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Research report

# Individual differences affecting caffeine intake. Analysis of consumption behaviours for different times of day and caffeine sources ☆

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ABSTRACT

The main purpose of the present study was to investigate the individual variables contributing to determine the high variability in the consumption behaviours of caffeine, a psychoactive substance which is still poorly investigated in comparison with other drugs. The effects of a large set of specific personality traits (i.e., Impulsivity, Sensation Seeking, Anxiety, Reward Sensitivity and Circadian Preference) were compared along with some relevant socio-demographic variables (i.e., gender and age) and cigarette smoking behaviour. Analyses revealed that daily caffeine intake was significantly higher for males, older people, participants smoking more cigarettes and showing higher scores on Impulsivity, Sensation Seeking and a facet of Reward Sensitivity. However, more detailed analyses showed that different patterns of individual variables predicted caffeine consumption when the times of day and the caffeine sources were considered. The present results suggest that such detailed analyses are required to detect the critical predictive variables that could be obscured when only total caffeine intake during the entire day is considered.



## Introduction

Caffeine, an alkaloid found in many natural products (e.g., coffee beans, tea leaves, cola nuts, cocoa beans, etc.), is a psychoactive substance acting as a central nervous system stimulant. On the one hand, heavy and prolonged caffeine intake is likely to impair sleep and enhance anxiety, and when over-consumption becomes chronic it may induce dependence and cause or worsen psychiatric symptoms, especially in hypersensitive individuals (Juliano, Anderson, & Griffiths, 2011; Ogawa & Ueki, 2007; Rihs, Muller, & Baumann, 1996). On the other hand, however, caffeine induces positive effects in both cognitive and affective domains: it enhances alertness, reduces fatigue, improves performance in simple tasks requiring vigilance and sustained response, elevates mood, reduces depressive symptoms, and decreases the risk of suicide (Attwood, Higgs, & Terry, 2007; Glade, 2010; Lara, 2010). Many of the above benefits likely account for why caffeine is the most commonly used psychoactive substance in the world (Gilbert, 1984). Nevertheless, despite its spread, scientific investigation of individual and social factors able to explain the considerable high variation in the amount of caffeine consumption is still poor in comparison with that of other drugs, possibly because caffeine is often considered to have a low profile as a drug of abuse. Furthermore, results appear rather inconsistent across studies. In this perspective, our main target was to determine which individual differences can affect caffeine intake, by considering a high number of factors usually counted in caffeine consume investigation, although not simultaneously as we did in the present study.

With regard to the relationship between personality and caffeine consumption, several studies suggest that both general and specific personality traits can affect caffeine intake. In detail, in a seminal study of Landrum (1992), a positive correlation has been shown between caffeine consumption and Extroversion. This relationship could have been mediated by the specific constructs of Impulsivity and/or Sensation Seeking. In line with this view, more recent studies found a positive relationship between caffeine intake and Impulsivity (Waldeck & Miller, 1997), Sensation Seeking (Jones & Lejuez, 2005) and cognate traits (Gurpegui et al., 2007). Importantly, all the mentioned personality constructs appear to share a temperamental low basal level of resting arousal (Pickering & Gray, 1999), which might explain why people scoring high in these traits consume larger amount of caffeine as a means to reach the optimum level of activation.

In an interesting study on a large sample of young adults (Adan, 1994), separate analyses on the various sources of caffeine detected a main effect of personality only for caffeine from cola

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beverages (i.e., the greater the score of Neuroticism the higher the intake of this beverage), whereas complex interactive effects of general traits accounted for total caffeine consumption. These findings are relevant because they suggest that caffeine intake can be affected by a complex pattern of personality dimensions, and highlighted that a fine-grained investigation of the various caffeine sources helps identifying specific effects of personality that cannot be detected when examining total caffeine intake. The same research (Adan, 1994) was one of the few studies which explored whether caffeine consumption could be affected by individual Circadian Preference (morningness vs. eveningness). This is a very critical issue given that the consumption of substances like caffeine appears intrinsically linked to the circadian rhythms and patterns of individual activation, as reflected by morningness/eveningness dimension. Consistent with most of the previous data showing a higher consumption of caffeine for evening-types, especially during the evening (Ishihara et al., 1985; Mitchell & Redman, 1993; Shohet & Landrum, 2001; Sánchez-Turet, Adan, & Sierra, 1992), Adan (1994) confirmed that evening-types consumed more caffeine in general, but also found that caffeine intake from coffee and cola was higher for evening-types, whereas caffeine intake from tea was higher for morning-types.

