The impact of cognitive and noncognitive factors on odor discrimination performance

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Abstract
This study aimed to investigate which components among a range of cognitive and noncognitive factors contribute to odor discrimination and to which extent. One hundred sixty participants were assessed for olfactory discrimination considering (a) the sequence of presentation of the detection target and (b) response time taken to perform the discrimination task. Participants were tested with several cognitive tests covering executive functioning, and semantic memory and noncognitive tests measuring optimism, mindset, general self-efficacy, and self-esteem. Hierarchical regression analyses conducted in classic and Bayesian ways demonstrate a strong impact of semantic memory and age on odor discrimination performance. Conversely, executive functions together with noncognitive factors and response time were rather weak predictors of odor discrimination performance. Additionally, the positioning of the target odor, when presented last, facilitated the correct choice in odor discrimination. In conclusion, odor discrimination is related to semantic memory, while noncognitive factors exert only minor influences on odor discrimination scores.

Practical Applications
In the present study, we found that the target odor, when presented as the last of the three pens, facilitated the correct choice in odor discrimination process. Even though, the influence of the target odor position was noticed only in case of several trials, it should be considered in the future studies. Moreover, the amount of time taken to respond when performing odor discrimination task did not contribute strongly to the final outcome. Thus, controlling for the response time in this kind of task appears not to be highly significant.

INTRODUCTION

Main components of olfactory function are odor threshold, odor identification and odor discrimination (Oleszkiewicz, Schriever, Croy, Hähner, & Hummel, 2019). Research indicates that the three individual subtests contribute differently to olfactory function. While odor threshold appears to be the more related to peripheral functions of the olfactory system (Lötsch, Reichmann, & Hummel, 2008), odor discrimination and identification are considered to reflect higher-order olfactory abilities. Among the two, odor discrimination is more strongly influenced by memory function (Larsson, Nilsson, Olofsson, & Nordin, 2004).

In the odor discrimination task, participants are required to detect differences between presented odorants (Engen, 1986). One of the
most commonly used measures of this component is included in the “Sniffin’ Sticks” test battery, a well-characterized tool to measure olfactory performance (Oleszkiewicz et al., 2019). Participants are presented with 16 triplets of pens and have to discriminate the one containing an odorant different from the other two. While completing this task, participants should stay concentrated. The task requires intact memory and other cognitive abilities such as executive functions. Hedner, Larsson, Arnold, Zucco, and Hummel (2010) showed that executive function and semantic memory composites contributed a significant portion to the variance (11.5%) in odor discrimination. However, no studies have been conducted to measure the extent to which particular cognitive components impact on odor discrimination performance.

Cognitive abilities reflect also on several methodological elements of the procedure of the odor discrimination task. First, the position of the discrimination target in the sequence of presentation is related to allocating attention and might lead to a different outcome in sensory tasks (Barnes & Johnston, 2010). Second, the amount of time given to participants to respond in a multiple-choice task is known to differentiate their ability in making decisions. Brown and Heathcote (2008) suggest that incorrect responses tend to come quicker than correct responses when choices are easy and participants are asked to respond fast, while they tend to come slower than correct responses when choices are difficult and accuracy is emphasized. The question of whether manipulating these two elements would lead to different outcomes in odor discrimination task remains open.

Little is known about noncognitive factors related to odor discrimination. Several individual differences in risk-taking, sensitivity to immediate rewards (Bettison, Mahmut, & Stevenson, 2013), and impulsive behavior (Herman, Critchley, & Duka, 2018) were related to odor discrimination. Furthermore, some studies indicated an association between odor discrimination and depression (e.g., Atanasova et al., 2010; Croy et al., 2014). Depression, in turn, has countless consequences, including low self-esteem (Kollndorfer, Reichert, Brückler, Hinterleitner, & Schüpf, 2017), and impairment in self-efficacy (Schwarzer, 2014), optimism (Sing & Wong, 2011), and mindset (Tuckwiller & Dardick, 2018). Hence, the present study aimed to determine the relative predictive value of a range of cognitive and noncognitive variables for odor discrimination performance. Furthermore, we decided to investigate to what extent these variables predictors would predict odor discrimination performance.

