Exploring the relationship between dysfunctional personality traits with metacognition and confidence

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Highlights

1) We put to test an association between metacognition and dysfunctional personality traits (DPT).
2) Some DPT facets were significantly related with confidence or metacognition.
3) Results shed light on the potential metacognition's role in personality disorders.

Abstract

The ability to assess one's own cognitive processes is known as metacognition. Although it has been hypothesized that people with certain personality disorders have trouble understanding their own mental states, the relationship between dysfunctional personality traits (DPT) and metacognition remains unclear. In an online study, neurotypical participants completed the Personality Inventory Disorders 5 (PID-5) for DSM-5 after completing a dot-density perceptual task. We found evidence that Grandiosity, Perceptual Dysregulation, Restricted Affectivity, Separation Insecurity, Hostility, Impulsivity and Submissiveness DPT facets are associated with confidence level. Moreover, Anxiousness and Emotional Lability showed connections with metacognitive sensitivity. These results support the idea of a potential link between metacognition and mental health in the context of a transdiagnostic framework for personality disorders.

Keywords: Metacognition, Dysfunctional Personality Traits, Confidence, PID-5

1. Introduction

Metacognition is defined as the ability to evaluate one's own cognitive processes across different domains (Flavell, 1979; Fleming & Lau, 2014). Currently, deficits in metacognition have been linked to several diagnoses, including depression (Fu, Koutstaal, Fu, Poon & Cleare, 2005; Hoven et al., 2019; Hoven, Rouault, van Holst & Luigjes, 2022; Hoven, Luigjes, Denys, Rouault & van Holst, 2023; Rouault, Seow, Gillan & Fleming, 2018; Seow, Rouault, Gillan & Fleming, 2021), anxiety (Hoven et al., 2019, 2023; Rouault et al., 2018; Seow et al., 2021), obsessive-compulsive disorder (Hoven et al., 2019, 2023; Rouault et al., 2018; Seow et al., 2021; Seow & Gillan, 2020), schizophrenia (Hoven et al., 2019; Seow et al., 2021), nicotine dependence (Soutschek, Bulley & Wittekind, 2022), and autism spectrum disorder (Embon, Cukier, Iorio, Barttfeld & Solovey, 2023; Nicholson, Williams, Lind, Grainger & Carruthers, 2020). Moreover, metacognition has been suggested to be related to personality disorders (PDs) (Carcione et al., 2019; Dimaggio et al., 2007; Dimaggio & Lysaker, 2015; Pellecchia et al., 2018; Semerari et al., 2014; Vega, Torrubia, Marco-Pallarés, Soto & Rodriguez-Fornells, 2020). A connection between metacognition and PDs could lead to therapeutic interventions addressing the shared aspects of general personality pathology across different PDs (Carcione et al., 2019). The observed association of metacognition with diverse diagnoses has led some studies to propose that metacognition may be a transdiagnostic process (Hoven et al., 2019, 2022, 2023; Rouault et al., 2018; Seow et al., 2021; Seow & Gillan, 2020; Wise, Robinson & Gillan, 2023).

Metacognition is commonly studied with simple decision-making tasks where participants have to report their choice and subjective confidence on being correct. In these tasks, two separate aspects related to metacognition are identified: metacognitive bias and metacognitive sensitivity (Fleming & Lau, 2014). The former refers to the overall level of

reported confidence, i.e., the tendency of a participant to report high or low confidence, regardless of response accuracy (Fleming & Lau, 2014); while the latter is a key component of metacognition, operationally defined as the ability to differentiate between correct and incorrect decisions based on confidence ratings (Fleming & Lau, 2014). For example, a participant with high metacognitive sensitivity would exhibit greater confidence in correct decisions than in incorrect ones. Using bias-free measures of metacognition enables the separation of metacognitive sensitivity from metacognitive bias (Fleming & Lau, 2014).

This study explores the association between visual metacognitive sensitivity and PDs in a sample (n=224) of the general population, using a dot-density perceptual task. To assess PDs, we adopted a dimensional perspective which considers psychopathological disorders not as discrete, diagnosable categories, but as a blend of dimensional maladaptive traits within normal personality (Eaton et al., 2023; Stover, Castro Solano & Fernández Liporace, 2019).