Some demographic variables, like gender and age, and cigarette smoking behaviours have been frequently reported as correlated of caffeine intake. Both in healthy and clinical samples, men generally consume more caffeine than women (Ciapparelli et al., 2010; Lee, McEnany, & Weekes, 1999; Waldeck & Miller, 1997). On the contrary, findings on the relationship between age and caffeine consumption are less consistent, reporting no association (Scott, Chakraborty, & Marks, 1989), higher intake for older than younger individuals (Hewlett & Smith, 2006; Johnson-Greene, Fatis, Sonner, & Shawchuck, 1988), or the opposite pattern (Ciapparelli et al., 2010). The co-occurrence between caffeine and tobacco consumptions is well-documented (Brice & Smith, 2002; Istvan & Matarazzo, 1984; Martínez-Ortega, Jurado, Martínez-González, & Gurpegui, 2006). Beyond cultural factors (e.g., common social settings of consumption behaviours), such relationship could partially be mediated by specific personality dimensions which generally predict smoking (i.e., Impulsivity and Sensation Seeking), and partially stem from the pharmacokinetic interactions between the two substances. First, nicotine seems to increase caffeine metabolism in such a way that, for the same ingested quantity of caffeine, smokers have lower plasmatic caffeine concentrations than non-smokers (De Leon et al., 2003). Second, because nicotine can directly enhance the reinforcing efficacy of food (Donny, Caggiula, Weaver, Levin, & Sved, 2011), it could plausibly act in the same manner also with caffeine, thus increasing its reinforcing value. Therefore, because tobacco consumption could affect caffeine intake *per se*, or as consequence of a certain personality constellation, smoking necessarily needs to be considered, although, so far only few studies have taken this health-related variable into account (Gurpegui et al., 2007; Hewlett & Smith, 2006).

This brief review on the individual factors able to influence caffeine intake makes clear that personality traits, gender, age, and cigarette smoking seem to be somehow involved, although the strength of the effects and the predictive value of each variable change depending on the study. The inconsistence of the findings can be ascribed to many reasons: samples not controlled for the mentioned critical factors; differences in the dependent variable measurement (i.e., sometimes caffeine is identified with only coffee, sometime it is more correctly measured as the sum of the various sources that contain it); differences in the methodological approaches (i.e., analyses on participants separated in artificial extreme groups, for instance by percentiles, rather than analyses extended to all participants in order to better investigate the full continuum of the dependant variable). However, in our opinion, the most likely reason behind inconsistent findings is the high degree of overlap between the various potential predictors. Impulsivity, Sensation Seeking and some facets of Reward Sensitivity are positively correlated to each other, and the same holds true for these personality traits and eveningness. In addition these variables are commonly higher in males, young people and smokers. On the contrary, Anxiety is usually negatively associated to many of the above variables (i.e., Impulsivity, Sensation Seeking), although the aim of reducing the negative feelings caused by this trait can often result in strong motivation for drug consumption. Therefore, investigating incomplete subsets of these factors would translate in detecting spurious effects. In contrast, exploring simultaneously the combined effects of all these individual variables may reveal more theoretically robust effects, and help disentangling unique contributions (if any) of each factor.

Following this reasoning, the main aims and hypotheses of the present research can be summarized as follows:

(1) Determining which individual factors could predict daily caffeine intake, by investigating simultaneously both critical personality traits (i.e., Impulsivity, Sensation Seeking, Anxiety, Reward Sensitivity and Circadian Preference) and socio-demographic variables potentially relevant to caffeine consumption, as gender, age and smoking behaviour. By concurrently exploring the combined effects of all these individual factors we aimed at disentangling the unique contributions of each factor on caffeine consumption.
(2) Evaluating whether specific patterns of individual variables could predict caffeine consumption behaviours in *different times of day*. Since activation levels undergo daily fluctuations that have both a general average trend (i.e., more activation in the morning, less activation during postprandial or nocturnal hours), and a specific development depending on chronotype, the influence of Circadian Preference on caffeine intake was expected to vary as a function of the various times of day.
(3) Verifying whether the *different sources* of caffeine could be affected by different sets of individual variables, in order to reduce the possibility of overlooking effects at work on specific caffeine sources. In line with the scant evidence on this issue (Adan, 1994), we anticipated to find specific patterns of predictors associated to the different caffeine sources.

## Methods

### *Participants and procedure*

Five-hundred-eighty Italian adults (300 females, 280 males) in the age range of 18–60 years were recruited at universities and work places of northern and central Italy. In order to evaluate the effect of smoking behaviour on caffeine consumption, the sample was selected by roughly balancing smokers and non-smokers. Thirty (5.2%) booklets of questionnaires were discarded because of unfinished or inconsistent completion, leading to a final sample of 550 participants (295 females, 255 males), constituted by college students and workers without night shifts ($n = 290$ and $n = 260$, respectively). The proportion of males and females did not differ in the student and worker groups ($\chi^2 = 1.62$, df = 1, $p = .20$). The mean age of overall sample was 28.51 years (SD = 8.62, range: 18–58), and females' mean age (28.45 ± 9.04 years) did not significantly differ from that of males (28.57 ± 8.13 years). Participants anonymously reported their socio-demographic characteristics, including the information on tobacco consumption (*average number* of *cigarettes* smoked *per day*), filled

out the personality inventories and answered to the questionnaire on their caffeine consumption. To avoid systematic sequence and fatigue effects, the order of the questionnaires in the booklets was pseudo-randomised across subjects. Booklets were filled out anonymously and required about 30 min for completion. All participants gave informed consent prior to the collection of data and the study was carried out in accordance with the principles of the Declaration of Helsinki. The Ethical Committee of the Department of Psychology at the University of Bologna approved the entire experimental procedure.

