviations and Spearman Correlations

| Variable | Cronbach's α | M | SD | Range | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|
| 1. Spirituality | .88 | 100.95 | 15.03 | 26-1561 | | | | |
| 2. Life Satisfaction | .87 | 24.73 | 5.82 | 5-352 | .35** | | | |
| 3. Depression | .86 | 1.55 | 2.52 | 0-123 | -.24** | -.45** | | |
| 4. Resilience | .90 | 130.16 | 18.52 | 25-1754 | .53** | .47** | -.46** | |

** p< .01 (two-tailed).
Cut-off values: 1) 26 – not spiritual, 156 – very spiritual, 2) 5 – very dissatisfied, 35 – very satisfied, 3) 0 – normal, 12 – strongly elevated, 4) 25 – less resilient, 175 – very resilient

Due to the fact that most variables were not distributed normally nonparametric tests were used to test correlation. Spirituality was positively related to life satisfaction and resilience. Depression displayed significant correlations with spirituality, resilience and life satisfaction in the expected negative direction. Life satisfaction and resilience were positively correlated. All correlations were significant at the .01 level (two-tailed) (see Table 1).

### Differences between language groups

Mean-scores varied between the different native languages (see Table 2). Germans scored highest and Dutch natives lowest on spirituality. Similar results were found for depression. Germans showed the fewest symptoms, while Dutch the most. German natives were furthermore most satisfied with their lives while English and Dutch natives displayed slightly lower scores. Only on resilience scores English natives scored the highest while Dutch had a much lower mean score.

**Table 2** Means and Standard Deviations per Language

| Variable | English | German | Dutch |
|---|---|---|---|
| 1. Spirituality | | | |
| M (SD) | 99.58 (16.15) | 105.56 (13.37) | 90.11 (12.58) |
| Cronbach's α | .877 | .850 | .850 |
| 2. Life Satisfaction | | | |
| M (SD) | 22.38 (8.21) | 25.53 (4.95) | 23.98 (5.97) |
| Cronbach's α | .933 | .826 | .888 |
| 3. Depression | | | |
| M (SD) | 1.89 (3.15) | 1.26 (2.29) | 2.11 (2.61) |
| Cronbach's α | .907 | .855 | .825 |
| 4. Resilience | | | |
| M (SD) | 135.67 (22.54) | 133.26 (16.87) | 119.47 (16.00) |
| Cronbach's α | .917 | .889 | .854 |

Mean age (MDutch = 21.42, MEnglish = 31.18, MGerman = 36.16) significantly differed between the three language groups ($F(2,341)=29.546$, $p<.001$) as well as mean scores of all four variables (spirituality: $F(2,340)= 39.64$, $p<.001$; life satisfaction: $F(2,340)= 6.59$, $p<.002$; depression: $F(2,340)= 3.98$, $p< .02$; resilience: $F(2,340)= 21.41$, $p<.001$). Results of the post-hoc tests are displayed in Figure 1.

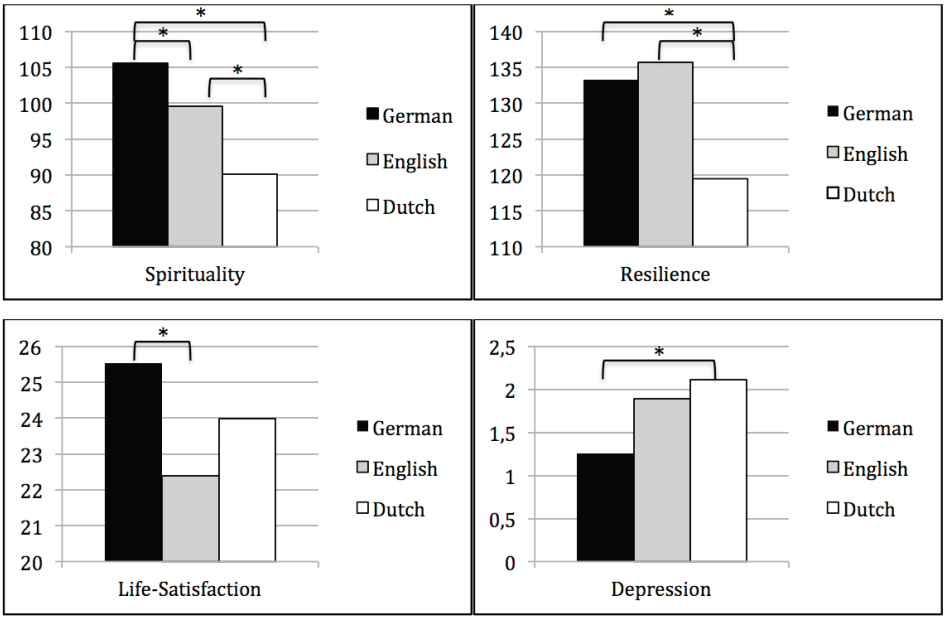


**Figure 1.** Differences Between Language Groups.
* significant at the .05 level

## Mediation analysis

The hypotheses were further tested with the linear regression approach. In the first step spirituality was entered as a predictor for life satisfaction to test hypothesis 1. The results confirm that spirituality is a significant predictor for life satisfaction. The same significant result was found for spirituality as a predictor for depression (see Table 4.a and 4.b).

**Table 4.a** Results of Regression Analysis and Mediating Effect of Resilience on the Relation of Spirituality With Life Satisfaction

| | Step 1 | | | Step 2 | | | Step 3 | | | Step 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Predictor | ΔR2 | B | β | ΔR2 | B | β | ΔR2 | B | β | ΔR2 | B | β |
| Spirituality | .15* | .15* | .39* | .31* | .69* | .56* | | | | | .06** | .15** |
| Resilience | | | | | | | .27* | .16* | .52* | | .14* | .44* |
| R2 total | | | | | | | | | | .29* | | |

*p<.01, **p<.05,

**Table 4.b** Results of Regression Analysis and Mediating Effect of Resilience on the Relation of Spirituality With Depression

| | Step 1 | | | Step 2 | | | Step 3 | | | Step 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Predictor | ΔR2 | B | β | ΔR2 | B | β | ΔR2 | B | β | ΔR2 | B | β |
| Spirituality | .07* | -.04* | -.26* | .31* | .69* | .56* | | | | | .00 | .03 |
| Resilience | | | | | | | .25* | -.07* | -.50* | | -.07* | -.52* |
| R2 total | | | | | | | | | | .25* | | |

*p<.01

If resilience functions as a mediator between spirituality and the two dependent variables it has to meet the following conditions according to Baron and Kenny (1989): "(a) variations in levels of the independent variable significantly account for variations in the presumed mediator (i.e. Path a), (b) variations in the mediator significantly account for variations in the dependent variable (i.e. Path b), and (c) when Paths a and b are controlled, a previously significant relation between the independent and dependent variables is no longer significant" (p.1176). The pathways are displayed in Figures 2 and 3.