2. Material and methods

2.1 **Participants:**

The final sample consisted of 224 participants (of the 267 participants who took part in the experiment). Participants in the final sample met the following criteria: no use of psychotropic medication and being over 18 years of age. Also, 43 participants were excluded from the initial sample of 267, a typical number for web-based experiments (Chandler, Mueller & Paolacci, 2014). Exclusion criteria were: reporting not having performed the experiment carefully (3 participants), performing less than 60% in the dot-detection task (1 participant), having pressed the same confidence key more than 85% of trials (22 participants), having less than 70 trials remaining after filtering for reaction time (3 participants) and having an AUROC2 (see Data Analysis section) less than 1.5 standard deviations from the mean (11 participants). In

relation to gender, this study took into account participants' personal identification, as they were asked the question: "How do you identify in terms of gender?" and were provided with options to choose from (female, male, or non-binary). We also excluded participants whose selection in response to the gender question did not reach a representative number (non-binary, 3 participants). The final sample had an average age of 27.45 (sd = 9.02, range = 70 - 19), including 63 males and 161 females. Each participant gave informed consent to participate in the experiment. This study was approved by the ethics committee of the Instituto de Investigaciones Psicológicas (CONICET, Córdoba, Argentina).

2.2 **Task:**

The experiment involved a visual perceptual task in which participants were presented with two horizontally aligned circles. They were then required to select the circle with the highest number of dots based on their own criteria using the arrow buttons. After that, participants were required to rate their level of confidence that the prior selection was accurate using a Likert scale of 4 points, ranging from "I don't know" to "I am very sure,". Participants complete 130 trials in a single block, after having completed 15 practice trials. Every trial started with a fixation cross (500ms), followed by the circles (500ms). Subjects responded by pressing the left/right arrows keys. Lastly, subjects reported their confidence on a Likert scale (Figure 1). The task was programmed in JavaScript and run on a JATOS server (Lange, Kühn & Filevich, 2015). A staircase procedure of one up/two down, identical to Faivre, Filevich, Solovey, Kühn & Blanke (2018), was used to keep all participant’s performance at a 71% level approximately.

2.3 **Personality Inventory for DSM-5:**

The test to measure PDs proposed by the DSM-5 (American Psychiatric Association, 2013) is the Personality Inventory Disorders 5 (PID-5) for DSM-5, a self-reported instrument

adapted to Argentinian population (Krueger, Derringer, Markon, Watson & Skodol, 2012; Stover et al., 2019). It is based on the III section of the DSM-5, where the Dimensional Five Factor Model is incorporated. The PID-5 evaluated five domains (see Table 1) and 25 facets (see Table 2) through 220 self-report with 4-point Likert scale items (Stover et al., 2019).

2.4. **Data analysis**

Data analysis was carried out in R. Trials with reaction times (RT) larger than 5000 ms and shorter than 200 ms in the dot discrimination task were discarded (5.04% discarded). Trials with RT higher than 5000 ms were also eliminated from the confidence task (0.04% discarded). Each participant's first 20 trials were also discarded to give the staircase time to settle.

Several statistical analyses were conducted to address each of our research questions (Embon et al., 2023; Steegen, Tuerlinckx, Gelman & Vanpaemel, 2016). When employing several regression models with a unique dysfunctional personality trait (DPT), p-values were adjusted for multiple comparisons using the Bonferroni correction.

2.4.1 Models for Confidence

The response variable is a rescaled confidence mean by participant, that was obtained by subtracting 1 and dividing by 3 (we call this variable C). Then, to study the association of confidence and personality facets and domains we used multiple models with personality facets and domains as the explanatory variables.

Assuming that C_i is beta-distributed and a random continuous variable with values between 0 and 1, we used a beta regression model:

$\text{logit}(C_i) = \alpha + \text{PID facet score} \times \beta_1 + \text{gender} \times \beta_2 + \text{age} \times \beta_3 + \text{PID facet score} \times \text{gender} \times \beta_4 + \text{PID facet score} \times \text{age} \times \beta_5$,

where the $\text{logit}(C_i)$ is $\ln\{C_i/(1 - C_i)\}$, and the PID facet score is a respective facet of the PID. One regression model was run for each facet.