### Measures

*Barratt Impulsiveness Scale*, (*BIS-11*, Fossati, Di Ceglie, Acquarini, & Barratt, 2001; Patton, Stanford, & Barratt, 1995). The questionnaire consists of 30 items, rated on a 4-point Likert-like scale (from "never" to "always"). The BIS-11 total scale can be obtained by summing the scores of three facets: (1) tendency to act without forethought on the spur of the moment (*Motor Impulsiveness*); (2) orientation to the present or lack of planning for the future (*Non-planning Impulsiveness*); (3) difficulty in maintaining attention or concentrating (*Attentional Impulsiveness*).

*Sensation Seeking Scale version V* (*SSS-V*, Zuckerman, 1994). The questionnaire consists of 40 pairs of antithetical items that can be allocated to four facets: (1) tendency to engage in dangerous or adventurous activities (*Thrill and Adventure Seeking*); (2) tendency to engage in new experiences, that may or may not be dangerous, through the mind and senses (*Experience Seeking*); (3) interest in socially and sexually disinhibited activities (*Disinhibition*); (4) aversion for the routine and repetitive activities (*Boredom Susceptibility*). For each participant, *SSS-V* total score was calculated by summing the four subscale scores.

*Behavioural Inhibition System and Behavioural Approach System Scales (BIS/BAS Scales*, Carver & White, 1994; Leone, Pierro, & Mannetti, 2002). The scales assess the sensitivity of the aversive and appetitive behavioural systems (Gray, 1987) measured by *BIS-Anxiety* and *BAS* scales, respectively. The questionnaire includes 20 items rated on 4-point scales, which can be allocated to two primary scales: the *BIS* (7 items) and the *BAS* (13 items). *BAS* items can be further divided into three subscales: (1) positive responses to the occurrence/anticipation of rewards (*Reward Responsiveness: BAS-Reward*); (2) persistence in the pursuit of reward (*Drive BAS-Drive*); (3) desire for novel rewards and willingness to approach potentially rewarding situations (*Fun Seeking: BAS-Fun*). In the present research the three *BAS* subscales were used instead of the total *BAS* score, since, although intercorrelated, recent studies (Leone & Russo, 2009; Smillie, Jackson, & Dalgleish, 2006) have emphasized the need of considering them as measures of separate constructs, particularly so when investigating *BAS* effects on risky choices (like those related to health behaviours).

*Morningness–Eveningness Questionnaire, Reduced version* (*rMEQ*, Adan & Almirall, 1991; Natale, 1999). The questionnaire, which comprises five items related to sleep–wake rhythm preferences, was used to determine participants' Circadian Preference, that can be considered as a continuum between two opposite dimensions: morningness and eveningness (Natale & Cicogna, 2002), higher rMEQ scores indicating a morningness preference.

*Caffeine Consumption Questionnaire* (*CCQ*, Shohet & Landrum, 2001). The questionnaire allows one to collect very detailed information on participants' caffeine consumptions since it requires to distinguish both the source of caffeine intake (i.e., different kinds of coffee beverages, tea, cola, chocolate, energy drinks) and the daily time interval of caffeine consumption: i.e., morning (6 am–12 nn), afternoon (12 nn–6 pm), evening (6 pm–12 mn), night (12 mn–6 am). Participants were explicitly asked to report average daily frequencies of their caffeine consumptions referred to the last month.

### Data analysis

Each participant's information on frequency of caffeinated beverage consumption was converted in the average daily caffeine intake for both the total day and for the four above described daily time intervals. The caffeine amounts for the different sources were computed as follows: espresso coffee/cappuccino: 100 mg of caffeine; instant coffee: 70 mg; decaffeinated coffee: 3 mg; cup of tea: 40 mg; cup of chocolate: 5 mg; can of cola drink: 40 mg; can of energy drink: 80 mg (Brown, Kreiger, Darlington, & Sloan, 2001; Ciapparelli et al., 2010; Reissig, Strain, & Griffiths, 2009). The average daily consumption of caffeine differentiated on the basis of the source of caffeine (i.e., coffee, tea, cola drinks, chocolate, energy drinks) was also computed.