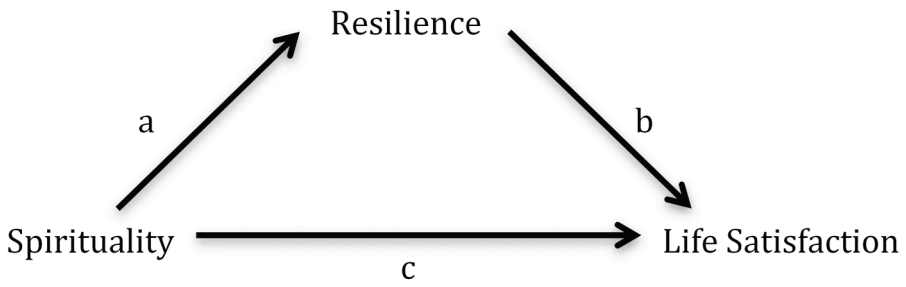


**Figure 2** Mediation Model 1. Pathway a exemplifies the effect of the independent variable (spirituality) on the mediator (resilience), pathway b illustrates the effect of the mediator on the dependent variable (life satisfaction), pathway c demonstrates the direct effect of the independent on the dependent variable.

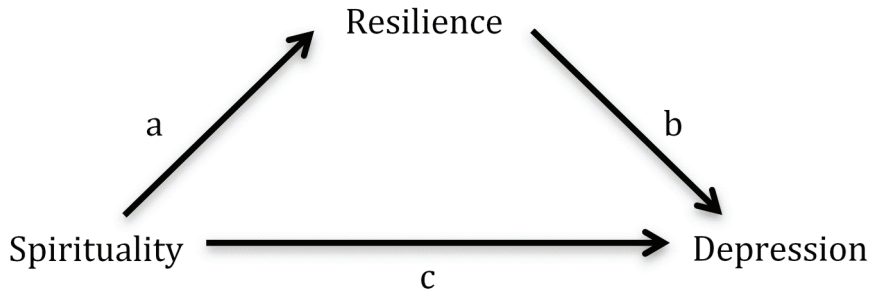


**Figure 3** Mediation Model 2. Pathway a exemplifies the effect of the independent variable (spirituality) on the mediator (resilience), pathway b illustrates the effect of the mediator on the dependent variable (Depression), pathway c demonstrates the direct effect of the independent on the dependent variable.

Additionally to step 1.a and 1.b (spirituality as a predictor for life satisfaction (step 1.a in Table 4a) and as a predictor for depression (step 1.b in Table 4b)), spirituality was tested as a predictor for resilience to fulfill condition (a) (Step 2). The significant result shows that 31% of variance of resilience is explained by spirituality (see Table 4a, Step 2 $\Delta R2$). Step 3 involved a test for the direct relation between resilience and life satisfaction or depression. Step 4 tested if resilience fully mediated the relation between spirituality and life satisfaction and the relation between spirituality and depression. This test requires a regression equation with spirituality and resilience both as predictors of life satisfaction and depression respectively. The results revealed that resilience functions as a partial mediator for the effect between spirituality and life satisfaction and as a full mediator for the effect between spirituality and depression. There is still a significant correlation between spirituality and life satisfaction (see Table 4.a, Step 4 $\beta$=.15). The prior significant Path c between spirituality and depression is not significant anymore when resilience is entered as a predictor, fulfilling condition c (see Table 4.b, Step 1 $\beta$=-.26 ($p<.01$), Step 4 $\beta$=.03 ($p>.71$)).

The results of the regression analysis confirm that resilience functions as a mediator for the effect between spirituality and depression but only partially mediates the relation between spirituality and life satisfaction.

*Mediation analysis of German language group*

The same mediation analysis was conducted separately for the group of German natives to test the effects in the biggest, culturally more homogenous sample. Results are displayed in Tables 5.a and b. Even though the effect of spirituality on life satisfaction was not significant anymore when resilience was added as a predictor (Step 4), the correlation does not dissolve completely. As a result there is a tendency of resilience as a mediator for the effect between spirituality and life satisfaction, but it does not fully mediate this effect. The rest of the results were comparable to those of the analysis of the whole sample.

**Table 5.a** Results of Regression Analysis and Mediating Effect of Resilience on the Relation of Spirituality With Life Satisfaction Analyzing German Natives Only

| | Step 1 | | | Step 2 | | | Step 3 | | | Step 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Predictor | ΔR2 | B | β | ΔR2 | B | β | ΔR2 | B | β | ΔR2 | B | β |
| Spirituality | .12* | .13* | .34* | .25* | .63* | .50* | | | | | .05 | .14 |
| Resilience | | | | | | | .23* | .14* | .48* | | .12* | .42* |
| R2 total | | | | | | | | | | .25* | | |

*p<.01

**Table 5.b** Results of Regression Analysis and Mediating Effect of Resilience on the Relation of Spirituality With Depression Analyzing German Natives Only

| | Step 1 | | | Step 2 | | | Step 3 | | | Step 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Predictor | ΔR2 | B | β | ΔR2 | B | β | ΔR2 | B | β | ΔR2 | B | β |
| Spirituality | .06* | -.04* | -.25* | .25* | .63* | .50* | | | | | .00 | .02 |
| Resilience | | | | | | | .23* | -.07* | -.48* | | -.06* | -.47* |
| R2 total | | | | | | | | | | .23* | | |

*p<.01

## DISCUSSION

The questionnaire implemented in this study investigated the role of spirituality as a source of resilience and its effects on life satisfaction and depression. While the first hypothesis, namely the positive correlation of spirituality with life satisfaction could be confirmed, the negative correlation between spirituality and depression (hypothesis 2) dissolved after resilience was added as a mediator. The results thus

indicate a significant direct effect between spirituality and life satisfaction but no such effect for depression. The data from the mediation analysis indicate that spirituality positively correlates with resilience, which in turn negatively correlates with depression. This suggests that spiritual people may be more resilient and should be less vulnerable for depression. Although spirituality has no direct effect on depression it can be seen as valuable contributor to the mental health of people through building resilience.

