Mediterranean Journal of Clinical Psychology

ISSN 2282-1619

MJCP

Volume 8, n 1, 2020

Clinical Psychology

Executive Functioning and Personality Traits in Insomnia Disorder: A Preliminary Report on the Clinical Importance of Objective and Subjective Reduction of Total Sleep Time

Antonella Somma [1], Sara Marelli [1, 2], Margherita Barranca [1], Giulia Gialdi [1], Chiara Lucini [1], Alessandra Castelnuovo [2], Samantha Mombelli [2], Luigi Ferini-Strambi [1, 2], Andrea Fossati [1]

Abstract

To confirm and extend previous findings on the relationships between executive functioning (EF) and insomnia, as well as the available evidence on the associations between personality traits and insomnia, 30 consecutively-admitted insomnia participants and 30 community dwelling adult participants matched on age, gender and educational level, were administered a battery of EF measures and the Personality Inventory for *DSM-5* (PID-5). Insomnia participants underwent two full-night polysomnographic (PSG) recording, followed by a morning assessment of subjective sleep parameters. A misperception index (MI) was computed in order to identify participants characterized by objective insomnia and non-objective insomnia. The EF performance associations between insomnia and poor performance on selected executive functions was confirmed. However, the objective insomnia and non-objective insomnia sub-groups show significant differences on specific EF indices, as well as on dysfunctional personality dimensions.

[1] School of Psychology, Vita-Salute San Raffaele University, Milan, Italy

[2] Neurology – Sleep Disorder Center, IRCCS San Raffaele Scientific Institute, Milan, Italy

E-mail corresponding author: fossati.andrea@hsr.it

Keywords:
Insomnia; Sleep misperception; Executive functions; PEBL; PID-5.

Received: 12 November 2019
Accepted: 1 April 2020
Published: 20 April 2020

Citation: Somma, A., Marelli, S., Barranca, M., Gialdi, G., Lucini, C., Castelnuovo, A., Mombelli, S., Ferini-Strambi, L., Fossati, A. (2020). Executive Functioning and Personality Traits in Insomnia Disorder: A Preliminary Report on the Clinical Importance of Objective and Subjective Reduction of Total Sleep Time. *Mediterranean Journal of Clinical Psychology*, *8*(1). Doi: https://doi.org/10.6092/2282-1619/mjcp-2325

1. Introduction

Insomnia is defined as a persistent difficulty with sleep initiation, duration, consolidation or quality that occurs despite adequate opportunity and circumstances for sleep, and results in some form of day-time impairment (International Classification of Sleep Disorder, 2014).

The worldwide prevalence of insomnia symptoms is approximately 30–35%, and epidemiological studies from different countries yield similar prevalence estimates (e.g., Morin et al., 2015; van de Laar, Verbeek, Pevernagie, Aldenkamp, Overeem, 2010), with the 1-year incidence of insomnia varying between 7% and 15% (e.g., Pillai, Roth, Mullins, & Drake, 2014). Many studies have established that insomnia is highly comorbid with psychiatric disorders and is a risk factor for the development of depression (e.g., Riemann, Krone, Wulff, & Nissen, 2020), anxiety, and suicide (e.g., Baglioni et al., 2016; Basta, Chrousos, Vela-Bueno, & Vgontzas, 2007; Ford & Kamerow, 1989). Moreover, insomnia may have a negative impact on psychological wellbeing and quality of life (Zammit, Weiner, Damato, Sillup, & McMillan, 1999). Complaints of cognitive impairment are also often encountered in clinical practice and have been documented in previous reports (Buysse et al., 2007; Leger & Bayon, 2010; Riedel & Lichstein, 2000), with number of studies comparing the performance of individuals with insomnia and normal sleepers on functional magnetic resonance imaging sessions (e.g., Baglioni et al., 2014), and neuropsychological tests (e.g., Fulda & Schulz, 2001; Shekleton, Rogers, & Rajaratnam, 2010). Specifically, impairments in the domain of concentration, memory, attention, and emotion regulation are generally reported in insomnia patients (Edinger, Means, Carney, & Krystal, 2008; Fortier-Brochu & Morin, 2014; Harris et al., 2015; Kyle et al., 2013), with insomnia patients showing hypoactivation of the medial and inferior prefrontal cortical areas (e.g., Altena et al., 2008).

Notably, Fortier-Brochu and colleagues (Fortier-Brochu, Beaulieu-Bonneau, Ivers, Morin, 2012) performed the first quantitative summary of evidence (k = 24) regarding the performance of individuals with primary insomnia (N = 639) as compared to normal sleepers (N = 558) on a broad range of neuropsychological measures. In their meta-analysis, Fortier-Brochu and colleagues (2012) identified reliable differences of mild to moderate magnitude between individuals with insomnia and normal sleepers in working memory, episodic memory, and problem-solving domain. Building on these findings, recently, Ballesio and colleagues (Ballesio, Aquino, Kyle, Ferlazzo & Lombardo, 2019) carried out a systematic review and meta-analysis of the published literature (k =28) on insomnia and executive functioning, and confirmed the evidence of impaired performance of small to moderate magnitude in individuals with insomnia as compared to controls in inhibitory control, cognitive flexibility tasks, and working memory tasks.

Interestingly, Fernandez-Mendoza and colleagues' (2009) population-based study showed that objective sleep duration, assessed by polysomnographic (PSG) sleep duration less than 6 hours of sleep, may predict the severity of chronic insomnia and its effect on neurocognitive function. Thereafter, Fortier-Brochu and Morin (2014) investigated the nature of cognitive impairment in individuals with primary insomnia (*N* =25) who underwent 3 consecutive nights of PSG recordings, whose performance was compared to the one of 16 controls matched for sex, age, and education. Fortier-Brochu and Morin (2014) findings suggested the presence of clinically significant deficits in attention and episodic memory in individuals with insomnia and showed that these deficits were associated with objective sleep continuity. Against this background, scholars have started seeing as potentially misleading considering individuals with insomnia as a homogeneous sample with regard to daytime symptoms and cognitive performance (e.g., Ballesio et al., 2019).

Notably, because of the absence of empirically validated cut-off values for objective sleep parameters defining insomnia, the heterogeneity of objective findings within the insomnia population, and the cost and feasibility of PSG (e.g., Castelnovo et al., 2019; Parrino, Ferri, Bruni, & Terzano, 2012), objective sleep quality and quantity are not included as formal criteria for diagnosing insomnia (American Academy of Sleep Medicine, 2014; American Psychiatric Association, 2013). Without any instrumental assessment, physicians are unable to quantify the discrepancy between subjective and objective sleep parameters such as total sleep time (TST), which may represent important information for the diagnosis and therapy of insomnia (Castelnovo et al., 2019). Indeed, it is well-known that, compared to good sleepers, insomnia patients tend to underestimate their TST and overestimate their sleep onset latency (SOL) and wakefulness after sleep onset (WASO) (e.g., Carskadon et al., 1976; Edinger & Krystal, 2003; Manconi et al., 2010; Vanable et al., 2000). These findings imply that, whatever the reason, a discrepancy between objective and subjective sleep features (i.e., sleep misperception) is an essential aspect to understand insomnia (Castelnovo et al., 2019). Moreover, although different definitions of paradoxical insomnia exist (Castelnovo et al., 2019), the difference between subjective TST and objective TST is one of the features distinguishing the paradoxical from other subtypes of insomnia, and this information may be crucial to better understand the impairments in executive functioning tasks associated with insomnia. Indeed, Ballesio and colleagues' (2019) systematic review and meta-analysis highlighted that the magnitude of executive functions impairments was larger in studies including participants with insomnia and shorter objective TST as compared to the controls.

In order to try to better characterize sleep misperception in chronic insomnia, in a subsequent study, Fernandez-Mendoza and colleagues (2011) examined the role of objective sleep duration and psychological profiles in a large cross-sectional general random sample using PSG measures and psychological testing (i.e., Minnesota Multiphasic Personality Inventory-2). Participants with insomnia and normal objective sleep duration showed a MMPI-2 profile of high depression and anxiety, and low ego strength, whereas insomniacs with short objective sleep duration showed the psychological profile typical of outpatients with a medical disorder (Fernandez-Mendoza et al., 2011).

These findings are intriguing because personality features may represent important predisposing and/or perpetuating factors for insomnia (van de Laar, Verbeek, Pevernagie, Aldenkamp, Overeem, 2010) and selected Five Factor Model (FFM) personality traits are known to be associated with sleep quality (e.g., Stephan, Sutin, Bayard, Križan, & Terracciano, 2018). For instance, Stephan and colleagues (2018) showed in 4 samples of middle-aged and older adults (*N* > 22,000), that low neuroticism (i.e., the tendency to experience a wide range of negative emotions; McCrae & John, 1992), high extraversion (i.e., the tendency to experience positive emotions and to be sociable; McCrae & John, 1992), and low conscientiousness (i.e., the tendency to be self-disciplined and organized; McCrae & John, 1992) were associated with a worse sleep quality over time.