In order to explain C_i from domains, we replicated the regression equation used earlier. For this purpose, we substituted in the equation "PID facet score" by "PID domain score", where PID facet score was a respective domain of the PID (a regression was run for each domain, replacing the domain each time).

We also run a comprehensive model incorporating all facets/domains as explanatory variables to explain C_i. This is the multitrait regression model, in contrast to the unitrait regression model (where the model encompassed only one DPT, either a facet or a domain).

We repeated the same regression equation in order to explain C_i from domains. All numeric explanatory variables were normalized for the beta regression models.

Additionally, to explain C_i we use various personality facets as explanatory variables, employing regularized elastic-net regression. The lambda and alpha parameters were chosen through leave-one-out cross validation, using the caret library. Then, the regularized normal regression was run through the glmnet library.

2.4.2 Models for metacognitive sensitivity

To explore the relationship between metacognitive sensitivity and DPT, we estimated metacognition sensitivity with the type 2 Receiver Operating Characteristic (ROC) curve (or AUROC2; Fleming & Lau, 2014). Afterward, we conducted both a beta regression model to explain AUROC2 from facets and from domains. For this purpose, we employed the same

equations as those used to explain C_i but substituted C_i with AUROC2 in the equation. As in the case for confidence, a regression was run for each facet, replacing the facet each time. In order to explain AUROC2 from domains, we replicated the regression equation used earlier. For this purpose, we substituted in the equation "PID facet score" by "PID domain score", where PID facet score was a respective domain of the PID (a regression was run for each domain, replacing the domain each time).

In addition to running separate models for each facet/domain to explain AUROC2, a global model was constructed incorporating all facets/domains as covariates to explain AUROC2. We repeated the same procedure to explain AUROC2 from domains. All numeric explanatory variables were normalized for the beta regression models. AUROC2, was scaled differently to achieve a better fit to the beta distribution: (AUROC2 - 0.5) * 2.

In addition, we carried out another normal regression model but with elastic net regularization to explain AUROC2 only from facets.

3. Results

The results for the facets and domains of DPT can be observed in Table 1 and Table 2.

3.1 Association between DPT and confidence:

Our analyses revealed a significant relationship between dysfunctional personality facets and the average confidence level (see Figure 2). Specifically, Grandiosity exhibited a significantly positive association with confidence both for the beta multitrait regression model (β = 0.146, se = 0.068, 95% CI = [0.013, 0.279], p = 0.032) and the beta unitrait regression model (β = 0.204, se = 0.059, 95% CI = [0.088, 0.32], p = 0.001). Furthermore, the coefficient of Grandiosity in the regression elastic net model (β = 0.043) was significantly different from zero.

To determine the optimal lambda (λ) and alpha (α) parameters for the elastic net regression, a leave-one-out cross-validation approach was employed, resulting in $\lambda = 0.155$ and $\alpha = 0.229$. Conversely, Perceptual Dysregulation had a significant negative association with confidence in the beta multitrait regression model (β = -0.196, se = 0.087, 95% CI = [-0.367, -0.024], p = 0.025). Similarly, Restricted Affectivity had a significant positive association with confidence in the beta multitrait regression model (β = 0.130, se = 0.066, 95% CI = [0.001, 0.259], p = 0.048) and its positive beta coefficient was different from 0 in the elastic net regression model (β = 0.016). Notably, Separation Insecurity exhibited a significant negative relationship with confidence in both the beta multitrait regression model (β = -0.128, se = 0.059, 95% CI = [-0.244, -0.012], p = 0.031) and its negative beta coefficient was different from 0 in the elastic net regression model (β = -0.026). Additionally, Hostility and Impulsivity displayed a positive association with confidence (β = 0.034 and β = 0.058 respectively), while Submissiveness exhibited a negative relationship with confidence in the elastic net regression model (β = -0.039). Interestingly, mean confidence per participant did not show a significant association with any dysfunctional personality domains.