A similar effect was found for the mediating role of resilience on the relation between spirituality and life satisfaction, however resilience only partially mediates this relation and a direct effect of spirituality on life satisfaction remains. These results show the positive direct correlation of spirituality with life satisfaction as well as an indirect effect of spirituality on life satisfaction (partially mediated by resilience). Nevertheless, as the direct effect is smaller than the indirect effect there seems to be more to life satisfaction than just spirituality. Lyubomirsky, Sheldon, and Schkade (2005) proposed in their model of happiness that apart from 50% being due to genetics and 10% due to the circumstances, 40% of happiness could be influenced by deliberate actions. Among other things, these 40% could be determined by spiritual activities as well as building resilience and thus lead to higher life satisfaction. Similarly, depression can be caused by a variety of factors, such as a genetic predisposition, an unfortunate life experience or a negative way of thinking (Davey, 2008). While resilience can help people recover ("bounce back") from unfortunate experiences, spirituality can positively influence their way of thinking. Saying this, both factors seem to be valid contributors to mental health.

Besides life satisfaction and depression, which are influenced by many factors, resilience also has multidimensional characteristics. All three exhibit internal and external aspects such as genetics, personal characteristics or an active and positive way of thinking as internal factors and supportive structures, circumstances or relationships as external factors. Resilience can thus be an internal as well as an external contributor to life satisfaction and depression and can itself be influenced by spirituality, either as a way of thinking or seeing things along with building a community of support.

The strong correlation of resilience with both life satisfaction and depression makes it a good predictor for a positive mental health status. Overall, resilient people seem to have good coping skills to be significantly more satisfied with their life and be less vulnerable for depression. In a longitudinal study Kasen, Wickramaratne, Gameroff, and Weissman (2012) identified religiosity/spirituality and service attendance as a resilience factor in participants with high risk for major depression. When interpreting these results it has to be taken into account that these authors did not differentiate between the concepts of religiosity and spirituality. In line with this study the current research supports these findings and expands the current knowledge by introducing resilience as a mediator. It defines the relation between spirituality, resilience and depression by establishing a mediation model and evidences that there is no direct effect of spirituality on depression.

Taking the current increase in workload and the resulting consequences into account, an establishment of protective factors is of utmost importance. In the academic field, the present study extends the existing knowledge about the positive

influence of spirituality on general health to the field of mental health and its results suggest that spirituality could function protectively against depression through resilience. The data suggests that, besides other factors, spirituality is as a worthy contributor to peoples' mental health and it advocates that spirituality should be promoted as a natural support factor that has been known in many cultures for centuries. It should not be waved aside as a backward tradition that is not necessary in a modern society. The current research highlights the broader implication that even though spirituality is a very wide and open concept it has a great influence of peoples' frame of mind and can improve peoples' ability to successfully conquer stress. This is especially valuable in economically difficult times, when for example people fear losing their job. What is more is that in modern societies up to 50% of all marriages break up (Eurostat, 2012) and families become less coherent. This poses a great source of stress for all persons involved and can threaten their mental health. Overall this research evidences that spirituality can be seen as an important resource to build resilience to improve chances of a positive outcome of such situations.

**Limitations and future directions**

This present study contains some limitations. Even though resilience has been identified as a mediator, mediation is only a theoretical model and does not explain any causality. Therefore, the role of resilience in this context needs further investigation. Moreover, the concept of resilience is still not fully understood and future research should focus on locating further factors that contribute to resilience. The differences between the three languages groups in this research might result from the different mean age as well as differences in the translations of the questionnaires.

To correct for the effect of age an Analysis of Covariance (ANCOVA) should be applied with age as the covariate to discover if there is a relation between age on the one hand and resilience, spirituality, life satisfaction, and depression on the other hand.

Culturally different interpretations of the questions could have occurred and the reliability of the results of this research might be limited due to the translation of some of the scales, however the analysis of the internal consistency of each of the scales per language shows that they are comparable to the original scales. It remains unclear if the effects of spirituality and resilience are equally present in men and women.

Due to the large sample size and the cross-cultural character of this research the results are more generalizable. Moreover, the diversity of participants (gender, age, and education) makes the data applicable to a variety of other populations. The mediation analysis of the German language group displayed very similar results and it can be thus concluded that the results are applicable to more homogenous samples as well. However it should be analyzed if the relations found in this research are the same within each of the different samples. This analysis was not possible in this research due to small sample sizes in the English and Dutch language groups. Future research could further investigate the impact of spirituality and resilience, by dividing people into groups according to their spirituality and encourage and support parts of these groups in building resilience. With controlled experimental

research it might be possible to establish spirituality as a causal influence on life satisfaction and depression and to further establish resilience as a powerful mediator.

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DAAN SCHETSELAAR

# Modality-specific encoding of conceptual person identity in the Fusiform Face Area

Original Paper

I employed multi-voxel pattern analysis to fMRI data from two functionally defined clusters in the Fusiform Face Area (FFA); mFus and pFus. Stimulus information was decoded from hemodynamic response patterns evoked by three fictional identities. These were comprised of sets of semantic person information and corresponding faces. By presenting identities with overlapping visual and semantic features we could attribute successful decoding to the differentiating feature. Our data suggest a functional differentiation between pFus and mFus. Analysis of response patterns in pFus indicated that this cluster is engaged in perceptual analysis during face presentation and in retrieval of the corresponding face representation during presentation of semantic stimuli. In mFus semantic items appear to evoke a single corresponding face representation whereas during face perception this cluster is likely to be engaged in retrieval of semantic features by activation of a collection of corresponding visual representations. I propose that mFus supports conceptual knowledge of people by activating visual features that correspond to semantic categories.