It is interesting that an Alternative Model of Personality Disorder (AMPD) was provided in *DSM-5* Section III (APA, 2013), along with traditional personality disorder (PD) symptom criteria listed in *DSM-5* Section II. A core component of the *DSM-5* AMPD is an empirically based model of maladaptive personality domain which represents dysfunctional variants of the FFM personality dimensions (APA, 2013). Specifically, Negative Affectivity (i.e., frequent and intense experiences of high levels of a wide range of negative emotions) represents the maladaptive variant of neuroticism, Detachment (i.e., avoidance of socio-emotional experience) characterizes the maladaptive variant of extraversion, Antagonism (i.e., behaviors that put the individual at odds with other people) denotes the maladaptive variant of agreeableness, Disinhibition (i.e., orientation toward immediate gratification and impulsive behavior) depicts the maladaptive variant of conscientiousness, and Psychoticism (i.e., a wide range of culturally incongruent odd, eccentric, or unusual behaviors and cognition) represents the dysfunctional variant of openness to experience (e.g., Suzuki et al., 2015). This system of dysfunctional domain may be useful to dimensionally assess dysfunction in personality in insomnia samples (e.g., Somma et al., 2018; van de Laar, Verbeek, Pevernagie, Aldenkamp, Overeem, 2010), in order to help delineating the specific personality profiles of subgroups of individuals suffering from insomnia. However, to the best of our knowledge, no previous studies tried to assess the relationships between maladaptive personality domains and insomnia, particularly taking into consideration the difference between insomniacs with normal objective sleep duration (i.e., sleep misperception) and insomniacs with objective short sleep duration.

The aims of the present study were: (a) further investigating the impairment in executive functioning in individuals with insomnia. The performance of a sample of consecutively admitted insomnia patients was compared to the performance of community-dwelling participants matched on age, gender and education. In the present study, executive functioning was assessed through computerized measures contained in the Psychology Experiment Building Language Test Battery (PEBL; Mueller & Piper, 2014). Test battery included the Berg's (i.e., "Wisconsin") Card Sorting Test (BCST; Berg, 1948) as a measure of cognitive flexibility, the Continuous Performance Task (CPT; Conners et al., 2003; Piper et al., 2012) as a measure of attention processes (i.e., core components of monitoring/ updating), the Go/No-Go task (Bezdjian et al., 2009) and the Balloon Analog Risk Task (BART; Lejuez et al., 2002) as tests of response inhibition, and the Tower of London task (ToL; Anderson et al., 2012) as an index of planning (a component of monitoring/updating). Based on previous meta-analytic findings (Ballesio et al., 2019; Fortier-Brochu et al., 2012), we expected insomnia patients to show a poorer performance on cognitive flexibility and response inhibition; (b) comparing the performance on executive functioning tasks of participants with objective insomnia and non-objective insomnia, and controls. In the present study, we relied on the misperception index (MI; Manconi et al., 2010) in order to select participants characterized by objective insomnia and non-objective insomnia. Although different indices could be computed (e.g., Castelnovo et al., 2019), in the present study, we relied on the MI because it showed significant and positive correlations with the magnitude of subjective sleep underestimation and it gives a reliable and immediate description of sleep misperception in healthy and insomnia subjects; moreover, it has been validated in Italy (Manconi et al., 2009). All insomnia participants underwent two full-night polysomnographic study, followed by a morning assessment of subjective sleep parameters. The MI was computed as the ratio of the difference between objective total sleep time (oTST) and subjective total sleep time (sTST) on the oTST (Manconi et al., 2009). Based on previous findings (e.g., Ballesio et al., 2019; Fortier-Brochu & Morin, 2014), we expected to observe significant differences on the performance of participants with "objective" insomnia and "non-objective" insomnia; (c) extending previous data on the relationships between personality traits and insomnia (e.g.,). Specifically, we evaluated dysfunctional variants of the FFM in insomnia adult participants with objective reduction in total sleep time, insomnia adult participants with subjective perception of reduced total sleep time, and community-dwelling adults (i.e., controls). *DSM-5* Section III maladaptive personality domains were assessed by administering the Personality Inventory for *DSM-5* (PID-5; Krueger, Derringer, Markon, Watson, & Skodol, 2012), a self-report questionnaire, which has been validated also in its Italian translation (Fossati et al., 2013). Although extensive studies have been conducted on the personality correlates of insomnia (e.g., van de Laar et al., 2010), to the best of our knowledge, no previous study focused on the maladaptive variants of FFM traits.

2. Methods

2.1 Participants

The current study was based on insomnia participants (*N* = 30) and community-dwelling adult participants (*N* = 30) who were matched on age, sex and educational level. Insomnia participants were consecutively admitted to the Neurology - Sleep Disorders Center of the IRCCS San Raffaele Turro Hospital, after an assessment conducted by a neurologist expert in sleep medicine. Inclusion criteria were as follows: the absence of dementia (Mini Mental State Examination ≥ 24), psychiatric disorders, other sleep disorders and neurological comorbidities. All participants with insomnia disorder met the clinical criteria for chronic insomnia disorder according to International Classification of Sleep Disorders (ICSD-3; American Academy of Sleep Medicine, 2014). In addition, patients had to be drug-free for at least 2 months before their inclusion in the study or had a stable therapy for 6 months.

To improve the accuracy of insomnia diagnosis, all participants completed the Italian translations of the Pittsburg Sleep Quality Index (PSQI; Curcio et al., 2013) and the Insomnia Severity Index (ISI; Castronovo et al., 2016), mean values were 13.25 (*SD* = 4.13; Cronbach's *a* = .74) and 17.83 (*SD* = 3.92; Cronbach's *a* = .70) for PSQI and ISI, respectively. All insomnia participants underwent two consecutive nights of polysomnographic (PSG) evaluation. The first night was used for adaptation to the recording environment. During the second night the PSG evaluation was carried out. Lights-out time was based on the individual's usual bedtime and ranged between 11:00 and 11:30 pm. The following signals were recorded: electroencephalogram (six channels, including C3 or C4 and O1 or O2, referred to the contralateral mastoid); electrooculogram; electromyography (EMG) of the submentalis muscle; EMG of the right and left tibialis anterior muscles; electrocardiogram (one derivation) according to the American Academy of Sleep Medicine (2014) scoring criteria. The sleep respiratory pattern of each patient was monitored using oral and nasal air flow thermistors and/or nasal pressure cannula, thoracic and abdominal respiratory effort strain gauge, and by monitoring oxygen saturation (pulse-oximetry). Sleep stages were scored following standard criteria (e.g., Berry et al., 2012) on 30-s epochs.

Community-dwelling participants were recruited in train station in Milan. In each sample, 18 (60.0%) participants were male and 12 (40.0%) were female; 3 (10%) participants had a junior high school degree, 16 (53.3%) participants had a high school degree, and 11 (36.6%) participants had a University degree; participants' mean age was 44.30 years, *SD* = 13.46 years (range: 23–71 years).

2.2 Procedures

All participants volunteered to take part in the study after being presented with a detailed description and all were treated in accordance with the Ethical Principles of Psychologists and Code of Conduct; none of the participants received an incentive, either directly or indirectly for participating. Insomnia participants were administered all measures as part of their routine clinical assessment.

All PEBL test battery tasks were completed on an IBM-compatible laptop personal computer. For each participant, the order of administration of the individual executive functioning tasks was randomized within the PEBL test battery in order to control for order and carry-over effects. Participants were administered individually the PID-5 in a previous occasion, blind to PEBL tasks scores; moreover, clinical psychologists who scored the PID-5 were blind to PEBL tasks scores, as well as to this study aims, and clinical psychologists administering PEBL test battery tasks were blind to PID-5 profiles, and to the aims of the present study.

2.3 Measures

All participants were administered the Italian translation of the PID-5 (Fossati et al., 2013), and PEBL tasks. In the translation process, the authors closely followed Denissen, Geenen, van Aken, Gosling, and Potter's (2008) indications.

Psychology Experiment Building Language and Test Battery (PEBL; Mueller & Piper, 2014). The Psychology Experiment Building Language (PEBL) is a free, open-source software system that allows researchers and clinicians to design, run, and share behavioral tests (Mueller & Piper, 2014). Extensive data providing evidence for the validity of EF tasks included in the PEBL test battery were previously published (Piper et al., 2012).

In the present study, we administered the following executive functioning tasks that are included in the PEBL test battery: (a) Berg's ("Wisconsin") Card Sorting Test (WCST; Berg, 1948); (b) Balloon Analog Risk Task (Lejuez et al., 2002); (c) Go/No Go Task (Bezdjian et al., 2009); (d) Tower of London Task (ToL; Anderson et al., 2012); and (e) Continuous Performance Test (CPT; Conners et al., 2003; Piper, 2012).