3.2 Association between DPT and metacognitive sensitivity:

Two personality facets were significatively associated to metacognition (Figure 3). We found that Anxiousness exhibited a positive relationship with metacognitive sensitivity in the beta multitrait regression model (β = 0.164, se = 0.068, 95% CI = [0.031, 0.297], p = 0.015). Conversely, Emotional Lability was negatively associated with metacognitive sensitivity in the beta multitrait regression model (β = -0.127, se = 0.062, 95% CI = [-0.249, -0.005], p = 0.042). No other significant relationships were observed between DPT and metacognitive sensitivity.

For the elastic net regression, the lambda and alpha parameters were selected through leave-one-out cross-validation, resulting in $\lambda = 0.013$ and $\alpha = 0.651$. However, using these parameters, the regression did not yield coefficients different from 0 for any facet, indicating no significant findings. In contrast, when metacognitive sensitivity was explained based on dysfunctional personality domains, we did not find any statistically significant result.

4. Discussion

We investigated the relationships between confidence levels, metacognitive sensitivity, and personality traits, taking a dimensional approach to PDs. We found links between specific personality traits, confidence levels, and metacognition levels, supporting the notion that metacognitive alterations can be observed from a transdiagnostic perspective. There results align with other studies in this research domain (Hoven et al., 2019, 2022, 2023; Rouault et al., 2018; Seow et al., 2021; Seow & Gillan, 2020).

4.1 Confidence

Hoven et al. (2019) argued that in non-clinical populations, the relationship between confidence and anxiety, as well as depression, is inconsistent. Some studies reported a positive association between depression and confidence (Dunning & Story, 1991; Soderstrom, Davalos & Vázquez, 2011), while others indicated a negative association (Stone, Dodrill & Johnson, 2001). Similar inconsistences were found between anxiety-related symptoms and confidence (Hoven et al., 2023; Rouault et al., 2018; Seow & Gillan, 2020). However, it is important to note that in Seow & Gillian (2020), the negative association observed between confidence, depression, and anxiety stemmed from the Anxiety-Depression dimension, as leveraged by a transdiagnostic approach. In other words, this study did not find a direct relationship between confidence and

anxiety, or confidence and depression separately (Seow & Gillan, 2020). In contrast, in Rouault et al. (2018), besides identifying a negative relationship between the Anxiety-Depression dimension and confidence, negative relationships were also evident between confidence and Depression, Social Anxiety, and Generalized Anxiety. Conversely, studies focusing on clinical populations found lower levels of confidence in individuals with Major Depressive Disorder, while the connection between confidence and anxiety disorders yielded mixed results (Hoven et al., 2019). In the present study, we did not observe a negative relationship between confidence levels and Anxiousness or Depressivity DPT facets. Nevertheless, it is paramount to consider that the instruments used to assess anxiety and depression are not always the same. Therefore, certain discrepancies identified could be linked to the specific psychometric tools employed.

Similarly, Seow & Gillan (2020) reported a positive relationship between impulsivity and confidence, in contrast to Rouault et al.'s (2018) finding of no significant association. In our study, while the regularized normal regression model indicated a positive link between impulsivity and confidence, this relationship was not observed in beta regressions. These divergent outcomes emphasize the importance of exploring different statistical approaches. Consequently, the inconsistent findings suggest that the observed relationship may lack robustness, warranting further investigation and replication studies to establish a more conclusive understanding of the association between impulsivity and confidence.

Our study revealed a significant negative association between Perceptual Dysregulation and confidence. Anomalous perception is a hallmark of schizotypy or schizophrenia-related disorders (Rollins et al., 2020; Silverstein, Demmin & Skodlar, 2017). Previous studies have hinted at positive associations between confidence and schizotypy and/or schizophrenia as a potential explanation for positive symptoms such as delusions and hallucinations (Hoven et al.,

2019; Lehmann & Ettinger, 2023; Moritz et al., 2017; Rouault et al., 2018). While some studies have demonstrated a positive link between schizotypy or schizophrenia-related disorders and confidence, conflicting evidence exists (Hoven et al., 2019; Lehmann & Ettinger, 2023). The results presented in this study support the notion of a negative relationship between confidence and traits associated with schizophrenia and/or schizotypy. The observed inconsistencies in these findings have been attributed to a lack of performance control, which could be a confounding factor (Faivre et al., 2021). However, this was mitigated in our study, as we determined this negative association between perceptual dysregulation and confidence while controlling for performance using a staircase procedure. Future research should investigate these inconsistencies in greater detail.