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## INTRODUCTION

The human face perception system provides us with the extraordinary ability to recognize a seemingly unrestricted number of faces and quickly match them to available biographic information. A major node in the underlying neural network is The Fusiform Face Area (FFA), a patch of ventral temporal cortex on the posterior Fusiform Gyrus (FG) and mid-Fusiform Sulcus (Haxby, Hoffman and Gobbini,

2002). Besides its manifest role in visual face processing (e.g. Tong, Weinrib & Kanwisher, 2000; Yovel and Kanwisher 2005; Bruce and Young, 2011), there are also various reports that implicate the FFA in processing of non-visual semantic information related to people.

A fairly direct approach to measure whether a brain area encodes certain information employs multivariate analysis of fMRI data, known as multi-voxel pattern analysis (MVPA). It aims to find information present in the distributed pattern of activation across multiple voxels. Using MVPA Van den Hurk (2011) found that evoked activity patterns in the FFA could be consistently mapped to word stimuli in either a person context or a non-person context, suggesting that the FFA has access to non-visual semantic information. This is in line with Turk, Rosenblum, Gazzaniga, & Macrae (2005) who found that making a semantic judgment about a face on an individual level (i.e. the name of the person) is accompanied by an increase in hemodynamic response compared to judgments of a face on a category level (occupation) in the posterior Fusiform cortex among other regions.

Previously other researchers had pointed out a possible extensive role of the FFA in social cognition even when no face stimuli are presented. Schultz et al. (2003) found increased BOLD-responses in the FFA when movements of animated geometric shapes were interpreted as social interaction in a social attribution task (SAT). The region activated by the SAT closely overlapped with the FFA although its center of mass was slightly more medial and anterior. The authors propose that the functions of the region include encoding semantic attributes of people, which might aid in defining faces as distinct objects.

These findings of involvement of the FFA in processing of non-visual person information are remarkable because previous research has fairly unanimously implicated its location on the bilateral FG (BA 37) in relatively elementary, pre-semantic visual processing (e.g. Ungerleider & Haxby, 1994; Thompson-Schill, Aguirre, D'Esposito & Farah, 1999; Bright, Moss & Tyler, 2004). Furthermore the absence of increased FFA-response to famous faces (assumedly associated with richer semantic information) compared to unknown faces, has been a strong reason to rule out the availability of non-visual semantic information in the region (Kanwisher & Yovel, 2006).

**Is FFA functionally subdivided?**

Rare intracranial experiments in humans add to the dissonance in the debate on the role of the FFA in semantic person processing. When Parvizi (2012) electrically stimulated cells in the right FFA the subject reported highly selective changes in visual face perception. However other electronic brain stimulation (EBS) experiments demonstrated no distorted face perception but instead only deficits in naming faces (Allison et al., 1994; Puce, Allison, & McCarthy, 1999). Since from these earlier studies the exact location of the stimulated area cannot be distilled, discrepant findings may stem from stimulation of slightly different regions across studies (Parvizi, 2012).

This suggestion of fine-grained local differences in functionality within face-selective Fusiform cortex is supported by refined mapping of the region with improved functional magnetic resonance imaging methods. The face selective

region on the FG is now accepted to consist of at least two anatomically separate clusters (e.g.: Weiner and Grill-Spector, 2012). These clusters, located on the middle Fusiform Sulcus and on the posterior Fusiform Gyrus are named mid-Fusiform face cluster or mFus and posterior Fusiform face cluster or pFus respectively (also referred to as FFA-1 and FFA-2, respectively; Pinsk et al., 2009). Researchers have just begun to investigate whether these clusters differ functionally and in what respect.

Given the current parcellation of the FFA Van den Hurk (2013) could replicate his earlier finding of semantic representation in FFA and relate it to a functional subdivision of its two clusters, again by using MVPA. Subjects viewed semantic person information while actively associating this to a previously seen face. Semantic stimuli could be reliably decoded from the hemodynamic response patterns in pFus. However this was not the case in the more anterior mFus cluster. Neural activity in this cluster nevertheless proved to contain stimulus information when it was evoked by visual face stimuli, which was not apparent in pFus.

Van den Hurk's work seems to suggest that non-visual semantic information is present in pFus but not in mFus. However a functional allocation of semantic processing exclusively to the posterior cluster is not in line with the general increasing complexity of neural response properties along the ventral visual pathway (e.g. DiCarlo et al., 2012, but see Kravitz, Saleem, Baker, Ungerleider & Mishkin, 2013). This organizational principle has also been demonstrated specifically in the domain of face perception (Ungerleider and Haxby, 1994). If non-visual semantic processing is conducted in the FFA it would thus be expected to appear in its anterior part.

**A visual account of semantic representations in FFA**

The mentioned findings of responses in FFA elicited by non-face stimuli might be parsimoniously explained without assuming conceptual information being stored or processed in this area. Possibly the semantically induced activity in FFA reflects retrieval of visual representations. In Van den Hurk's (2013) study this is a particularly plausible scenario since subjects were explicitly asked to associate visual and non-visual information in the task. Indeed imagining faces has been demonstrated to activate the FFA similarly to face perception in neuroimaging experiments (O'Craven & Kanwisher, 2000).

The distinct response patterns in mFus during face presentation in Van den Hurk's study (2013) might result from retrieval as well. Plausibly visual representations of a person get activated when associated non-visual semantic information is retrieved upon the presentation of the face. This is implicitly predicted by the interactive modality-specificity hypothesis (Thompson-Schill, Aguirre, D'Esposito & Farah, 1999). It states that for objects that are predominantly defined by their visual form such as living things, retrieval of non-visual features is strongly associated with activity in areas involved in visual processing. This claim is supported by findings of increased activation in the FG when subjects retrieved semantic information about living things as opposed to non-living things (Thompson-Schill, et al., 1999; Chao, Haxby and Martin 1999).

When viewed in this light finding distinct activity patterns during retrieval of semantic information particularly in mFus fits the anterior shift in cortical activity

as observed by Martin, Haxby, Lalonde, Wiggs and Ungerleider (1995). When their subjects were asked to retrieve knowledge about color and motion of known objects an increased BOLD-response was detected slightly anterior to sites that showed maximum activation during perception of the same object features. According to the modality-specificity hypothesis this is also expected when retrieved information about persons is non-visual.

**The present study**

The information reflected in distinct neural activity patterns in FFA clusters might be visual, semantic or a combination (visuosemantic). In Van den Hurk's (2013) experiment the informational content remains unclear because local processing could reflect perception of the currently presented stimulus or retrieval of the associated information. Therefore we implemented a similar but slightly adapted design to investigate fMRI response patterns elicited by written words (conveying biographical information e.g. residence, hobby and occupation) and visual face stimuli. Fixed combinations of word and face stimuli defined three different fictional person identities. Subjects were asked to actively associate semantic and visual information belonging to the same identity and think of them as describing a person.