PEBL Wisconsin (Berg's) Card Sorting Test (BCST; Piper et al., 2012). BCST is classic test of executive functioning. Participants were provided two decks of cards on computer screen and asked to match each card, one at a time, to one of four key cards, after which they received feedback from the computer program (i.e., correct or incorrect). Test cards can be matched to the key cards based on "color" (red, green, blue, or yellow), "form" (triangle, star, cross, or circle), and/or "number" (1, 2, 3, or 4 shapes on the card), with some cards matching the key cards based on multiple sorting principles (i.e., a test card depicting two green circles would match a key card depicting two green triangles based on both the number and color principles). However, only one of these sorting principles is correct at any given time and the correct sorting principle changes each time the participant achieves 10 consecutive correct responses (i.e., one completed category). The correct sorting principle is initially unknown to the participant and is never explicitly stated by the examiner during the test. The participant is instructed that the experimenter cannot tell him or her *how* to match the cards, but the computer program will indicate after each trial whether the participant's card placement was correct or incorrect. Participants are expected to utilize this feedback to learn the correct sorting principle to accurately advance through the test. In the present study, after each trial, feedback of "correct!" or "incorrect" was displayed for 500 ms.; the maximum number of trials was 128 (i.e., two decks of 64 cards).

Balloon Analog Risk Task (Lejuez et al., 2002). The BART was designed to provide a context in which actual risky behavior could be examined. During the task, the computer screen showed a small simulated balloon accompanied by a balloon pump, a reset button labeled "Collect $$$", a permanent money-earned display labeled "Total Earned", and a second display listing the money earned on the last balloon and labeled "Last Balloon" (Lejuez et al., 2002). Each click on the pump inflated the balloon of about 0.125 in. [0.3 cm] in all directions. With each pump, 5 cents were accrued in a temporary reserve (the amount of money in this reserve is never indicated to the participant). When a balloon was pumped past its individual explosion point, a "pop" sound effect was generated from the computer. When a balloon exploded, all money in the temporary bank was lost, and the next uninflated balloon appeared on the screen. At any point during each balloon trial, the participant could stop pumping the balloon and click the "Collect $$$ button". Clicking this button would transfer all money from the temporary bank to the permanent bank, during which the new total earned would be incrementally updated cent by cent while a slot machine payoff sound effect played. After each balloon explosion or money collection, the participant's exposure to that balloon ended, and a new balloon appeared until a total of 90 balloons (i.e., trials) had been completed. These 90 trials comprised 3 different balloon types (i.e., blue, yellow, and orange). Each balloon color had a different probability of exploding (Lejuez et al., 2002). Participants were given no detailed information about the probability of an explosion, and they were not informed that different balloon colors had different probabilities of exploding (Lejuez et al., 2002). They were told that at some point each balloon would explode and that this explosion could occur as early as the first pump all the way up to the point at which the balloon had expanded to fill the entire computer screen (Lejuez et al., 2002). As the blue balloon allowed the widest range of possible number of pumps and therefore was likely to capture the greatest amount of individual variability in task performance, the number of pumps on this balloon served as the primary dependent measure in the present study (Lejuez et al., 2002). In line with Lejuez and colleagues (2002), instead of using an absolute average number of pumps, we relied on the average number of pumps excluding balloons that exploded (i.e., the average number of pumps on each balloon prior to money collection).

Go/NoGo task (Bezdjian et al., 2009). The Go/NoGo task is a response inhibition task where a motor response must either be executed or inhibited. During this task, participants were required to watch a sequential presentation of letters and respond to a target letter by pressing a button. The presentation began with a 2 x 2 array with four stars (one in each square of the array). A single letter (P or R) was then presented in one of the squares for a duration of 500 milliseconds with an inter-stimulus interval of 1,500 ms. In the first condition (P-Go), participants were asked to press a button in response to the target letter P and withhold their response to the non-target letter R. The ratio of targets to non-targets was 80:20. The first condition consisted of 160 trials.

A second, reversal condition (R-Go) was then administered, and participants were now asked to make a response to the target letter R and withhold their response to the non-target letter P (the letter that they were initially conditioned to make a motor response to in the first, P-Go condition). The ratio of targets to non-targets stays exactly the same during the reversal (R-Go) condition (ratio of targets to non-targets-80:20). Together, the two conditions consisted of 320 trials total. Prior to the task, the participants were administered a brief practice session to ensure the task was fully comprehended. Behavioral performance of the task was assessed by calculating four values in each condition: 1) correct responses to the target (Go) letter (hits); 2) errors of omission (misses) to the Go letter; 3) errors of commission (false alarms) (i.e. responding incorrectly to the NoGo letter); and 4) correct rejections to the NoGo letter. In addition, reaction time (RT) to the Go letter was assessed and calculated for each participant. Go errors are typically considered as an indicator of inattention to the task, while NoGo errors and RT to Go responses are considered as indicators of impulsivity (Barkley, 1991; Halperin et al., 1991).

Tower of London (ToL; Anderson et al., 2012; Piper et al., 2012). ToL is a test of planning in which colored disks or balls on pegs are moved individually from an initial state to match a goal state.

Optimal performance involves forming, retaining, and implementing a plan to make as few moves as possible. The cognitive and neurophysiological substrates of ToL performance have been frequently and thoroughly examined (e.g., Phillips, Wynn, Gilhooly, Della Sala, & Logie, 1999; Ward & Allport, 1997).

In PEBL ToL task, participants are instructed that they can move only one disk at a time, and they cannot move a disk onto a pile that has no more room (indicated by the size of the grey rectangle). To move a disk, participants have to click on the pile they want to move a disk off of, and it will move up into the hand. Then, they have to click on another pile, and the disk will move down to that pile. PEBL ToL placed no restrictions on the height of the pegs or the number of moves allowed to solve the problem. The primary index of PEBL ToL was the total number of moves across the seven trials, although the total time was also recorded.

Continuous Performance Test (CPT; Conners et al., 2003; Piper, 2012). Each participant completed a practice session until the examiner was confident that the participant understood the task completely. The task consisted of 360 letters (approximately 1 in. in size) which appeared on the computer screen, one at a time, for approximately 250 ms. The 360 trials were presented in 18 consecutive blocks of 20 trials. The 18 inter-stimulus intervals blocks consisted of a separate inter-stimulus interval (1, 2, or 4 s). The inter-stimulus intervals were block-randomized so that all three ISI conditions would occur every three blocks but in a different order. Therefore, the entire CPT could be divided into six consecutive time blocks with each time block containing all three inter-stimulus interval conditions. Participants were required to depress the spacebar when any letter except the letter "X" appeared on the screen. The event rate, or percentage of trials when letters other than "X" appeared, was 90% and this percentage was constant across ISI and time blocks. The total CPT task takes approximately 14 min for the patient to complete.

The CPT was shown to have adequate split-half and three-month test-retest reliability (Conners et al., 2003), and efficiently discriminated ADHD participant groups from non-ADHD controls (Seidel & Joschko, 1990).

Personality Inventory for DSM-5 (Krueger et al., 2012). The PID-5 is a 220-item questionnaire with a 4-point response scale (0 = *very false or often false* to 3 = *very true or often true*), which was explicitly designed to measure the *DSM-5* AMPD traits. Seventeen (approximately 8%) of 220 items are reverse coded; the majority of the items reflect greater levels of personality pathology. PID-5 items are summed to compose PID-5 trait scale scores; then, PID-5 trait scales are summed to generate PID-5 domain scale scores. The PID-5 has 25 primary scales that load onto 5 higher order dimensions (Krueger et al., 2012), and this structure is replicable (Somma, Krueger, Markon, Fossati, 2019). The reliability and construct validity of the Italian translation of the PID-5 in nonclinical adult participants have been published (Fossati et al., 2013). In the insomnia participants sample, Cronbach *a* coefficient values were .94, .95, .89, .87, and .94 for PID-5 Negative Affectivity, Detachment, Antagonism, Disinhibition, and Psychoticism domain scales, respectively. In the community-dwelling participant sample, Cronbach *a* was .96 for Negative Affectivity, .95 for Detachment, .96 for Antagonism, .90 for Detachment, and .97 for Psychoticism.

2.4 Data analysis

In the present study, Mann-Whitney *U* test was used to compare the performance of insomnia participants and community-dwelling adult participants on PEBL task index scores. The rank-biserial correlation coefficient was used as an effect size measure for Mann-Whitney *U* test (Cureton, 1956).

The misperception index (MI; Manconi et al., 2010) was used in order to identify participants with "objective" insomnia and "non-objective" insomnia; it is computed as the ratio of the difference between objective total sleep time (oTST) and subjective total sleep time (sTST) on the oTST (i.e., $\mathrm{MI} = \frac{\mathrm{oTST}-\mathrm{sTST}}{\mathrm{oTST}}$; Manconi et al., 2010). In the present study, we considered insomnia participants scoring higher than .90 for the "non-objective" insomnia group.

Kruskal-Wallis *H* statistics and Dunn post-hoc comparisons were used to compare executive function index scores and maladaptive personality domain scores among insomnia adult participants with objective reduction in total sleep time, insomnia adult participants with subjective perception of reduced total sleep time, and community-dwelling adults (i.e., controls). Epsilon-squared estimate (Kelley, 1935) was used as an effect size measure for the Kruskal-Wallis *H*. Dunn (1964) rank contrasts were computed after significant *H* test result to identify significant pairwise group comparisons; Rosenthal's (1994) *r* was used to evaluate the effect size of the Dunn contrasts.