2 | METHODS

2.1 | Participants

A total of 160 participants were enrolled in the study (112 women, 48 men; mean age 37.7 years, SD = 17.6, median = 32, range 18–86 years). Data were collected at the Smell & Taste Clinic of the Department of Otorhinolaryngology of the TU Dresden and the Department of Internal Medicine at the “St. Joseph Stift” Hospital Dresden. The study was performed according to the principles of the Declaration of Helsinki on biomedical research involving human subjects. Its design was approved by the Ethics Committee at the Medical Faculty of the TU Dresden (EK number 156052012). All participants provided written informed consent.

2.2 | Olfactory, cognitive, and noncognitive testing

Simplified experimental protocol is presented in Figure 1. The discrimination task was performed in all participants by means of the “Sniffin’ Sticks” test battery (Burghart, Wedel, Germany), in a three alternative forced-choice paradigm. Participants were presented with 16 triplets of pens and had to discriminate the pen containing an odorant different from the two others containing a different odor (Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997). Detailed characteristics of the odors used in the present study are shown in Table 1 (see also Hummel et al., 1997). Within-triplet time intervals were approximately 3 s and between-triplets time intervals were 20–30 s. The final score was counted as the sum of correctly discriminated odors (0–16 points). All participants were blindfolded to avoid visual identification of target pens.

Since we aimed to investigate whether manipulating the position of the target odor and the amount of response time would lead to different outcomes, participants were divided into two groups regarding (a) the sequence of presentation of the detection target and (b) response time taken to discriminate one pen. In this way, the first group consisted of 60 participants that took part in the sequence of presentation with random order of detection target that varied randomly from trial to trial and unlimited time to respond. Every stick was presented only once in each group. Participants were instructed to take as much time as needed to discriminate the target odor. The second group consisted of 100 participants that were enrolled in the sequence of presentation where targets were always presented in

FIGURE 1 Simplified experimental protocol
the same serial position (see Table 2), following the original instruction (Hummel, 2013), and limited time to respond in this way that the participants were reminded constantly during the odor presentation to hurry up in discrimination of the target odor. The average interval between the presentation of the last pen and participant’s decision was about 4 s.

In order to allow for the measurement of the response time, performance of all participants in the odor discrimination test was recorded by a Sony HDR-CX240E Handycam camera (Sony Corporation, 1-7-1 Konan Minatoku Tokyo, 108-0075 Japan). The camera was placed on the table where participants were completing the task, at a 1.5 m distance.

In order to explore cognitive and noncognitive predictors of odor discrimination performance, two cognitive domains were investigated: executive functions and semantic memory. One measure targeted verbal functions, and four measures targeted other noncognitive predictors: optimism, self-efficacy, mindset and self-esteem were included in the study (see details below).

2.2.1 | Cognitive measures

**Executive function**

The Digit Span test was used to assess executive functioning (Wechsler, 1945). In this task increasing numbers of orally presented digits at a rate of one per second have to be repeated in (a) normal and (b) reversed order. Digit Span starts with three digits while Digit Span Backward starts with two digits. In every other trial, the number of digits is increased by one. Each test comprises 14 series of digits. When errors in two consecutive trials are made, the tests are ended. The number of correctly recalled trials in both tests is counted. Thus, a score between 0 and 28 is attainable (0–14 in Digit Span test and 0–14 in Digit Span Backward test).

**Semantic memory**

One test targeting verbal fluency and one test assessing general knowledge were employed to measure semantic memory. Letter fluency was evaluated by asking the participants to generate as many words as possible in 1 min, beginning with the letter B
Benton & Hamsher, 1976). Participants were awarded 0.5 points for each generated word. The higher was the final score, the better was considered letter fluency performance. General knowledge was measured by a vocabulary test. Here, participants were presented with 16 pairs containing two words each, showed in Table 3.

In case of each pair, participants were asked to create an appropriate, matching generic term. Wide criterium of acceptance was used, for example, in case of the first pair: orange–banana, accepted answers included: fruits, food, and tropical fruit. For each correct response, participants received 0.5 points so the resulting score ranged from 0 to 8 points. Because performance in verbal fluency and general knowledge were significantly correlated ($r = .4, p < .001$), for later analyses the two measures were combined into one category—semantic memory.

### 2.2.2 Noncognitive predictors

#### Optimism

The revised Life-Orientation-Test (Carver, Scheier, & Segerstrom, 2010) was used to assess individual differences in generalized optimism versus pessimism. In this test, participants are asked to rate on a 5-point Likert scale (0–4) how much they agree with 10 presented items (i.e., “In uncertain times, I usually expect the best;” “I rarely count on good things happening to me”). While responding to all questions is mandatory, the final score is only based on response to six nonfiller questions, thus it can range from 0 to 24.