Key is that in the current experiment not every identity consisted of a unique face and unique semantic information. Instead two identities shared an identical face ('twins') and one of these shared (almost) identical biographical descriptions with the third identity. This enabled us to assign decodable activation patterns to the unique component and thus allowed disentangling neural activity representing visual face information from non-visual semantic identity information.

Contrary to the order of stimulus presentation in Van den Hurk's design, in the present study each identity started with presentation of the semantic stimuli followed by the corresponding face. Each block of semantic stimuli commenced with an item that was uniquely assigned to one identity, serving as a cue to notify the subject of the current identity (for two identities the remaining semantic stimuli were identical). The use of identical stimuli for different identities would otherwise provide insufficient information for the subject to associate face and semantic information. We assessed task feasibility outside the scanner with the same stimuli and similar procedure but different subjects (because of possible learning effects; Robinson-Long, Eslinger, Wang, Meadowcroft & Yang, 2009).

To the fMRI-data we applied multi-voxel pattern analysis (MVPA). In this procedure we decoded stimuli (written words or pictures) belonging to combinations of two different identities from their evoked responses in the two bilateral face selective clusters on the FG. Since each identity was construed of at most only one unique identity-component, correctly classified patterns must reflect activity that is related to this differentiating component or is otherwise visuosemantic.

We hypothesized that pFus response patterns evoked by semantic stimuli can only be accurately classified when the associated faces are different. Similarly we expected that mFus response patterns evoked by face stimuli are also only accurately classified when the face stimuli are different. This would support the idea that the intelligible patterns in FFA reflect visual representations.

## METHODS

### Participants

Two native Dutch speaking volunteers (1 female, age 32 and 27) were recruited to participate in the neuroimaging experiment. Both were right handed and had normal or corrected to normal eye sight. They were screened for fMRI compatibility and signed informed consent.

### Stimuli

Semantic stimuli were created from a 5 * 2 word matrix, consisting of five categories (capital cities, professions, marital status, music styles and hobby's). We used only Dutch words, the native language of all participants.
The two different face stimuli were obtained from a stimulus set provided by Mark Steyvers (http://psiexp.ss.uci.edu/research/software.htm). The pictures were all taken under similar lighting with neutral facial expressions. We selected two faces that are easily recognizable but at the same time do not have obvious distinctive features (see figure 1).

### Procedure

Sessions consisted of four runs, each of approximately ten minutes duration. Three identities, each comprised of a face and a set of semantic items, were presented in random order. A sequence of the three identities was repeated six times per run, resulting in 24 presentations per identity. Subjects were asked to actively associate semantic and face information belonging to the same identity.

Presentation of each identity (comprising an identity block) commenced with five semantic items, presented one at a time with a duration of 1800 ms and interstimulus interval of 200 ms. After the presentation of the semantic items a fixation cross was presented for twelve seconds to allow the BOLD-response to return to baseline level. Next a face stimulus was presented for two s. An interval of 12 - 16 s separated identity blocks to allow the BOLD-signal to return to baseline. Each participant was presented with fixed combinations of semantic items and faces. The three identities thus remained consistent in their visual and semantic attributes throughout each session. Across participants however the semantic items were scrambled within each category before assigning them to the different identities. Also the order in which the semantic items were presented was randomized form trial to trial.

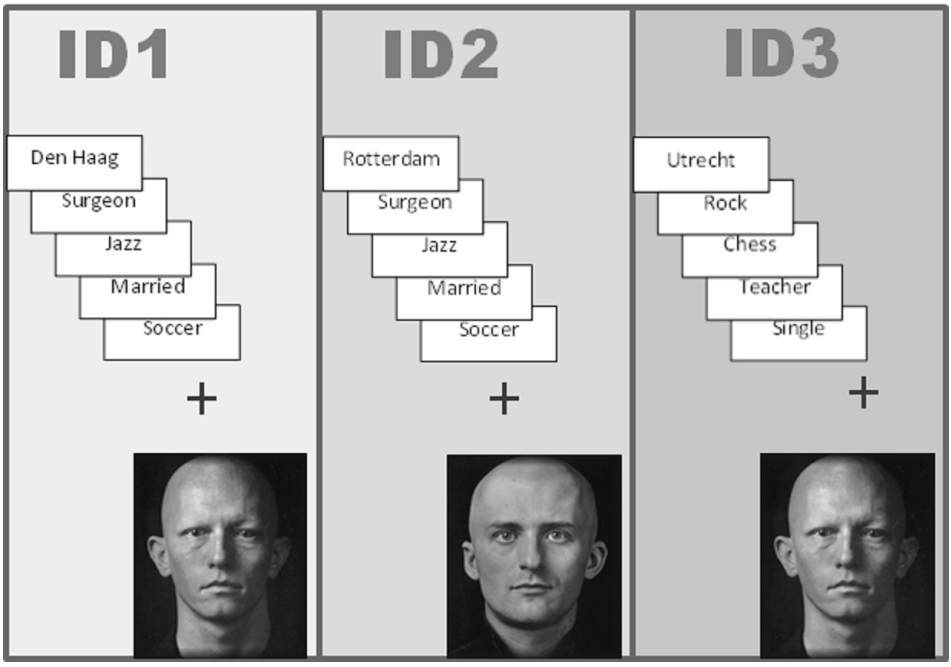


**Figure 1**. Example of three identities each composed of five semantic items and a face. For every subject the same set of stimuli was used, but across participants the semantic items within each category were scrambled before assigning them to the different identities. The order in which the semantic items were presented was randomized form trial to trial.

Based on the prior behavioral assessment we decided to let subjects view one block from the actual experiment (6 X 3 identities) with the actual stimulus combinations previous to scanning. We verbally verified whether the task was clear and if the subject was confident about his/her ability to associate the faces and semantics to their correct counterparts.

In separate runs face sensitive regions were localized as well as the nearby Visual Word Form Area (to be able to exclude responses to the mere shape of words in the semantic items). The participants passively watched blocks of faces, scrambled faces, houses, words and random letter strings. Each block consisted of ten gray scale images or white letters on a dark-gray background. Stimuli were presented for 1500 ms followed by 300 ms fixation. Blocks were repeated eight times and presented in random order, divided over two separate runs.