3. Results

The non-parametric comparisons between insomnia adult participants and community-dwelling adult participants matched on age, gender, and education level on executive function tasks are summarized in Table 1.

Table 1. Executive Function Measures in Insomnia Adult Participants (*n* = 30) and Community-Dwelling Adult Participants (*n* = 30) Matched on Age, Gender, and Education Level: Descriptive Statistics and Non-Parametric Comparisons.

	Insomnia Adults (*n* = 30)		Community Adults (*n* = 30)			
Berg's Card Sorting Test	*M*	*SD*	*M*	*SD*	*U*	$r_{rank\text{-}biserial}$
Number of correct responses	90.95	16.87	96.68	8.46	409.50	.09
Total number of errors	28.68	12.01	24.26	10.08	327.50	.27
Number of perseverative errors	37.04	11.30	40.68	7.23	390.00	.13
Number of non-perseverative errors	13.66	14.05	8.96	6.89	301.50*	.33
Number of unique errors	0.87	1.22	0.50	1.17	353.00	.22
Number of trials to first category	20.73	18.83	14.30	7.22	305.50*	.32
Failure to maintain set	1.47	1.46	0.53	0.63	275.00**	.39
Learning to learn	-0.68	4.82	0.33	2.90	370.50	.12
Level of conceptual complexity	85.80	19.49	88.70	11.14	444.50	.01
Balloon Analogue Risk Task						
Mean Blue Balloon Adjusted	14.77	14.25	16.87	12.57	362.50	.17
Go/NoGo Task						
Number of omission errors	11.61	36.59	6.50	24.45	298.50	.07
Number of commission errors	51.04	10.66	51.86	6.67	304.00	.06
Mean total reaction time (*ms.*)	1007.62	200.01	1027.46	155.17	306.00	.05
Tower of London						
Total number of moves	76.29	23.12	65.17	10.79	186.50*	.41
Total time (*ms.*)	311.72	140.25	987.47	3879.73	241.50	.23
Continuous Performance Test						
Number of perseverative errors	0.46	0.92	0.97	1.92	349.50	.14
Number of omission errors	8.46	16.28	7.69	9.31	328.00	.19
Number of commission errors	17.32	10.69	18.52	11.65	382.50	.06
Number of trials	54.64	10.75	53.21	11.84	381.00	.06
Hit mean reaction time (*ms.*)	445.67	75.62	452.52	96.39	404.50	.00
C index	-0.86	0.56	-0.75	0.88	376.00	.07
d index	0.07	3.16	0.85	2.75	344.00	.15

Note. * p <.05; ** p <.01.

According to the misperception index, in our insomnia group 13 (43.3%) participants were identified as suffering from non-objective insomnia. In our study, participants who were considered to suffer from non-objective insomnia showed a significantly higher total sleep time (M = 420.92, SD = 64.62) than participants who were considered to suffer from objective insomnia (M = 371.56, SD = 74.36), Mann-Whitney U = 70.00, 1-tailed exact p <.05, rank-biserial r = .37.

Spearman r between polysomnographic indices and executive function measures in insomnia participants are summarized in Table 2. With the exception of the negative association between the sleep latency index and the PID-5 Psychoticism domain scale score, Spearman r = .41, p <.05, and the positive relationship between the wake after sleep onset (WASO) index and the PID-5 Detachment domain scale score, Spearman r = .51, p <.01, none of the other polysomnographic indices correlated significantly with the PID-5 domain scale scores among insomnia participants.

Table 2. Spearman Correlations Between Polysomnographic Indices and Executive Function Measures in Insomnia Participants (N = 30).

Berg's Card Sorting Test	TST	SL	WASO	SE-%	N-AWK	N1	N2	N3	REM	REM-L
Number of correct responses	.25	.00	**-.48**	**.43**	**-.54**	**-.48**	.22	.02	-.11	-.27
Total number of errors	-.35	.30	**.43**	**-.54**	.24	.16	-.23	.24	-.17	.19
Number of perseverative errors	.13	**.45**	**-.39**	.08	**-.42**	**-.40**	.22	-.13	.02	-.16
Number of non-perseverative errors	-.29	.19	**.46**	**-.42**	.28	.25	-.21	.27	-.26	.21
Number of unique errors	.06	-.09	.04	.14	.22	.07	-.04	.04	.09	.05
Number of trials to first category	-.20	.03	.27	-.15	.04	.08	.00	.12	-.11	.07
Failure to maintain set	-.16	.14	-.26	.05	**-.41**	-.25	-.30	.05	.25	-.19
Learning to learn	-.11	-.19	-.17	.10	-.07	-.26	.19	.06	-.05	-.30
Level of conceptual complexity	.33	**-.36**	**-.39**	**.57**	-.32	-.29	.22	-.11	.03	-.17
Balloon Analogue Risk Task										
Mean Blue Balloon Adjusted	**.41**	-.03	-.21	.18	-.16	**-.37**	.13	.06	.06	**-.36**
Go/NoGo Task										
Number of omission errors	**-.41**	.15	**.38**	**-.57**	.16	-.07	**-.43**	.31	-.19	.03
Number of commission errors	.03	.26	**-.48**	.20	**-.59**	**-.39**	-.13	.13	**.38**	**-.36**
Mean total reaction time (*ms.*)	-.24	.16	.22	**-.36**	.13	.34	-.24	-.05	-.25	.25
Tower of London										
Total number of moves	.04	-.14	-.14	.09	.02	-.25	-.03	-.01	.24	.12
Total time (*ms.*)	.15	-.29	-.10	.24	.03	-.09	**-.50**	**.36**	.32	-.33
Continuous Performance Test										
Number of perseverative errors	**-.36**	.25	.25	**-.47**	.29	.19	-.35	.03	.08	.22
Number of omission errors	-.01	.31	.05	-.22	.30	.09	-.32	.01	.30	-.26
Number of commission errors	-.29	.00	-.08	-.03	.19	-.13	-.21	.29	.23	-.25
Number of trials	.29	.00	.08	.03	-.19	.13	.21	-.29	-.23	.25
Hit mean reaction time (*ms.*)	-.06	.33	-.14	-.13	-.25	-.06	.02	-.12	-.10	.21
c index	.26	.17	-.13	.01	-.07	-.15	-.13	.04	.33	-.24
d index	.29	-.04	.15	.01	.37	.30	.14	-.30	.13	.23
M	392.95	13.28	52.58	85.59	11.23	7.95	43.39	26.39	22.27	107.80
SD	73.47	16.20	46.74	10.80	5.91	4.66	8.05	8.37	6.87	60.29

Note. TST: Total sleep time (min.); SL: Sleep latency (min.); WASO: Wake after sleep onset; SE-%: Sleep efficiency in percentage; N-AWK: Number of awakes; N1: Stage N1 sleep (min.); N2: Stage N2 sleep (min.); N3: Stage N3 sleep (min.); REM: Rapid eye movement sleep (min.); REM-L: REM latency (min.). Spearman *r* values >|.36| are significant at $p < .05$; bold highlights significant *r* values.

Kruskal-Wallis *H* and Dunn rank multiple comparison test results for executive function tasks among objective insomnia participants, non-objective insomnia participants, and community-dwelling adults are listed in Table 3.

Table 3. Executive Function Measures in Insomnia Adult Participants with Objective Reduction in Total Sleep Time (*n* = 17), Insomnia Adult Participants with Subjective Perception of Reduced Total Sleep Time (*n* = 13), and Community-Dwelling Adults: Descriptive Statistics and Non-Parametric Comparisons (Kruskal-Wallis H Statistics and Dunn Post-Hoc Comparisons.