Interestingly, Grandiosity showed a robust positive association with confidence, aligning with finding from previous studies that have provided supporting evidence for the relation between overconfidence and narcissism (Littrell & Fugelsang, 2023; Littrell, Fugelsang & Risko 2020; Macenczak, Campbell, Henley & Campbell, 2016; O'Reilly & Hall, 2021). Grandiosity, a fundamental characteristic of the grandiose subtype of narcissism, often manifests as aggressiveness and a pronounced sense of superiority (Littrell et al., 2020). In contrast, the vulnerable subtype of narcissism is more commonly associated with expressions of insecurity, introversion, and heightened defensiveness (Littrell et al., 2020). It is plausible that confidence in decision-making could serve as a distinguishing factor between these two subtypes of narcissism. Indeed, Littrell et al. (2020) reported a positive relationship between overconfidence and grandiose narcissism, whereas no such relationship was found with vulnerable narcissism. These results were replicated in a recent study (Littrell et al., 2023). Furthermore, additional associations were observed between confidence and several personality facets, such as Restricted

Affectivity, Separation Insecurity, Hostility, and Submissiveness, for which no readily apparent explanations are evident. Given the absence of prior studies investigating these specific relationships, further exploration of their implications is deferred to future studies.

4.2 Metacognitive sensitivity

Anxiousness revealed a positive relationship with metacognitive sensitivity, indicating that individuals with higher levels of Anxiousness exhibit greater awareness and sensitivity to their own cognitive processes. This finding aligns with the research conducted by Rouault et al. (2018), who identified a positive association between a dimension of symptoms related to Anxiety and Depression and metacognitive efficiency. Moderate evidence suggests that individuals with high anxiety symptoms also report higher scores on measures assessing awareness of their cognitive processes, such as the "Cognitive self-consciousness" subscale (Capobianco, Faija, Husain & Wells, 2020; Donnellan et al., 2016; Quattropani, Lenzo & Filastro, 2017). Additionally, considering that metacognition can be trained (Carpenter et al., 2019), it could be hypothesized that individuals with higher anxiety symptoms, who are also associated with higher scores in self-awareness on subjective self-report scales, may have developed enhanced metacognitive skills. However, although depression also scores high on self-awareness scales, in contrast to Rouault et al., (2018) findings, we did not find a relationship between metacognition and Depressivity (Donnellan et al., 2016; Quattropani, Lenzo, Mucciardi & Toffle, 2016).

Moreover, Emotional Lability exhibited a negative association with metacognitive sensitivity, suggesting that individuals with greater emotional volatility or instability may present reduced metacognitive awareness.

4.3 Limitations

Firstly, this study primarily focused on local metacognitive computations. Global metacognitive evaluations of performance were not assessed in this study, yet they could be crucial for understanding the broader implications of metacognition (Seow et al., 2021). Lastly, this study exclusively evaluated metacognition within a specific task of visual perception, but metacognition may involve modality-specific components (Faivre et al., 2018; Morales, Lau & Fleming, 2018).

5. Conclusions

The findings of this study provide valuable insights about the relationships between specific dysfunctional personality traits with metacognitive sensitivity and confidence. In addition, when viewed through a dimensional and transdiagnostic lens, the present results suggest a possible connection between metacognition and not only certain PDs but also with other diagnoses that encompass traits such as grandiosity or anxiousness, among other traits that showed relevant results in this study.

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7. Conflict of interest

The authors declare no conflict of interest.