**Materials**

For the neuroimaging experiment we used a 3-T Siemens Magnetom Allegra head scanner (Siemens Medical Systems, Erlangen, Germany) using a standard head coil. Twenty-eight axial slices (2 X 2 mm, interslice distance 0 mm) covering the temporal lobe were collected using an echo-planar imaging sequence (repetition time [TR] = 2000 ms, matrix size 128 X 128, echo time [TE] = 30 ms). For each run the first two functional volumes were excluded due to T1 saturation.

Anatomical images covering the whole brain were obtained between experimental runs using a 1 X 1 X 1 mm resolution T1-weighted ADNI-sequence (TR=2250 ms; TE = 2.6 ms; flip angle = 9°). The participants were placed comfortably in the scanner with their head fixed with foam pads. The stimuli were projected on a screen, which was visible from inside the scanner via a mirror mounted on the head coil. Stimulus presentation was synchronized with MR data acquisition by triggering the Presentation® software (Version 16.3, www.neurobs.com) with the first MR pulse.

**Analysis**

Functional and anatomical data were preprocessed and analyzed using BrainVoyager QX 2.6 (Brain Innovation, Maastricht, the Netherlands). Functional volumes were first corrected for slice scan time differences and 3D head motion. Linear trends and low-frequency temporal drifts were removed from the data using a high pass filter, removing temporal frequencies below four cycles per run. No spatial smoothing was performed. After the preprocessing, functional data were co-registered to the high resolution anatomical volume and normalized to Talairach space.

Data from the localizer runs were analyzed by contrasting responses to faces with responses to scrambled faces and houses. The resulting functionally defined FFA-clusters served as regions of interest in the subsequent MVPA. Responses to words were contrasted with responses to random letter strings to localize the nearby visual word form area in order to prevent possible confounding from overlapping voxels.

For the experimental runs the pre-processed time series were split into responses to face stimuli (face trials) and responses to the blocks of five written words (semantic trials). This resulted in sets of 24 responses to face trials and 24 responses to semantic trials for each of the three identities, for each subject and for each of the four FFA-clusters. A general linear model was fitted to every voxel's response. The resulting regression coefficients were then used as a measure for each voxel's response amplitude from which trial-based response patterns were constructed, reflecting spatial differences in activation across voxels in the same ROI.

Subsequently each set of response patterns was randomly split into a train set consisting of 21 response patterns labeled with the corresponding identity and a test set with the remaining three unlabeled response patterns. A Support Vector Machine (SVM) algorithm was trained with two sets of train patterns belonging to the same stimulus category (semantic or visual), subject and ROI but to two different identities. SVM training entailed expressing the responses from the two train sets in a multidimensional space and determining an optimal decision boundary between the data from the two classes.

We tested the resulting model by assessing its accuracy in predicting the identities associated to the corresponding test patterns, based on the classification rule extracted from the train sets. Training and testing was done for each pair of identities (one pair with identical faces, one with overlapping semantics and one with different faces + different semantics), separately for face and semantic trials, for each subject and each of the FFA clusters. The whole procedure was repeated

40 times with different training/testing subsets. The number of times the response patterns in the test set were assigned to the correct identities yielded an average prediction accuracy (p.a.). This p.a. was ultimately tested against the empirically estimated chance level. Since Van den Hurk (2013) found no significant differences in p.a. between left and right hemispheres in a very similar identity-decoding paradigm we averaged the p.a.'s over subjects and hemispheres to increase statistical power.

For each identity pair the null hypothesis was empirically estimated by performing a permutation test. This yields the probability of making an accurate classification of response patterns if no systematic correspondence between patterns from the same class (identity) would exist. Similar to the MVPA described above, an algorithm was trained to learn the relation between response patterns and their identity-labels for each subject, FFA-cluster, identity-pair and stimulus category (face or semantics) separately. However in the permutation test the labels were randomly assigned to the training sample. Again training and testing was repeated 40 times, resulting in an average prediction accuracy. To test whether training the model with correctly labeled patterns yields significantly higher prediction accuracy than the permuted sample we used the nonparametric Wilcoxon signed-rank test.

## RESULTS

### Localizer results

We used two independent localizer runs per subject in order to bilaterally localize the mFus and pFus clusters as well as the nearby Visual Word Form Area (VWFA). Localization of the latter area would allow us to exclude responses to the mere shape of words in the semantic items. However we were not able to localize the VWFA in any of our subjects. Therefore mFus and pFus were bilaterally defined by the set of contiguous voxels in the mid-Fusiform Sulcus and posterior Fusiform Gyrus respectively that were significantly more active during presentation of faces than during presentation of scrambled faces and houses ($p < .001$). Four FFA-clusters were successfully localized in one subject, in the other subject mFus and pFus could only be localized in the left hemisphere.