	Objective Insomnia (*n* = 17)		Non-Objective Insomnia (*n*= 13)		Community Adults (*n* = 30)			
Berg's Card Sorting Test	*M*	*SD*	*M*	*SD*	*M*	*SD*	*H*(2)	E_R^2
Number of correct responses	86.86	18.04	96.29	14.11	96.68	8.46	5.05	.09
Total number of errors	30.37	15.19	26.48	5.63	24.26	10.08	3.36	.06
Number of perseverative errors	34.77	12.41	40.00	9.32	40.68	7.23	1.93	.03
Number of non-perseverative errors	15.72	17.86	10.96	6.13	8.96	6.89	4.88	.08
Number of unique errors	0.70	1.04	1.10	1.45	0.50	1.17	3.36	.06
Number of trials to first category	21.35	22.42	19.92	13.63	14.30	7.22	4.80	.08
Failure to maintain set	1.35 [a]	1.41	1.62 [a]	1.56	0.53 [b]	0.63	7.80*	.13
Learning to learn	0.99 [a]	2.77	-2.60 [b]	5.99	0.33 [a]	2.90	6.55*	.11
Level of conceptual complexity	82.82	23.72	89.69	11.76	88.70	11.14	0.36	.01
Balloon Analogue Risk Task								
Mean Blue Balloon Adjusted	9.75 [b]	9.32	20.95 [a]	17.03	16.87 [a]	12.57	6.18*	.11
Go/NoGo Task								
Number of omission errors	20.38	47.57	0.20	0.42	6.50	24.45	3.49	.06
Number of commission errors	50.54	13.88	51.70	4.50	51.86	6.67	0.33	.01
Mean total reaction time (*ms.*)	981.34	264.51	1041.79	47.01	1027.46	155.17	0.34	.01
Tower of London								
Total number of moves	85.55 [b]	28.69	66.10 [a]	7.29	65.17 [a]	10.79	10.39**	.18
Total time (*ms.*)	363.21	161.12	255.08	89.80	987.47	3879.73	3.43	.06
Continuous Performance Test								
Number of perseverative errors	0.56	1.09	0.33	0.65	0.97	1.92	1.29	.02
Number of omission errors	10.06	20.68	6.33	7.64	7.69	9.31	1.60	.03
Number of commission errors	18.56	10.51	15.67	11.16	18.52	11.65	0.86	.01
Number of trials	53.38	10.61	56.33	11.16	53.21	11.84	0.90	.02
Hit mean reaction time (*ms.*)	453.71	87.45	434.95	58.20	452.52	96.39	0.00	.00
C index	-0.96	0.72	-0.73	0.20	-0.75	0.88	1.14	.02
d index	0.38	2.96	-0.35	3.49	0.85	2.75	1.14	.02

Note. * p <.05; ** p <.01. Dunn post hoc contrasts were computed only in the case of significant Kruskal-Wallis H test; mean with different superscripts indicates significant (i.e., p <.05) Dunn post-hoc rank comparisons.

Based on Dunn post hoc rank contrasts, community-dwelling adults scored significantly lower on the BCST Failure to maintain set index than both objective insomnia participants, z = -2.18, p <.05, r = -.32, and non-objective insomnia participants, z = -2.37, p <.05, r = -.36. Rather, no significant difference was found between the two insomnia sub-groups on the BCST Failure to maintain set index, z = 0.34, p >.70, r = .06. According to Dunn post hoc rank contrasts, non-objective insomnia participants scored significantly lower on the BCST Learning to learn index than both objective insomnia participants, z = -2.44, p <.05, r = -.45, and community-dwelling adults, z = -2.10, p <.05, r = -.32, with no significant differences between the two latter groups, z = 0.72, p >.40, r = .11.

When we took into account the BART mean blue adjusted index, Dunn post hoc rank comparisons showed that objective insomnia participants scored significantly lower than both non-objective insomnia participants, z = -2.29, p <.05, r = -.42, and community-dwelling participants, z = -2.17, p <.05, r = -.32. No significant difference was observed between non-objective insomnia participants and community-dwelling participants, z = 0.56, p >.50, r = .09.

Finally, in our study Dunn post hoc rank contrasts showed that the number of moves on the ToL task did not significantly differentiate non-objective insomnia participants from community-dwelling participants, z = 0.62, p >.50, r = .09. Rather, a significantly higher number of moves on the ToL task was observed for objective insomnia participants than for both non-objective insomnia participants, z = 2.08, p <.05, r = .38, and community-dwelling participants, z = 3.22, p <.05, r = .47.

Kruskal-Wallis H and Dunn post hoc rank contrast results for the PID-5 domain scale scores among objective insomnia participants, non-objective insomnia participants, and community-dwelling adults are summarized in Table 4. The median inter-correlations (i.e., Spearman r values) among the PID-5 domain scale scores were .58, .30, and .36 among objective insomnia participants, non-objective insomnia participants, and community-dwelling participants, respectively. According to Dunn post hoc rank contrasts, non-objective insomnia participants scored significantly higher on the PID-5 Disinhibition domain scale than both objective insomnia participants, z = 2.47, p <.05, r = .45, and community-dwelling participants, z = 2.44, p <.05, r = .37. No significant difference on the PID-5 Disinhibition domain scale score was observed between objective insomnia participants and community-dwelling participants, z = 0.57, p >.50, r = .08.

Table 4. Personality Inventory for DSM-5 Scale Scores in Insomnia Adult Participants with Objective Reduction in Total Sleep Time (*n* = 17), Insomnia Adult Participants with Subjective Perception of Reduced Total Sleep Time (*n* = 13), and Community-Dwelling Adults: Descriptive Statistics and Non-Parametric Comparisons (Kruskal-Wallis H Statistics and Dunn Post-Hoc Comparisons).

	Objective Insomnia (*n* = 17)		Non-Objective Insomnia (*n*= 13)		Community Adults (*n* = 30)			
Personality Inventory for DSM-5 Domain Scales	*M*	*SD*	*M*	*SD*	*M*	*SD*	*H*(2)	E_R^2
Negative Affectivity	1.20	0.49	1.02	0.31	0.86	0.33	5.29	.09
Detachment	0.80	0.51	0.65	0.50	0.54	0.33	2.15	.04
Antagonism	0.46	0.31	0.58	0.36	0.38	0.25	3.58	.06
Disinhibition	0.84 [a]	0.26	1.13 [b]	0.34	0.88 [a]	0.14	7.61*	.13
Psychoticism	0.47	0.46	0.42	0.48	0.33	0.33	0.48	.01

Note. * *p* <.05; ** *p* <.01. Dunn post hoc contrasts were computed only in the case of significant Kruskal-Wallis *H* test; mean with different superscripts indicates significant (i.e., *p* <.05) Dunn post-hoc rank comparisons.

4. Discussion

Confirming and extending available evidence (Ballesio et al., 2019; Fortier-Brochu et al., 2012), our study provided further data suggesting an association between insomnia and selected executive functions, at least as they were assessed by the PEBL computerized tasks, while hinting at the potential usefulness of differentiating non-objective insomnia from objective insomnia based on the MI index (Manconi et al., 2010).

In this preliminary study insomnia participants seemed to be significantly (and non-negligibly) characterized by higher frequency response of non-perseverative errors (i.e., all incorrect responses other than perseverative errors) on the BCST, lower accuracy in identifying the correct rule and maintaining it until appropriate (i.e., higher BCST number of trials to complete the first category), higher distractibility, at least as it was operationalized in the BCST Failure to maintain set index (i.e., the number of incorrect changes of the sorting strategy before change is appropriate; Figueroa & Youmans, 2013), and lower planning ability (i.e., higher number of moves in the ToL task) than community-dwelling controls who were matched on age, gender, and education level.

Notwithstanding the small size of our insomnia participant group, in our study several theoretically relevant, significant associations were observed between polysomnographic index values and executive function task measures. This finding seemed to be highly consistent with previous studies suggesting relying on PSG evaluation – and even sleep microstructure – in order to improve our knowledge on the relationship between poor sleep quality and cognitive functioning (Ferini-Strambi, Galbiati, & Marelli, 2013; Manconi et al., 2017). As a whole, our data suggested that sleep efficiency may be positively associated with cognitive flexibility – at least as it is assessed by the BCST - whereas WASO index seemed to be related with poor cognitive flexibility among insomnia participants. Interestingly, sleep efficiency and WASO were the only PSG data yielding significant, albeit opposite findings with self-reports of dysfunctional personality domains in our insomnia participant sample. In other terms, these PSG data did not seem only to influence the performance on the BCST, but they seemed also to modulate the phenotypic manifestation of dysfunctional personality features in insomnia participants.

Our data seemed also to suggest that increased propensity towards risky choices among insomnia participants, at least as it was assessed by the BART, could be significantly associated with total sleep time, whereas latency of REM sleep and stage N1 sleep showed a significant and negative relationship with the propensity towards risky choices on the BART.

In our insomnia participant group, sleep efficiency, as well as total sleep time and sleep N2 stage showed non-negligible, significant and negative relationships with attention (i.e., omission) errors on the Go/NoGo task; rather, the frequency of attention errors on the Go/NoGo task was positively and significantly associated with the WASO index. Extending previous results on sleep REM density and impulsive personality pathology (Baglioni et al., 2016), in our study impulsivity (i.e., the frequency of commission errors) on the Go/NoGo task was positively associated with REM sleep time, whereas it showed significant and non-negligible negative correlations with number of awakes, WASO, stage N1 sleep, and REM latency.

Insomnia participants' performance (i.e., number of moves) on the ToL seemed to be unaffected by polysomnographic index values; however, participants' speed to complete the task showed opposite and significant associations with stage N2 sleep (-) and stage N3 sleep (+), respectively. Finally, among insomnia participants higher total sleep time and sleep efficiency percentage seemed to be significantly associated with lower frequency of impulsive (i.e., perseverative) errors on the CPT.