Since preliminary Kolmogorov–Smirnov (K–S) test evidenced the departure from normality of the caffeine intake scores, robust correlations, using Donoho–Stahel projection based estimator (Maronna & Yohai, 1995), implemented in "*R*" software, were run to explore the relationships between the critical variables and the caffeine consumption in both the entire days and the above described daily times. The criteria suggested by Cohen (1988) were used to classify the power of the relationships between variables: i.e., $.10 \leqslant r < .30$: weak relationship, $.30 \leqslant r < .50$: medium relationship, $r \geqslant .50$: strong relationship. However, to gauge the unique contribution of each variable, regression analyses were performed on daily caffeine consumption, using a robust approach which fits for not-normal data distributions too: i.e., maximum likelihood estimation with robust standard errors and Satorra–Bentler scaled test (Satorra & Bentler, 2001). In these analyses, gender, age, smoking (number of cigarettes smoked *per* day) and personality variables (i.e., *Impulsivity*, *Sensation Seeking*, *BIS-Anxiety*, *BAS-Reward*, *BAS-Drive*, *BAS-Fun*, and *Circadian Preference*) were used as predictors for caffeine intake. Similarly, three separate robust regressions were performed on the caffeine intake values differentiated in three daily time intervals: morning, afternoon, and evening/night (given the scarce caffeine consumption during nocturnal hours, the third interval was obtained by averaging caffeine consumptions in the two last time intervals of CCQ: i.e., 6 pm–12 mn and 12 mn–6 am). Finally, to ascertain whether the different sources of caffeine could be affected by different sets of individual variables, robust regressions were performed on the various caffeinated beverages categories, introducing the same factors as predictors.

## Results

### Sample characteristics

Descriptive statistics relative to personality scales and caffeine consumptions for the total sample, and for males and females separately, are reported in Table 1. It is noteworthy that males reported a significant higher amount of caffeine intake for both the entire day and the afternoon. Going into details of caffeine consumption behaviours, 97.1% of the entire sample took caffeine during the day, 90.4% consumed it in the morning, 90.0% in the afternoon, 68.5% in the evening, and 9.5% in the night.

With regard to the different sources of caffeine, as shown in Table 2, 88.9% of the entire sample took caffeine from coffee, 54.5% from tea, 46.2% from cola drinks, 20.9% from chocolate, and 7.5% from energy drinks.

With respect to tobacco consumption, the sample was composed of 42.2% non-smokers and 57.8% smokers, evenly distributed between females and males ($\chi^2 = 0.71$, df = 1, $p = .40$). In the group of smokers, females and males did not differ also in other relevant smoking-related variables ($ps > .05$), like the average number of cigarettes smoked *per* day (mean 11.42 ± 8.33 cigarettes), and time of the first cigarette (16.28 ± 3.08 years).

**Table 1**
Descriptive statistics of personality measures and caffeine consumptions.

| | Total sample ($N$ = 550) | Females ($N$ = 295) | Males ($N$ = 255) | $t$ value |
|---|---|---|---|---|
| *Personality measures* | | | | |
| BIS-11-Impulsiveness | 63.54 ± 10.11 | 62.62 ± 9.94 | 64.62 ± 10.22 | 2.32* |
| SSS-V-Sensation Seeking | 18.65 ± 6.54 | 16.91 ± 6.44 | 20.66 ± 6.06 | 7.00** |
| BAS-Reward | 20.59 ± 3.08 | 20.60 ± 2.97 | 20.57 ± 3.20 | -0.10 |
| BAS-Drive | 12.62 ± 3.28 | 12.57 ± 3.22 | 12.69 ± 3.35 | 0.40 |
| BAS-Fun | 11.66 ± 3.58 | 11.17 ± 3.35 | 12.23 ± 3.76 | 3.48** |
| BIS-Anxiety | 24.31 ± 4.94 | 25.91 ± 4.39 | 22.45 ± 4.89 | -8.76** |
| rMEQ-Morningness | 13.84 ± 3.86 | 14.28 ± 3.73 | 13.34 ± 3.95 | -2.87** |
| *Caffeine intake (mg)* | | | | |
| Total daily | 319.32 ± 180.94 | 299.02 ± 182.21 | 342.81 ± 176.93 | 2.85** |
| Morning | 137.95 ± 94.46 | 133.10 ± 92.47 | 143.56 ± 96.59 | 1.30 |
| Afternoon | 117.04 ± 79.84 | 106.02 ± 76.91 | 129.78 ± 81.39 | 3.52** |
| Evening | 59.51 ± 65.15 | 55.42 ± 63.68 | 64.25 ± 66.62 | 1.59 |
| Night | 4.83 ± 22.67 | 4.49 ± 23.44 | 5.22 ± 21.79 | 0.38 |

*Notes:* Values are reported for the entire sample and for females and males separately. For significant between groups $t$-test: $^{*}p \leqslant 0.05$, $^{**}p \leqslant 0.01$.

**Table 2**
Percentages of participants consuming caffeine from each caffeine source.

| Caffeine source | Percentage of consumers (%) | Percentage of females (%) | Percentage of males (%) | Mean (SD) age of consumers |
|---|---|---|---|---|
| Coffee | 88.9 | 52.4 | 47.6 | 29.1 ± 8.8 |
| Tea | 54.5 | 57.0 | 43.0 | 26.5 ± 6.8 |
| Cola beverages | 46.2 | 46.5 | 53.5 | 26.2 ± 5.9 |
| Chocolate | 20.9 | 60.9 | 39.1 | 24.0 ± 5.2 |
| Energy drinks | 7.5 | 36.6 | 63.4 | 23.6 ± 3.7 |

*Notes:* Percentages are calculated on the entire sample and separated for females and males; for each source consumers' mean (standard deviation) age is reported.