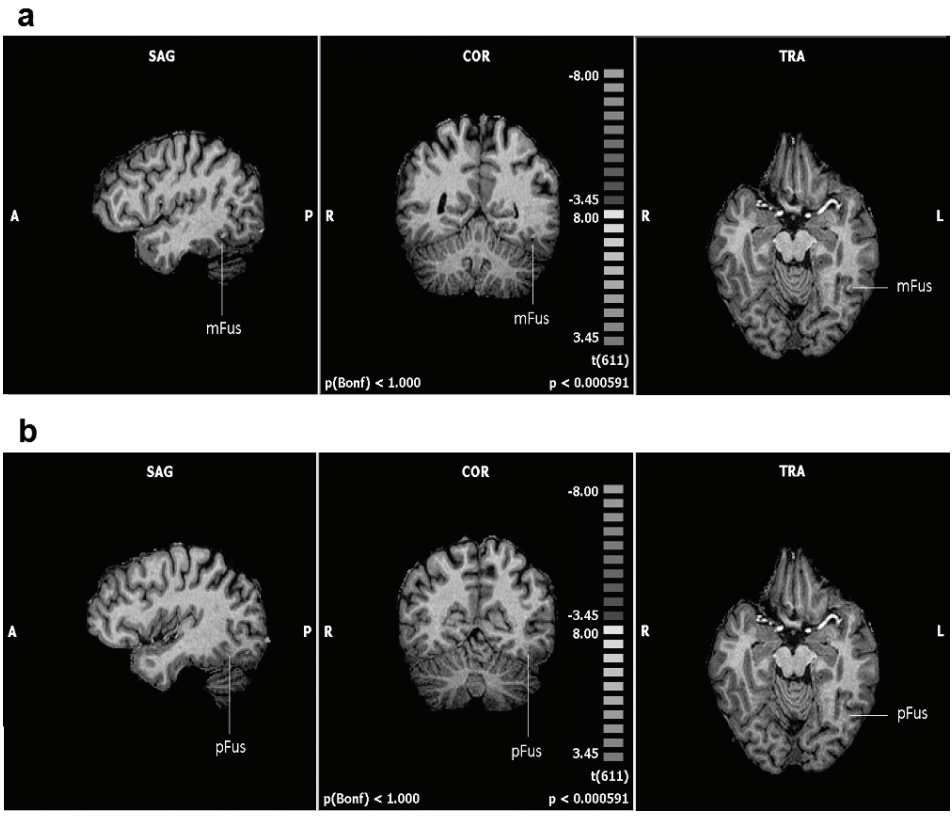


**Figure 2.** Univariate fMRI data from the localizer runs from one subject. Voxels in the mid-Fusiform Sulcus and posterior Fusiform Gyrus that were significantly more activated by faces than by scrambled faces and houses ($p < .001$) were defined as mFus (a) and pFus(b) respectively. This subject showed only face sensitive clusters in the left hemisphere.

## MVPA results

### *Face trials in mFus*

A Wilcoxon signed-rank test revealed that the p.a. for face trials in mFus (M = 59.582) was significantly higher than chance level (M = 49.742) for identity-pairs with identical faces but different semantics, Z = 4.667 p < .001. For identity-pairs with identical semantics but different faces the p.a. (M = 49.167) was not significantly different than chance level (M = 50.516), Z = -.646, p = .518, whereas p.a. for identities with different faces and different semantics (M = 60.003) was significantly above chance level (M = 48.810), Z = -4.382, p < 0,001 (see figure 3).

### *Semantic trials in mFus*

For semantic trials in mFus p.a.'s (M = 43.464) were significantly lower than in the

permuted sample (M = 47.619) for identity-pairs with identical faces but different semantics, Z = -3.035, p = .002. For identity-pairs with identical semantics but different faces p.a.'s (M = 55.426) were significantly higher than in the permuted sample (M = 52.381), Z = -2.466, p = .014, whereas identity-pairs with different faces and different semantics (M = 50.973) could not be predicted better than chance (M = 50), Z = -.477, p = .633 (see figure 3).

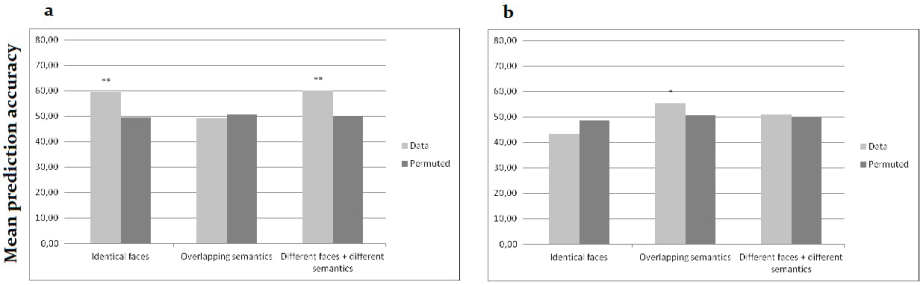


**Figure 3.** Mean prediction accuracies (p.a.'s, light gray) for response patterns evoked in mFus by face trials (a) and semantic trials (b) compared to their permuted counterparts (dark gray). P.a.'s were averaged over subjects and hemispheres.

### *Face trials in pFus*

In pFus face trials yielded a p.a. (M = 48.478) that not significantly differed from chance (M = 51.191), Z = -1.187, p = .235 for identity-pairs with identical faces but different semantics. P.a. (M = 48.47) was also not significantly different than chance (M = 52.381) for identity-pairs with identical semantics but different faces, Z = -1.666, p = 0.096, while p.a. (M = 55.754) was significantly higher than chance level (M = 47.619) for identity-pairs with different faces and different semantics, Z = -3.922, p < 0,001 (see figure 4).

### *Semantic trials in pFus*

Statistical analysis of p.a.'s for semantic trials in pFus indicated that performance (M = 49.585) was not different from chance level (M = 50) for identity-pairs with identical faces but different semantics, Z = -.459, p = .646. Identity-pairs with identical semantics but different faces were predicted significantly better (M = 56.943) than chance level (M = 51.191), Z = -3.210, p < .001, whereas p.a. for identity-pairs with different faces and different semantics (M = 54.308) did not differ significantly from chance level (M = 52.381), Z = -1.208, p = 0.227 (see figure 4).

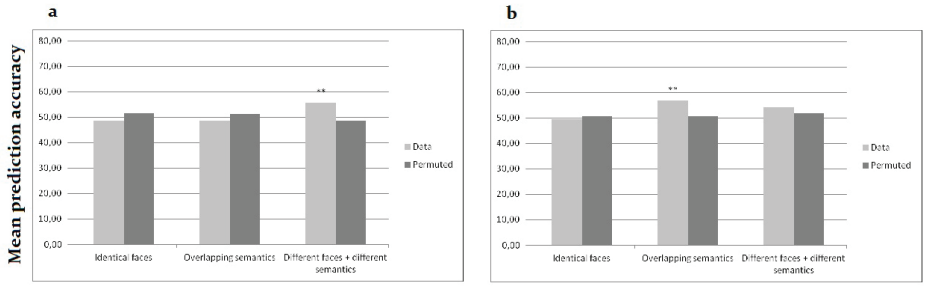


**Figure 4.** Mean prediction accuracies (p.a.'s, light gray) for response patterns evoked in pFus by face trials (a) and semantic trials (b) compared to their permuted counterparts (dark gray). P.a.'s were averaged over subjects and hemispheres.