When we assigned our insomnia participant to the non-objective insomnia and objective insomnia sub-groups based on the MI values, we observed that both sub-groups showed a significantly lower performance (i.e., higher number of errors) on the BCST Failure to maintain set index than community-dwelling control participants. In other terms, this finding seemed to confirm that distractibility problems significantly characterize insomnia participants with respect to community-dwelling controls matched on age, gender, and education level, with no significant differences between insomnia sub-groups. Rather, the non-objective insomnia subgroup seemed to be significantly characterized by lower conceptual efficiency, at least during the BCST (i.e., lower BCST learning to learn index value), than both objective insomnia and community dwelling control sub-groups.

In line with previous evidence (Ballesio et al., 2019), poor planning abilities, as they are measured by the number of moves on the ToL task, were significantly and selectively associated with objective insomnia, with no significant difference between non-objective insomnia participants and community-dwelling adult participants.

Confirming and extending previous data on the negative association between sleep deprivation and the willingness to engage in high risk activities under condition of uncertainty (i.e., higher scores on the BART; Gowen et al., 2019; Killgore, 2007), as well as our findings on the positive association between the BART and the total sleep time, participants characterized by objective insomnia showed a lower propensity towards risky behavior than both non-objective insomnia participants and community-dwelling adult participants. Notably, this finding should be considered also in the light of the positive and selective association that we observed between self-reports of orientation toward immediate gratification, leading to impulsive behavior driven by current thoughts, feelings, and external stimuli, without regard for past learning or consideration of future consequences (i.e., high scores on the PID-5 Disinhibition domain scale) and non-objective insomnia.

Limitations

Of course, our findings should be considered in the light of several limitations; we feel that independent replications are mandatory before accepting our results. Although we relied on consecutive admissions to select our insomnia participants, our data should be considered based on convenience study groups rather than on actually representative samples. Moreover, we relied on a relatively small sample of consecutively admitted insomnia patients. However, our participants were carefully assessed for to exclude other sleep disorders (e.g., PSG evaluation), maladaptive personality traits, and executive functioning. Excluding time for completing the PID-5, each participant was involved in 1.5-hour session for administering PEBL executive functioning tasks. Of course, gathering large amount of data when laboratory tasks are at issue may be unrealistic; however, this should not lead to overlooking the problems associated with small sample size (e.g., sample representativeness, precision of estimates, replicability, etc.). Moreover, in our study we relied exclusively on PID-5 self-reports in order to assess *DSM-5* AMPD maladaptive personality domains and traits; however, it should be observed that PID-5 currently represents the instrument of choice for *DSM-5* maladaptive personality assessment (e.g., Krueger & Markon, 2014). Finally, in the present study, we relied on the MI index in order to identify participants characterized by "objective" and "non-objective" reduction of total sleep time. Although it has been used in previous studies on Italian insomnia participants (e.g., Manconi et al., 2010), we are aware that different indices could be computed and that relying on different indices may lead to different results (Castelnovo et al., 2019); thus, further studies on this topic are needed.

Although a previous study showed that sleep spindles characteristics were not predictive of sleep misperception (Normand, St-Hilaire, & Bastien, 2016), future studies may consider the relationships among cyclic alternating pattern, subjective time perception during sleep (Parrino, Milioli, De Paolis, Grassi, Terzano, 2009), and maladaptive personality traits. Specifically, further investigation is mandatory to shed light on sleep misperception, internal representation of time, cognitive mechanisms, and different neurophysiological profiles.

In our study, we relied on sound computer-administered tasks in order to assess executive functioning indices. However, we would like to stress that identifying reduced performance on neuropsychological tasks does not imply impairment in corresponding brain area functions, since a number of cognitive, brain and behavioral correlates may interfere with subject's performance on neuropsychological tasks (e.g. Arnett, 2013). We are aware that commercial versions of PEBL tasks are available; however, previous studies documented the validity of PEBL tasks (Muller et al., 2014).

Conclusions

As a whole, the results of our study seemed confirm our hypotheses on the associations between insomnia and executive functions. Notably, our insomnia participants seemed to be characterized by higher distractibility than community participants who were matched on age, gender, and education level. Consistently, in our insomnia participant group, sleep efficiency, as well as total sleep time showed a negative relationship with attention. Moreover, both non-objective insomnia and objective insomnia sub-groups showed distractibility problems and lower planning performance as compared to community-dwelling controls, with no significant differences between insomnia sub-groups. Although further studies are needed before accepting our conclusions, we would like to stress that our consideration may find some external support from seminal data on neuro-cognitive and behavioral correlates of lucid dreaming. For instance, it has been documented that lucid dreaming (i.e., the attentive awareness that one is dreaming) may be linked to neural systems that regulate executive control processes (e.g., Baird et al., 2018; Dresler et al., 2015). From this perspective, assessing the relationship between different aspects of dreaming (e.g., nightmares, lucid dreams; see for instance, the Mannheim Dream questionnaire; Dyck, Schredl, & Kühnel, 2017; Schredl, Berres, Klingauf, Schellhaas, & Göritz, 2014; Settineri, Frisone, Alibrandi, & Merlo, 2019b) and executive functioning might be relevant. Recently, Bloxham (2018) suggested that waking and dream recall ability could be overlapping domains, whereas Kumar, Sasidharan, Nair, and Kutty (2018) found that lucid dreaming induction may lead to enhanced insight and memory for dreams. Interestingly, Schadow and colleagues' (2018) findings underscore the importance of considering the relationships between poor sleep quality and nightmares (see also Schredl, 2003).

Finally, it should be observed that the results of the present study showed that non-objective insomnia participants scored higher on the PID-5 Disinhibition domain scale and that objective insomnia participants were characterized by lower propensity toward risky behavior of than both non-objective insomnia participants and community dwelling participants in a laboratory task (i.e. BART). Further stressing the relevance of the relationships between sleep and personality features, Stumbrys and Daunytė's (2018) findings suggested the importance of considering the associations between the ability for lucid dreaming and creativity (i.e., high Openness to experience; see also, Saunders, Roe, Smith, & Clegg, 2016). Notably, Settineri and colleagues (2019 b) examined the relationships between defensive styles and dreaming, highlighting the relationships between emotional suppression and sleep disturbances in subjects with psychosomatic features.

Thus, even keeping the limitations of our study in mind, we think that it may be useful in order to better characterize people suffering from insomnia, identifying specific EF and personality correlates of objective insomnia and non-objective insomnia.

References

1. Altena, E., Van Der Werf, Y. D., Sanz-Arigita, E. J., Voorn, T. A., Rombouts, S. A., Kuijer, J. P., & Van Someren, E.J. (2008). Prefrontal hypoactivation and recovery in insomnia. *Sleep*, *31*(9), 1271–1276. Doi: 10.5665/sleep/31.9.1271
2. American Academy of Sleep Medicine (2014). *International classification of sleep disorders: Diagnostic and coding manual.* 3rd ed. Westchester, IL: American Academy of Sleep Medicine.
3. American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.
4. Anderson, K., Deane, K., Lindley, D., Loucks, B., Veach, E. (2012). *The effects of time of day and practice on cognitive abilities: The PEBL Tower of London, Trail-making, and Switcher tasks.* PEBL Technical Report Series [On-line].
5. Arnett, P. (2013). *Secondary influences on neuropsychological test performance.* New York, NY: Oxford University Press.
6. Baglioni, C., Nanovska, S., Regen, W., Spiegelhalder, K., Feige, B., Nissen, C., ... & Riemann, D. (2016). Sleep and mental disorders: A meta-analysis of polysomnographic research. *Psychological Bulletin*, *142*, 969-990. Doi: 10.1037/bul0000053
7. Baglioni, C., Spiegelhalder, K., Regen, W., Feige, B., Nissen, C., Lombardo, C., ... & Riemann, D. (2014). Insomnia disorder is associated with increased amygdala reactivity to insomnia-related stimuli. *Sleep, 37*, 1907-1917. Doi: 10.5665/sleep.4240
8. Baird, B., Castelnovo, A., Gosseries, O., & Tononi, G. (2018). Frequent lucid dreaming associated with increased functional connectivity between frontopolar cortex and temporoparietal association areas. *Scientific Reports*, *8*, 1-15. Doi: 10.1038/s41598-018-36190-w
9. Ballesio, A., Aquino, M. R. J., Kyle, S. D., Ferlazzo, F., & Lombardo, C. (2019). Executive functions in insomnia disorder: A systematic review and exploratory meta-analysis. *Frontiers In Psychology*, *10*, 101. Doi: 10.3389/fpsyg.2019.00101
10. Barkley, R. A. (1991). The ecological validity of laboratory and analogue assessments of ADHD symptoms. *Journal of Abnormal Child Psychology, 19*, 149–178. Doi: 10.1007/BF00909976
11. Basta, M., Chrousos, G. P., Vela-Bueno, A., & Vgontzas, A. N. (2007). Chronic insomnia and the stress system. *Sleep Medicine Clinics*, *2*(2), 279-291. Doi: 10.1016/j.jsmc.2007.04.002
12. Berg, E. A. (1948). A simple objective technique for measuring flexibility in thinking. *The Journal of General Psychology*, *39*, 15-22. Doi: 10.1080/00221309.1948.9918159
13. Berry, R.B., Brooks, R., Gamaldo, C.E., Harding, S.M., Lloyd, R.M., Marcus, C.L., & Vaughn, B.V. for the American Academy of Sleep Medicine (2012). *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications. Version 2.0.* Darien, Illinois: American Academy of Sleep Medicine.
14. Bezdjian, S., Baker, L. A., Lozano, D. I., & Raine, A. (2009). Assessing inattention and impulsivity in children during the Go/NoGo task. *British Journal of Developmental Psychology*, *27*, 365-383. Doi: 10.1348/026151008X314919