*Robust correlations on the total caffeine consumption*

Robust correlation analyses revealed that smoking showed medium positive associations with caffeine intake (entire day: $r$ = .40, morning: $r$ = .34, afternoon: $r$ = .30, evening/night: $r$ = .28). Further, being male was positively associated to caffeine intake in the entire day and in the afternoon ($r$ = −.12, $r$ = −.13, respectively). Age was positively associated to caffeine consumption in the entire day and in the morning ($r$ = .19, $r$ = .29, respectively). As regards the personality variables, Impulsivity and Sensation Seeking were positively associated to caffeine intake during the entire day ($r$ = .19, $r$ = .14, respectively) and the afternoon ($r$ = .16 for both); however whereas the former also showed a positive relationship with it during the evening/night ($r$ = .20), the latter was also positively associated to caffeine intake during the morning ($r$ = .11). As for BIS/BAS traits, BAS-Drive and BAS-Fun showed a positive association with caffeine intake during the entire day ($r$ = .11, $r$ = .10, respectively) and during the evening/night ($r$ = .11, $r$ = .12, respectively). Finally, *morningness* was positively associated to caffeine intake in the morning ($r$ = .15) and negatively associated to it in the afternoon and in the evening/night ($r$ = −.12, $r$ = −.16).

*Robust regressions on the total caffeine consumption*

The results of robust regression analyses testing the net effects of the socio-demographic and personality variables on the total caffeine intake are shown in Table 3 for both the entire day and separately for morning, afternoon and evening/night.

Regression model results (corrected $R^2$ = 0.160; $F_{(10,529)}$ = 11.27, $p$ < .001) revealed that significantly higher total daily caffeine consumptions occurred for males, older people, participants smoking more cigarettes and showing higher Impulsivity, Sensation Seeking, and BAS-Drive scores. Splitting caffeine consumptions in the different parts of the day, regressions revealed that in the morning (corrected $R^2$ = 0.171; $F_{(10,529)}$ = 12.13, $p$ < .001) higher caffeine intake was positively linked to age, smoking, Sensation Seeking, BIS-Anxiety and morningness. In the afternoon (corrected $R^2$ = 0.096; $F_{(10,529)}$ = 6.76, $p$ < .001), caffeine consumption was significantly associated to gender, smoking, Impulsivity, Sensation Seeking, BAS-Fun and Circadian Preference. Finally, during the evening/night (corrected $R^2$ = 0.115; $F_{(10,529)}$ = 8.02, $p$ < .001) caffeine intake was positively predicted by smoking and Impulsivity and negatively predicted by morningness (i.e., evening-types consuming significantly more caffeine than morning-types).[1]

*Robust regressions on the caffeine consumption differentiated for the source of caffeine*

Regressions with robust estimations were performed on the various caffeinated beverage categories, to verify whether the different sources of caffeine could be affected by different sets of individual variables. Daily caffeine intake when only coffee beverages (e.g., espresso, cappuccino, instant and decaffeinated coffee) are considered was significantly higher for males, older people, participants smoking more cigarettes, and showing higher scores of Impulsivity and Sensation Seeking, and scoring lower on BAS-Fun (corrected $R^2$ = .202; $F_{(10,529)}$ = 14.62, $p$ < .001; see Table 4, first column). Daily intake of caffeine from tea (corrected $R^2$ = .102; $F_{(10,529)}$ = 7.12, $p$ = .001) was significantly higher for females ($\beta$ = .12, $t$ = 2.86, $p$ < .01), younger participants ($\beta$ = −.17, $t$ = −5.01, $p$ < .001), and evening-types ($\beta$ = −.17, $t$ = −3.90, $p$ < .001). As regards daily caffeine intake from cola drinks (corrected $R^2$ = .094;

[1] To exclude the possibility that the estimation of caffeine intake during the night (12 mn–6 am) could include also morning types' consumptions (thus producing confounding effects on the results of evening/night intake), we performed a regression on caffeine intake during the evening only (6 pm–12 mn). The results of such control analysis entirely confirmed those found when collapsing evening and night time intervals (corrected $R^2$ = 0.096; $F_{(10,529)}$ = 6.73, $p$ < .001). This suggests that in our sample the results on evening/night consumptions were likely to reflect the consumption behaviour of evening types.