8. Author contributions

Iair Embon: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; and Writing - review & editing. **María Agostina Gerbaudo:** Conceptualization; Investigation; Methodology; Validation; Roles/Writing - original draft; and Writing - review & editing. **Alejandro Ramos Usaj:** Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization. **Alberto Andrés Iorio:** Conceptualization; Investigation; Supervision; Validation. **Pablo Barttfeld and Guillermo Solovey:** Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; and Writing - review & editing.

9. Tables

Table 1

Mean and standard deviation of dysfunctional personality domains in the collected sample

	mean	sd
Negative Affect	1.288	0.546
Detachment	0.902	0.527
Antagonism	0.741	0.509
Disinhibition	0.868	0.487
Psychoticism	0.682	0.499

Note. sd = standard deviation.

Table 2

Mean and standard deviation of dysfunctional personality facets in the collected sample

	mean	sd
Anhedonia	1.054	0.62
Anxiousness	1.664	0.747
Attention Seeking	1.198	0.68
Callousness	0.361	0.4
Deceitfulness	0.741	0.507

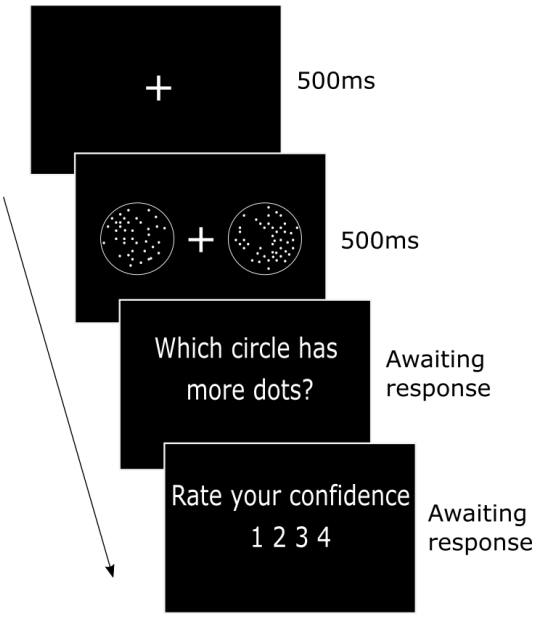
Depressivity	0.81	0.677
Distractibility	1.259	0.757
Eccentricity	0.897	0.706
Emotional Lability	1.394	0.662
Grandiosity	0.607	0.578
Hostility	1.125	0.58
Impulsivity	0.789	0.689
Intimacy Avoidance	0.85	0.618
Irresponsibility	0.557	0.452
Manipulativeness	0.875	0.697
Perceptual Dysregulation	0.656	0.495
Perseveration	1.12	0.638
Restricted Affectivity	1.111	0.677
Rigid Perfectionism	1.284	0.729
Risk Taking	1.085	0.515
Separation Insecurity	0.806	0.63
Submissiveness	1.251	0.714
Suspiciousness	1.108	0.594
Unusual Beliefs And Experiences	0.491	0.509
Withdrawal	0.802	0.667

Note. sd = standard deviation.

10. Figures

Figure 1

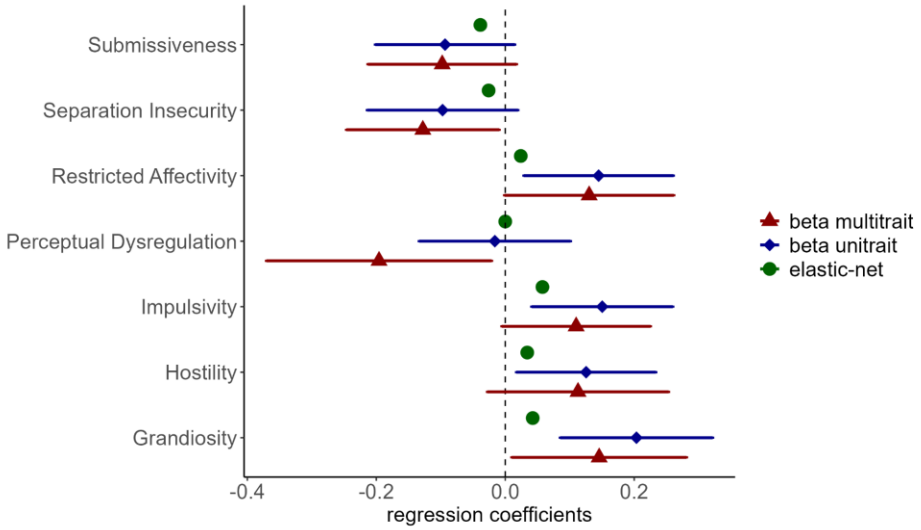
Experimental task.