15. Bloxham, A. (2018). Relationships between dream recall, motivation to remember dreams, and waking memory ability: A preliminary investigation. *International Journal of Dream Research*, *11*(2), 141-153. Doi: 10.11588/ijodr.2018.2.47120
16. Buysse, D. J., Thompson, W., Scott, J., Franzen, P. L., Germain, A., Hall, M., ... & Kupfer, D. J. (2007). Daytime symptoms in primary insomnia: a prospective analysis using ecological momentary assessment. *Sleep Medicine*, *8*, 198-208. Doi: 10.1016/j.sleep.2006.10.006
17. Carskadon, M.A., Dement, W.C., Mitler, M.M., Guilleminault, C., Zarcone. V.P., & Spiegel, R. (1976). Self-reports versus sleep laboratory findings in 122 drug-free subjects with complaints of chronic insomnia. *American Journal of Psychiatry, 133*, 1382-1388. Doi: 10.1176/ajp.133.12.1382
18. Castelnovo, A., Ferri, R., Punjabi, N. M., Castronovo, V., Garbazza, C., Zucconi, M., ... & Manconi, M. (2019). The paradox of paradoxical insomnia: a theoretical review towards a unifying evidence-based definition. *Sleep Medicine Reviews*, *44*, 70-82. Doi: 10.1016/j.smrv.2018.12.007
19. Castronovo, V., Galbiati, A., Marelli, S., Brombin, C., Cugnata, F., Giarolli, L., ... & Ferini-Strambi, L. (2016). Validation study of the Italian version of the Insomnia Severity Index (ISI). *Neurological Sciences*, *37*, 1517-1524. Doi: 10.1007/s10072-016-2620-z
20. Conners, C. K., Epstein, J. N., Angold, A., & Klaric, J. (2003). Continuous performance test performance in a normative epidemiological sample. *Journal of Abnormal Child Psychology*, *31*, 555-562. Doi: 10.1023/A:1025457300409
21. Curcio, G., Tempesta, D., Scarlata, S., Marzano, C., Moroni, F., Rossini, P. M., ... & De Gennaro, L. (2013). Validity of the Italian version of the Pittsburgh sleep quality index (PSQI). *Neurological Sciences*, *34*, 511-519. Doi: 10.1007/s10072-012-1085-y
22. Cureton, E.E. (1956). Rank-biserial correlation. *Psychometrika 21*, 287–290. Doi: 10.1007/BF02289138
23. Denissen, J. J., Geenen, R., van Aken, M. A., Gosling, S. D., & Potter, J. (2008). Development and validation of a Dutch translation of the Big Five Inventory (BFI). *Journal of Personality Assessment*, *90*, 152-157. Doi: 10.1080/00223890701845229
24. Dresler, M., Wehrle, R., Spoormaker, V. I., Steiger, A., Holsboer, F., Czisch, M., & Hobson, J. A. (2015). Neural correlates of insight in dreaming and psychosis. *Sleep Medicine Reviews*, *20*, 92-99. Doi: 10.1016/j.smrv.2014.06.004
25. Dunn, O. J. (1964). Multiple contrasts using rank sum tests. *Technometrics, 6*, 241-252. Doi: 10.1080/00401706.1964.10490181
26. Dyck, S., Schredl, M., & Kühnel, A. (2017). Retest reliability study of the Mannheim Dream Questionnaire (MADRE). International Journal of Dream Research, 173-176. doi: 10.11588/ijodr.2017.2.38122
27. Edinger, J. D., & Krystal, A. D. (2003). Subtyping primary insomnia: is sleep state misperception a distinct clinical entity?. Sleep Medicine Reviews, 7, 203-214. Doi: 10.1053/smrv.2002.0253
28. Edinger, J. D., Means, M. K., Carney, C. E., & Krystal, A. D. (2008). Psychomotor performance deficits and their relation to prior nights' sleep among individuals with primary insomnia. *Sleep*, 31, 599–607. Doi: 10.1093/sleep/31.5.599

29. Ferini-Strambi, L., Galbiati, A., & Marelli, S. (2013). Sleep microstructure and memory function. *Frontiers in Neurology, 4*, 159. Doi: 10.3389/fneur.2013.00159

30. Fernandez-Mendoza, J., Calhoun, S. L., Bixler, E. O., Karataraki, M., Liao, D., Vela-Bueno, A., ... & Vgontzas, A. N. (2011). Sleep misperception and chronic insomnia in the general population: the role of objective sleep duration and psychological profiles. *Psychosomatic Medicine*, *73*, 88-97. Doi: 10.1097/PSY.0b013e3181fe365a

31. Fernández-Mendoza, J., Vela-Bueno, A., Vgontzas, A. N., Olavarrieta-Bernardino, S., Ramos-Platón, M. J., Bixler, E. O., & De la Cruz-Troca, J. J. (2009). Nighttime sleep and daytime functioning correlates of the insomnia complaint in young adults. *Journal of Adolescence, 32*, 1059-1074. Doi: 10.1016/j.adolescence.2009.03.005

32. Figueroa, I. J., & Youmans, R. J. (2013). Failure to maintain set: A measure of distractibility or cognitive flexibility?. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 57*(1), 828-832). Doi: 10.1177/1541931213571180

33. Ford, D. E., & Kamerow, D. B. (1989). Epidemiologic study of sleep disturbances and psychiatric disorders: an opportunity for prevention?. *JAMA*, *262*, 1479-1484. Doi : 10.1001/jama.262.11.1479

34. Fortier-Brochu, É., Beaulieu-Bonneau, S., Ivers, H., & Morin, C. M. (2012). Insomnia and daytime cognitive performance: a meta-analysis. *Sleep Medicine Reviews*, *16*, 83-94. Doi: 10.1016/j.smrv.2011.03.008

35. Fortier-Brochu, É. & Morin, C. M. (2014). Cognitive impairment in individuals with insomnia: Clinical significance and correlates. *Sleep*, *37*, 1787–1798. doi: 10.5665/sleep.4172

36. Fossati, A., Krueger, R. F., Markon, K. E., Borroni, S., & Maffei, C. (2013). Reliability and validity of the Personality Inventory for DSM-5 (PID-5) predicting DSM-IV personality disorders and psychopathy in community-dwelling Italian adults. *Assessment, 20*(6), 689-708. Doi: 10.1177/1073191113504984

37. Fulda, S., & Schulz, H. (2001). Cognitive dysfunction in sleep disorders. *Sleep Medicine Reviews*, *5*, 423-445. Doi: 10.1053/smrv.2001.0157

38. Gowen, R., Filipowicz, A., & Ingram, K. K. (2019). Chronotype mediates gender differences in risk propensity and risk-taking. *PloS One, 14*(5). doi: 10.1371/journal.pone.0216619

39. Halperin, J. M., Wolf, L. E., Greenblatt, E. R., & Young, G. (1991). Subtype analysis of commission errors on the continuous performance test in children. *Developmental Neuropsychology, 7*, 207–217. Doi: 10.1080/87565649109540488

40. Harris, K., Spiegelhalder, K., Espie, C. A., MacMahon, K. M., Woods, H. C., & Kyle, S. D. (2015). Sleep-related attentional bias in insomnia: A state-of-the-science review. *Clinical Psychology Review*, *42*, 16-27. Doi: 10.1016/j.cpr.2015.08.001

41. Kelley, T. L. (1935). An unbiased correlation ratio measure. *Proceedings of the National Academy of Sciences of the United States of America, 21*, 554–559. Doi: 10.1073/pnas.21.9.554

42. Killgore, W. D. (2007). Effects of sleep deprivation and morningness-eveningness traits on risk-taking. *Psychological Reports*, *100*(2), 613-626. Doi: 10.2466/pr0.100.2.613-626