**Table 3**
Summary of robust regression analyses for the total caffeine consumption.

| Predictors | Total daily caffeine ($R^2$ = .160) | | Morning caffeine ($R^2$ = .171) | | Afternoon caffeine ($R^2$ = .096) | | Evening/night caffeine ($R^2$ = .115) | |
|---|---|---|---|---|---|---|---|---|
| | $\beta$ | $t$-value | $\beta$ | $t$-value | $\beta$ | $t$-value | $\beta$ | $t$-value |
| Gender | −0.09 | −1.99* | −0.04 | −0.84 | −0.12 | −2.75** | −0.04 | −0.80 |
| Age | 0.12 | 2.51* | 0.25 | 4.97** | 0.01 | 0.12 | −0.04 | −1.02 |
| Smoke (cigarettes/day) | 0.28 | 6.47** | 0.23 | 5.04** | 0.21 | 4.26** | 0.18 | 4.34** |
| BIS-11-Impulsiveness | 0.14 | 2.77** | 0.07 | 1.32 | 0.10 | 2.09* | 0.15 | 2.53* |
| SSS-V-Sensation Seeking | 0.14 | 2.73** | 0.18 | 3.52** | 0.13 | 2.44* | −0.03 | −0.56 |
| BAS-Reward | −0.05 | −0.98 | −0.07 | −1.68 | −0.06 | −1.15 | 0.04 | 0.86 |
| BAS-Drive | 0.09 | 2.21* | 0.09 | 1.9 | 0.04 | 0.82 | 0.08 | 1.77 |
| BAS-Fun | −0.10 | −1.71 | −0.08 | −1.47 | −0.12 | −2.11* | −0.01 | −0.14 |
| BIS-Anxiety | 0.08 | 1.69 | 0.09 | 2.19* | 0.05 | 1.15 | 0.01 | 0.28 |
| rMEQ-Morningness | −0.05 | −1.17 | 0.13 | 2.95** | −0.10 | −2.14* | −0.19 | −4.07** |

*Notes:* Values are reported for the entire day and for morning, afternoon and evening/night. $N = 550$, $^{*}p \leqslant 0.05$, $^{**}p \leqslant 0.01$.

**Table 4**
Summary of robust regression analyses for the caffeine intake resulting from only coffee beverage consumption.

| Predictors | Total daily caffeine from coffee beverages ($R^2$ = .202) | | Morning caffeine from coffee beverages ($R^2$ = .198) | | Afternoon caffeine from coffee beverages ($R^2$ = .097) | | Evening/night caffeine from coffee beverages ($R^2$ = .110) | |
|---|---|---|---|---|---|---|---|---|
| | $\beta$ | $t$-value | $\beta$ | $t$-value | $\beta$ | $t$-value | $\beta$ | $t$-value |
| Gender | −0.09 | −2.00* | −0.07 | −1.60 | −0.11 | −2.40* | −0.01 | −0.20 |
| Age | 0.23 | 4.84** | 0.28 | 5.55** | 0.12 | 2.23* | 0.10 | 2.14* |
| Smoking (cigarettes/day) | 0.28 | 6.09** | 0.23 | 5.14** | 0.19 | 3.99** | 0.20 | 3.90** |
| BIS-11-Impulsiveness | 0.12 | 2.36* | 0.06 | 1.29 | 0.09 | 1.81 | 0.12 | 2.05* |
| SSS-V-Sensation Seeking | 0.16 | 3.35** | 0.17 | 3.50** | 0.16 | 3.03** | −0.01 | −0.14 |
| BAS-Reward | −0.07 | −1.58 | −0.06 | −1.45 | −0.09 | −1.67 | 0.02 | 0.44 |
| BAS-Drive | 0.07 | 1.59 | 0.07 | 1.52 | 0.01 | 0.23 | 0.09 | 1.88 |
| BAS-Fun | −0.11 | −1.99* | −0.10 | −1.75 | −0.11 | −1.87 | −0.03 | −0.45 |
| BIS-Anxiety | 0.06 | 1.51 | 0.08 | 2.13* | 0.04 | 0.95 | −0.02 | −0.53 |
| rMEQ-Morningness | 0.02 | 0.52 | 0.14 | 3.14** | −0.02 | −0.44 | −0.17 | −3.63** |

*Notes:* Values are reported for the entire day and for morning, afternoon and evening/night. $N = 550$, $^{*}p \leqslant 0.05$, $^{**}p \leqslant 0.01$.

$F_{(10,529)} = 6.62$, $p < .001$), being male ($\beta = -.20$, $t = -4.23$, $p < .001$), younger ($\beta = -.22$, $t = -5.10$, $p = .001$), heavier smoker ($\beta = .12$, $t = 2.40$, $p = .05$) and evening-type ($\beta = -.09$, $t = -2.02$, $p = .05$) were associated with higher consumption of this caffeinated soft drink. Daily intake of caffeine from chocolate (corrected $R^2 = .036$; $F_{(10,529)} = 3.00$, $p < .001$) was negatively predicted by both age ($\beta = -.20$, $t = -5.67$, $p = .001$) and smoking ($\beta = -.07$, $t = -2.11$, $p = .05$). Finally, higher caffeine intake from energy drinks (corrected $R^2 = .030$; $F_{(10,529)} = 2.66$, $p < .01$) was only predicted by lower age ($\beta = -.11$, $t = -2.35$, $p = .05$).

Since our models explained a relatively high amount of variance mostly for caffeine intake from coffee beverages (even higher than that explained for total caffeine intake), further analyses of daily oscillations in their consumption were performed (see Table 4).