Note. In each trial, participants compared dot clouds in two circles, selecting the cloud with a larger amount of dots count using the keyboard arrow keys. They subsequently rated their confidence on a 4-point Likert scale. Each trial started with a fixation cross (500ms), followed by the dots displays (500ms), and unlimited response time.

Figure 2

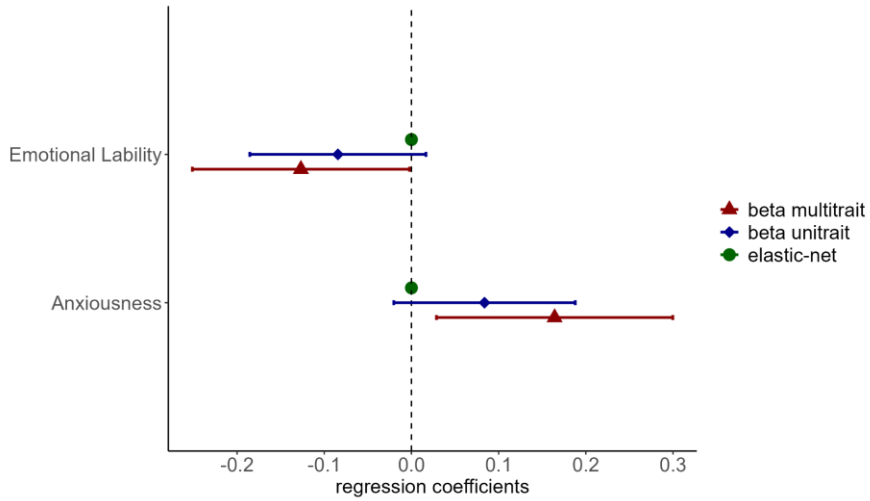
Regression models for explaining confidence levels based on specific facets



Note. Multiple regression models were employed to examine the association between confidence and dysfunctional personality traits. Separated beta regression models were run for each facet and domain, exploring their individual impact on confidence (unitrait models). A multitrait regression model encompassing all facets/domains was carried out. Additionally, an elastic-net regression approach was employed using personality facets as explanatory variables. Grandiosity displayed a positive association with confidence in both the beta multitrait and unitrait regression models. Additionally, its influence in the regression elastic-net model significantly diverged from zero. In contrast, Perceptual Dysregulation showed a significant negative association with confidence solely in the beta multitrait regression model. Similarly, Restricted Affectivity exhibited a positive association in the beta multitrait regression model, confirmed by a non-zero coefficient in the elastic net regression model. Notably, Separation Insecurity displayed a significant negative relationship with confidence in both the beta multitrait regression and elastic net models. Hostility and Impulsivity demonstrated positive associations, while Submissiveness showed a negative relationship with confidence in the elastic net regression model.

Figure 3

Regression models for explaining metacognitive sensitivity based on specific facets



Note. Multiple regression models were used to investigate the relation between metacognitive sensitivity and dysfunctional personality traits. Individual beta regression models were applied to each facet and domain, assessing their specific influence on metacognitive sensitivity (unitrait models). A comprehensive multitrait regression model was executed, encompassing all facets/domains. Furthermore, an elastic-net regression method was employed, employing personality facets as explanatory variables. Among the personality facets investigated, Anxiousness exhibited a noteworthy positive relationship with metacognitive sensitivity in the beta multitrait regression model, while Emotional Lability displayed a significant negative association.

11. Supplemental information

All the experimental data used in this study, the code to run the experiment and to perform data analysis is available at:

https://github.com/iair-embon/Metacognition.PersonalityTraits.git

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