43. Krueger, R. F., & Markon, K. E. (2014). The role of the DSM-5 personality trait model in moving toward a quantitative and empirically based approach to classifying personality and psychopathology. *Annual Review of Clinical Psychology*, *10,* 477-501. Doi: 10.1146/annurev-clinpsy-032813-153732
44. Krueger, R. F., Derringer, J., Markon, K. E., Watson, D., & Skodol, A. E. (2012). Initial construction of a maladaptive personality trait model and inventory for DSM-5. *Psychological Medicine, 42*, 1879-1890. Doi: 10.1017/S0033291711002674
45. Kumar, G., Sasidharan, A., Nair, A. K., & Kutty, B. M. (2018). Efficacy of the combination of cognitive training and acoustic stimulation in eliciting lucid dreams during undisturbed sleep: A pilot study using polysomnography, dream reports and questionnaires. *International Journal of Dream Research*, 197-202. Doi: 10.11588/ijodr.2018.2.46417
46. Kyle, S. D., Crawford, M. R., Morgan, K., Spiegelhalder, K., Clark, A. A., & Espie, C. A. (2013). The Glasgow Sleep Impact Index (GSII): A novel patient-centred measure for assessing sleep-related quality of life impairment in insomnia disorder. *Sleep Medicine*, *14*, 493-501. Doi: 10.1016/j.sleep.2012.10.023
47. Léger, D., & Bayon, V. (2010). Societal costs of insomnia. *Sleep Medicine Reviews*, *14*, 379-389. doi: 10.1016/j.smrv.2010.01.003
48. Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., ... & Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: the Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology: Applied, 8*, 75-84. Doi: 10.1037//1076-898X.8.2.75
49. Manconi, M., Ferri, R., Sagrada, C., Punjabi, N. M., Tettamanzi, E., Zucconi, M., ... & Ferini-Strambi, (2010). Measuring the error in sleep estimation in normal subjects and in patients with insomnia. *Journal of Sleep Research*, *19*, 478-486. Doi: 10.1111/j.1365-2869.2009.00801.x
50. Manconi, M., Ferri, R., Miano, S., Maestri, M., Bottasini, V., Zucconi, M., Ferini-Strambi, L., (2017). Sleep architecture in insomniacs with severe benzodiazepine abuse. *Clinical Neurophysiology*, 128, 875-881. Doi: 10.1016/j.clinph.2017.03.009
51. McCrae, R. R., & John, O. P. (1992). An introduction to the five-factor model and its applications. *Journal of Personality, 60*, 175-215. Doi: 10.1111/j.1467-6494.1992.tb00970.x
52. Mueller, S. T., & Piper, B. J. (2014). The psychology experiment building language (PEBL) and PEBL test battery. *Journal of Neuroscience Methods*, *222*, 250-259. Doi: 10.1016/j.jneumeth.2013.10.024
53. Normand, M. P., St-Hilaire, P., & Bastien, C. H. (2016). Sleep spindles characteristics in insomnia sufferers and their relationship with sleep misperception. *Neural plasticity*, 6413473. Doi: 10.1155/2016/6413473
54. Parrino, L., Ferri, R., Bruni, O., & Terzano, M. G. (2012). Cyclic alternating pattern (CAP): the marker of sleep instability. *Sleep medicine reviews*, *16*(1), 27-45. doi: 10.1016/j.smrv.2011.02.003
55. Parrino, L., Milioli, G., De Paolis, F., Grassi, A., & Terzano, M. G. (2009). Paradoxical insomnia: the role of CAP and arousals in sleep misperception. *Sleep Medicine*, *10*, 1139-1145. Doi: 10.1016/j.sleep.2008.12.014
56. Pillai, V., Roth, T., Mullins, H. M., & Drake, C. L. (2014). Moderators and mediators of the relationship between stress and insomnia: stressor chronicity, cognitive intrusion, and coping. *Sleep*, *37*, 1199-1208. Doi: 10.5665/sleep.3838

57. Piper, B. J., Li, V., Eiwaz, M. A., Kobel, Y. V., Benice, T. S., Chu, A. M., ... & Mueller, S. T. (2012). Executive function on the psychology experiment building language tests. *Behavior Research Methods, 44*(1), 110-123. Doi: 10.3758/s13428-011-0096-6
58. Piper, B. J., Li, V., Eiwaz, M. A., Kobel, Y. V., Benice, T. S., Chu, A. M., ... & Mueller, S. T. (2012). Executive function on the psychology experiment building language tests. *Behavior Research Methods*, *44*, 110-123. Doi: 10.3758/s13428-011-0096-6
59. Riedel, B. W., & Lichstein, K. L. (2000). Insomnia and daytime functioning. *Sleep Medicine Reviews*, *4*, 277-298. Doi: 10.1053/smrv.1999.0074
60. Rosenthal, R. (1994). Parametric measures of effect size. In H. Cooper & L. V. Hedges (Eds.), *The handbook of research synthesis* (p. 231–244). Russell Sage Foundation.
61. Saunders, D. T., Roe, C. A., Smith, G., & Clegg, H. (2016). Lucid dreaming incidence: A quality effects meta-analysis of 50 years of research. *Consciousness and Cognition, 43*, 197-215. Doi: 10.1016/j.concog.2016.06.002
62. Schadow, C., Schredl, M., Rieger, J., & Göritz, A. S. (2018). The relationship between lucid dream frequency and sleep quality: Two cross-sectional studies. *International Journal of Dream Research*, *11*(2), 154-159. Doi: 10.11588/ijodr.2018.2.48341
63. Schredl, M. (2003). Effects of state and trait factors on nightmare frequency. *European Archives of Psychiatry and Clinical Neuroscience, 253*(5), 241-247. doi: 10.1007/s00406-003-0438-1
64. Schredl, M., Berres, S., Klingauf, A., Schellhaas, S., & Göritz, A. (2014). The Mannheim Dream questionnaire (MADRE): Retest reliability, age and gender effects. *International Journal Of Dream Research, 7*(2). 141-147. Doi 10.11588/ijodr.2014.2.16675
65. Seidel, W. T., & Joschko, M. (1990). Evidence of difficulties in sustained attention in children with ADDH. *Journal of Abnormal Child Psychology, 18*(2), 217–229. Doi: 10.1007/BF01447206
66. Settineri, S., Frisone, F., Alibrandi, A., & Merlo, E. M. (2019a). Emotional suppression and oneiric expression in psychosomatic disorders: early manifestations in emerging adulthood and young patients. *Frontiers in psychology, 10,* 1897. doi: 10.3389/fpsyg.2019.01897
67. Settineri, S., Frisone, F., Alibrandi, A., & Merlo, E. M. (2019b). Italian adaptation of the Mannheim Dream Questionnaire (MADRE): age, gender and dream recall effects. *International Journal of Dream Research*, 119-129. Doi: 10.11588/ijodr.2019.1.59328
68. Shekleton, J. A., Rogers, N. L., & Rajaratnam, S. M. (2010). Searching for the daytime impairments of primary insomnia. *Sleep Medicine Reviews*, *14*, 47-60. Doi: 10.1016/j.smrv.2009.06.001
69. Somma, A., Krueger, R. F., Markon, K. E., & Fossati, A. (2019). The replicability of the personality inventory for DSM–5 domain scale factor structure in U.S. and non-U.S. samples: A quantitative review of the published literature. *Psychological Assessment, 31*(7), 861–877. Doi: 10.1037/pas0000711
70. Somma, A., Marelli, S., Giarolli, L. E., Maffei, C., Ferini-Strambi, L., & Fossati, A. (2018). Interview-based ratings of DSM-IV Axis II/DSM-5 Section II Personality Disorder symptoms in consecutively admitted insomnia patients: A comparison study with consecutively admitted psychotherapy patients matched on age and gender. *Comprehensive Psychiatry*, *87*, 100-106. Doi: 10.1016/j.comppsych.2018.09.005

71. Stephan, Y., Sutin, A. R., Bayard, S., Križan, Z., & Terracciano, A. (2018). Personality and sleep quality: Evidence from four prospective studies. *Health Psychology, 37*, 271-281. Doi: 10.1037/hea0000577
72. Stumbrys, T., & Daunytė, V. (2018). Visiting the land of dream muses: The relationship between lucid dreaming and creativity. *International Journal of Dream Research*, 207-212. Doi: 10.11588/ijodr.2018.2.48667
73. Suzuki T., Samuel D. B., Pahlen S., Krueger R. F. (2015). *DSM–5* alternative personality disorder model traits as maladaptive extreme variants of the five-factor model: An item-response theory analysis. *Journal of Abnormal Psychology,* 124, 343–354. Doi: 10.1037/abn0000035
74. van de Laar, M., Verbeek, I., Pevernagie, D., Aldenkamp, A., & Overeem, S. (2010). The role of personality traits in insomnia. *Sleep Medicine Review, 14*, 61–8. Doi: 10.1016/j.smrv.2009.07.007
75. Vanable, P.A., Aikens, J.E., Tadimeti, L., Caruana-Montaldo, B., Mendelson, W.B. (2000). Sleep latency and duration estimates among sleep disorder patients: Variability as a function of sleep disorder diagnosis, sleep history, and psychological characteristics. Sleep, 23, 71-79. Doi: 10.1093/sleep/23.1.1d
76. Ward, G., & Allport, A. (1997). Planning and problem-solving using five-disc tower of London task. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 50A*(1), 49–78. Doi: 10.1080/027249897392224
77. Zammit, G. K., Weiner, J., Damato, N., Sillup, G. P., & McMillan, C. A. (1999). Quality of life in people with insomnia. *Sleep: Journal of Sleep Research & Sleep Medicine, 1,* S379-S385.

DOI: 10.6092/2282-1619/mjcp-2325