In the morning, coffee consumption (corrected $R^2 = 0.198$; $F_{(10,529)} = 14.41$, $p < .001$) was significantly higher for older participants, heavier smokers, morning-types and more sensation seekers and anxious participants. In the afternoon, (corrected $R^2 = 0.097$; $F_{(10,529)} = 6.77$, $p < .001$) males, older people, heavier smokers and participants scoring higher on Sensation Seeking consumed more coffee beverages. In the evening/night, coffee intake (corrected $R^2 = 0.110$; $F_{(10,529)} = 7.63$, $p < .001$) was predicted by being older, heavier smoker, more impulsive and evening-type.

## Discussion

The present study adds to the previous literature on caffeine consumption behaviours in a critical aspect: we simultaneously compared the effects of a large set of inter-related personality traits, concurrently considering some relevant socio-demographic variables (i.e., gender, age) and cigarette smoking behaviours, which have been often reported to affect caffeine intake.

The higher amount of caffeine consumed by men in comparison with women replicated many previous findings (Ciapparelli et al., 2010; Lee et al., 1999; Waldeck & Miller, 1997). In this respect, however, in order to rule out the possibility that the gender differences detected in caffeine consumptions can depend on uncontrolled variables related to different work patterns, in future studies, male and female groups need to be balanced for the most relevant work variables (i.e., work type, schedule, etc.). In line with some studies (Hewlett & Smith, 2006; Johnson-Greene et al., 1988), daily total caffeine was found to positively vary with age, a pattern which was also found for consumptions in the morning and when caffeine only from coffee beverages was considered. Crucially, the pattern was reversed for caffeine from all the remaining caffeine sources, suggesting that conflicting findings on the relationship between age and caffeine intake could be possibly due to opposite trends in its consumption depending on caffeine source. In agreement with previous studies (Gurpegui et al., 2007; Hewlett & Smith, 2006), daily total caffeine was positively associated to smoking. Therefore, since tobacco consumption continued to affect caffeine intake even controlling for the personality variables which are generally assumed to influence smoking itself, it is reasonable to conclude that this health-related behaviour can influence caffeine consumption *per se*.

As concerns personality traits, in line with previous findings (Gurpegui et al., 2007; Jones & Lejuez, 2005; Waldeck & Miller, 1997), we found that both Sensation Seeking and Impulsivity were significantly associated to caffeine intake, people scoring high in these traits showing higher amount of caffeine ingestion. Since the above specific constructs have been linked to variations of basal dopaminergic tone (Cloninger, 1987), and caffeine indirectly acts by enhancing dopaminergic neurotransmission (Garrett & Griffiths, 1997), it is plausible to assume that high sensation seekers and impulsive individuals consume larger amount of caffeine in

order to increase their basal arousal level (Gurpegui et al., 2007). Finally, although BAS-Drive and BAS-Fun were both significantly correlated to caffeine intake, regression revealed that BAS-Drive was the only facet of Reward Sensitivity which positively predicted total caffeine intake. Because this facet is linked to the persistence in the pursuit of rewards, its involvement in caffeine consumption was somehow unexpected. One possibility is that, for individuals with high BAS-Drive, caffeine does not represent the target-reward *per se*. It may be hypothesized that for these individuals caffeine consumption is instead the way to reach the optimum level of activation for high performance, which in turn allows for attaining other kind of rewards available in the environment (for example rewards from social or working contexts).

*Caffeine consumption across the day*

The second purpose of the present study was to evaluate whether specific patterns of individual variables could predict caffeine consumption behaviours in different times of day, given that caffeine consumption is intrinsically linked to daily fluctuations of activation levels (which are moderated in turn by individual differences in Circadian Preference). The analyses of the different daily time intervals showed significant relationships that were absent when total daily consumption was analyzed. Crucially, results did not reveal a caffeine consumption simply depending on Circadian Preference, but highlighted a caffeine consumption differently distributed throughout the day depending on Circadian Preference. In particular, morningness positively predicted caffeine intake during the morning (morning-types consuming more caffeine than evening-types), and negatively during the afternoon and evening/night (evening-types consuming more caffeine than morning-types), with the latter finding replicating previous studies (Ishihara et al., 1985; Shohet & Landrum, 2001). A similar pattern of results held true also when considering caffeine from coffee beverages only: with morning-types consuming more coffee than evening-types in the morning and the opposite during the evening/night. The pattern we found may seem surprising at first glance given that, for participants with both morningness and eveningness preference, the increase in caffeine consumption pertained to the time of day in which they are supposed to be already well-aroused on the basis of their circadian rhythm (i.e., in the morning for morning-types and in the evening for evening-types). However, it must be noted that such relationship could be explained by the fact that subjects with high morningness, preferring to wake-up early, can have more chances of consuming coffee in the morning than subjects having an eveningness tendency. Similarly, subjects with high eveningness, preferring to delay their bedtime, can have more chances of consuming coffee in the evening/night than subjects having a morningness tendency. The present data do not allow for drawing clear conclusions on this finding and, in order to correctly interpret this relationship, further studies are needed, collecting more detailed information on effective mean awakening time and bedtime, which generally depend on both Circadian Preference and social constraints (i.e., work schedule). As concerns the other individual factors, we unexpectedly found that specific personality traits (i.e., Sensation Seeking, Impulsivity and BIS-Anxiety) were able to differently predict caffeine intake as a function of specific daily times. We hypothesize that the last finding may reflect patterns of consumption behaviours determined by complex interactions between external and internal rhythms of activity, varying on the basis of personality traits. However, being unexpected and not easily readable, this last result necessarily deserves further investigations.