## DISCUSSION

### pFus contributes to visual retrieval and perception

In pFus the successful decoding of responses evoked by overlapping semantics indicates activation of the associated unique face representations. It can thus be inferred that pFus response patterns in semantic trials predominantly reflected retrieved visual (face) information. Note that retrieval of associated information was explicitly instructed in the task. pFus responses to face trials did not yield above chance level p.a. for identities with identical faces, suggesting that this cluster is not involved in retrieval of semantic information. Neither did pFus responses to face trials allow for accurate decoding of identities with overlapping semantics. This suggests the absence of face information as well. However, the p.a. was above chance level for identity pairs with both different faces and different semantics. Plausibly pFus is engaged in perceptual analysis of face stimuli, but this only leads to decodable responses when unique semantic information is available, possibly enhancing the perceptual process (Turk et al., 2005). We can only speculate why distinct responses in this cluster and trial type were not found by Van den Hurk (2013) who exclusively used unique faces and semantics. The reason for this contradiction might conceivably be related to the reversed order of face and semantic information in the current experiment.

### mFus contributes to retrieval of visual and semantic information

In mFus the p.a. was significantly lower than the empirically estimated chance level for identity-pairs with identical faces in semantic trials. This phenomenon of anti-learning is known to occur in some machine learning tasks when classification is done on small sample sizes in high dimensional feature spaces. Analysis of a synthetic dataset has demonstrated that anti-learning is a property of the data and is distinct from overfitting the model (Kowalczyk & Chapelle, 2005). However it is not clear how below chance-level prediction can be interpreted; therefore results from the concerned condition are not discussed further.

The remaining p.a.'s for face and semantic trials in this cluster showed a seemingly contradicting pattern. In semantic trials responses evoked by overlapping semantics (associated to different faces) could be reliably classified, suggesting retrieval of visual content. In face trials on the other hand, responses evoked by identical faces (associated to different semantics) allowed for accurate classification as well while responses to different faces (associated to overlapping semantics) did not, suggesting retrieval of semantic content. This seems to imply that the informational content of mFus changes modality between semantic and face trials. It is conceivable that this results from the activity of two different neuronal populations. This can be tested in an fMRI adaptation design (Chadwick, Bonnice and Maquire, 2012). However we propose that the seemingly opposing results can be parsimoniously reconciled under the assumption of only visual information being stored in the region.

**Semantic person information encoded by face representations**

According to the task instructions subjects retrieve semantic information during face trials. Response patterns in mFus during face trials appear to contain information about the semantic features of the identity. However this does not necessarily imply semantic or abstract representations in mFus. Instead retrieval of semantic features might activate the corresponding face representations in mFus. Thus mFus activity during face trials might not necessarily reflect a single individual face but instead encodes all visual information corresponding to semantic categories (e.g. surgeons, jazz fans and married men). For two identities with overlapping semantics, semantic retrieval would lead to a similar activation of two face representations simultaneously. For the identity with different semantics, semantic retrieval would lead to activation of only one face representation. Such a scheme predicts that in the current experiment face trials (cueing semantic retrieval) generate distinct response patterns for identities with identical faces (because these are associated to different semantics) but not for identities with overlapping semantics, which matches our results. On the other hand, during semantic trials the task instructions would instigate the person perception system to find a matching unique face representation. This would plausibly drive the system to activate a unique exemplar as is reflected in the above chance level p.a. for identity-pairs with overlapping semantics but different faces.

In this framework semantic content is encoded in mFus without requiring local processing of non-visual information. In the two clusters processes of perception and retrieval plausibly lead to different activations of essentially the same kind of visual representations. This account would also predict an above chance level p.a. for identity-pairs with both different faces and different semantics in the two clusters during semantic trials. However this was not found. It is possible that these identities were not accurately classified due to noise in the response patterns, although one of these identities was reliably decoded during classification of identity-pairs with overlapping semantics.

**A modality-specific account of semantic retrieval**

The successful decoding of identities that differ only in their semantic features suggests that the FFA is not merely involved in recognizing faces by their visual form. At least its anterior/medial part (mFus) seems to support the retrieval of semantic attributes by activating corresponding visual representations. This does not contradict the commonly found implication of the FFA in recognition of faces (Kanwisher & Yovel, 2006). Functional evidence indicates that the neural system for recognition of objects at least closely matches the system that enables semantic retrieval (Chao, Haxby and Martin, 1999). Interestingly it has been demonstrated that semantic retrieval evokes neural activation slightly anterior to some occipital sites that were maximally activated during perception of those visual features (Martin, et al., 1995). The current study indicates that a similar organizational principle might apply to the domain of face perception.

Our modality-specific account of conceptual person information in the FFA is in support of theories that describe semantic memory as a distributed network of sensory-motor features (e.g. Carbonnel, Charnallet, David & Pellat, 1997). We propose that conceptual person information is encoded by activating multiple corresponding visual feature representations simultaneously. Neuropsychology, modeling and neuroimaging evidence indeed indicates that concepts are represented by patterns of activation over multiple properties (Tyler & Moss, 2001). Certainly a distributed semantic memory might coexist with a more abstract level of representations where modality-specific representations are bound (Vinson, Vigliocco, Cappa & Siri, 2003). Adaptations of the paradigm presented in this paper might prove suitable to target these and other specific hypotheses about the representation and topological organization of conceptual information in the brain. It would for instance be interesting to learn if our findings generalize to other highly specialized object selective regions such as the Parahippocampal Place Area.

**Unsuccessful localization of the VWFA**

A possible confounding issue is presented by our inability to successfully localize the VWFA in any of our subjects. Therefore we cannot entirely exclude the possibility that some responses in voxels attributed to the FFA might have originated from the nearby VWFA responding to the shape of written words. Apparently the sensitivity of the contrast of words with random letter strings was too low to detect the VWFA in our subjects. Possibly contrasting pseudowords with phase scrambled words might have accomplished better localization results (Yeatman, 2013). However contamination of our data with VWFA responses is unlikely because it would systematically favor decodability of identities with different semantics (that have different word forms), which is not apparent from our data.

**Conclusion**

Our results demonstrate that the anterior/medial FFA-cluster (mFus) contains information about semantic features of people during retrieval of these features. They further suggest that this semantic information is expressed modality-specific

by activation of corresponding visual attributes (face representations). On the other hand when a unique person's face is retrieved mFus aids its posterior/lateral neighboring cluster (pFus) by homing in on a single face representation. During face perception the latter cluster appears to be involved in perceptual analysis with face representations being enhanced when unique semantic information is available.

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