On the whole, the patterns reported above confirmed that different sets of individual variables have an impact on the total daily caffeine intake and on caffeine consumptions in the different times of day. This finding can partially explain inconsistent previous results and highlights the need of analyzing separately the different daily time intervals in order to identify specific effects undetectable when examining total daily caffeine intake.

*Caffeine consumption differentiated for the source of caffeine*

The third aim of the present research was to test whether the different sources of caffeine could be affected by different sets of individual variables. As regards coffee beverages, which are the most common source of caffeine, the pattern of predictors which explained their consumption was nearly similar to that of total caffeine: that is, the intake of both total caffeine and caffeine from coffee was significantly predicted by gender, age, smoking, Impulsivity and Sensation Seeking. In particular age predicted coffee intake in the entire day and in all its times, a finding which confirms that older individuals had a preference for the more common and "traditional" caffeine source (i.e., the various sorts of coffee beverages). Interestingly, unlike the other non-coffee caffeine sources, coffee beverages were the only caffeine source whose consumption showed to be affected by personality traits.

Turning the attention to the other sources of caffeine, regressions analyses showed that tea was the only source significantly preferred by females. In addition, whereas Adan (1994) found that morning-types consumed more tea than evening-types, we found the opposite pattern (in line with the consumption behaviour of cola beverages). The discrepancy between these findings may reflect several factors: diversity in sample composition, cultural variations in the spread of the various caffeine sources, difference in the data analyses. However, given the scarce literature on the intake of caffeine differentiated for the source, this issue needs to be clarified by further studies taking into account all the possible cultural and methodological factors which can influence caffeine consumption behaviours.

As anticipated, a result which can explain the inconsistent findings of previous studies on the association between caffeine and age, is that the positive relationship found between age and total caffeine intake was reversed for all non-coffee caffeine sources (i.e., all more consumed by younger participants). In particular, although energy drinks were not very spread in the present sample, it is remarkable the fact that age is the only significant predictor of this kind of substance, in line with recent data which underlined its quick diffusion among young people (Reissig et al., 2009).

These analyses demonstrated that the consumptions of different sources of caffeine are predicted by different sets of individual variables. Nevertheless, it must be noted that percentages of variance explained in the regressions varied considerably across the caffeine sources, being high for coffee beverages (i.e., ~20%) and low for the others caffeinated substances (i.e., ~10% for tea, ~9% for cola, ~4% for chocolate ~3% for energy drinks). This can be partially due to the fact that (at least in Italy) the consumption of some caffeine sources is not so spread like the consumption of coffee. Alternatively, this may suggest that the impact of individual (vs. situational) variables has a different value depending on which caffeine source is considered, with non-coffee sources appearing more affected by environmental and situational, rather than dispositional, factors.

*Conclusions*

The present research is not exempt from limitations. The study is retrospective in nature, and therefore more susceptible to various biases than studies controlling caffeine plasmatic levels. However, although the estimation of caffeine consumptions surely would benefit from multiple methods, recent data revealed strong correlations between salivary caffeine concentrations and self-re-

port measures of caffeine use. This confirms that self-report data can be considered a valid method for predicting actual caffeine levels (Addicott, Yang, Peiffer, & Laurienti, 2009). Furthermore, more detailed information should be collected on social/environmental factors relevant to exclude alternative interpretation of our data (i.e., awakening time and bedtime, kind and schedule of work, life style, habits, medications, and every other information useful to understand caffeine consumption behaviours).

Nevertheless, the present study reports novel findings: to the best of our knowledge, for the first time a large set of personality variables related to caffeine consumptions have been simultaneously considered to explain caffeine consumption, taking also into account other relevant individual variables. Robust regression analyses showed that, in addition to gender, age and smoking, Impulsivity, Sensation Seeking and Bas-Drive (a facet of Reward Sensitivity) were connected with daily caffeine consumption. The amount of variance explained by our model is not negligible when considering that the consumption behaviour here investigated is largely related to socio-cultural factors. Indeed, especially in economically developed countries, being the various caffeine sources easily available, their consumption appears more induced by external rather than internal variables. Further, more detailed analyses allowed us to reveal that the caffeine intake in the different times of day, on the one hand, and the consumption of the different sources of caffeine, on the other hand, were predicted by different patterns of individual variables. Therefore, for understanding the variables linked to caffeine consumption, such detailed analyses are required in order to avoid spurious effects and to miss important connections contingent with different levels of analyses. The use of a similar approach is encouraged also for other recreational drugs (i.e., nicotine, alcohol, etc.), for which the measurements of the average intake may mask specific patterns of consumptions.

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