#### General self-efficacy

General self-efficacy was assessed by means of General self-efficacy-scale (Schwarzer & Jerusalem, 1995). The scale was created to evaluate a general sense of perceived self-efficacy with the aim in mind to predict coping with daily hassles as well as adaptation after experiencing all kinds of stressful life events. It consists of 10 items (i.e., “I can always manage to solve difficult problems if I try hard enough,” “Thanks to my resourcefulness, I know how to handle unforeseen situations”) and 4 possible answers to all of them (1—not at all true; 2—hardly true; 3—moderately true; 4—exactly true). The total score is calculated by finding the sum of all the items. For the GSE, the total score ranges between 10 and 40, with a higher score indicating more self-efficacy.

#### Mindset

A shortened and modified version of Dweck’s (2000) quiz was used to measure mindset level. The tool consists of four items (a) “To be honest, I don’t think I can change how intelligent I am,” (b) “I have certain in-built talents, like sport or music, and I can’t do much to change what those talents are,” (c) “There are subjects, like maths or languages that I’m naturally good at, but others that I’m naturally poor at and I don’t think I could ever be good in,” (d) “Although I can learn new things, I can’t really change what my talents and abilities are”). Responses are based on a 6-point Likert scale (1 = strongly agree, 6 = strongly disagree). A higher final score indicates a higher level of mindset.

### 2.3 Statistical analyses

Descriptive statistics of participants’ demographics and performance in all the presented tests were analyzed. Possible differences between the two groups: (a) with and (b) without the specific sequence of presented target odors and limited response time, were investigated by means of independent samples two-way t test. The influence of the target odor position on the final result in odor discrimination, separately for each of 16 trials, was examined with analyses of variance (ANOVAs). One-way Pearson correlation analyses were conducted to investigate possible relationships between the total score in odor discrimination and its potential predictors. Stepwise regression analysis aimed to investigate the extent to which the total score in odor discrimination could be predicted by the variables indicated by the correlation analyses, was performed. The full model consisted of the total score in odor discrimination as a dependent variable and digit span, semantic memory (general knowledge, verbal fluency), mindset, response time and age as independent variables. The best model was obtained by backward elimination.

All the analyses were conducted twice, first with classical $p$-values and second with Bayesian statistics (Dienes, 2014). The Bayes factor (B) is a method that weighs evidence and shows which out of two hypotheses is better supported and to what extent. Adopting the B in statistical inference, it can be shown whether data provided stronger support for the null hypothesis, the alternative hypothesis or whether it is inconclusive and more data needs to be collected to provide more decisive evidence (Domurat & Białek, 2016). Furthermore, Bayesian statistics are resistant to multiple comparisons.

Data are presented as mean values ($±$SD). Statistical analyses were performed using JASP v. 0.11.1 (www.jasp-stats.org), with $p < .05$ set as the level of significance. The effect sizes are shown together with their 95% confidence intervals.

### 3 RESULTS

Details on descriptive statistics of participants’ demographics and performance in all the presented tests are presented in Table 4. The classical t test indicated that there was no significant difference in terms of the total score in odor discrimination between the
group with (a) the specific sequence of presented odors and limited time to respond and (b) no defined sequence of target odorants and no time limitation ($t_1 = 1.27$, $p = .207$).

Bayesian $t$ test results provided a clear evidence for the null hypothesis stating that the two groups did not, indeed, differ from each other ($B10 = 0.366$), what is presented in Figure 2. The robustness of evidence increased with higher prior width and with prior width of value 1 $B01$ was higher than 3 suggesting that the obtained evidence was relatively robust.

Detailed results of classical ANOVA showing the influence of the target odor position on the final outcome in odor discrimination, separately for each of the 16 trials, are presented in Table 5. In case of 9 out of 16 conducted trials, target odor position did not influence the final outcome while in case of the other 6 trials (sequentially: 5, 8, 10, 14, 15, 16), participants discriminated target odors more correctly when it was presented as the last one compared to the situation when it was introduced as the second one. Eventually, in case of the second trial, participants were more successful at detecting the target odor when it was presented as the last one as compared to the first one (see Table 5).

Bayesian ANOVA analyses confirmed these results for the following trials: the second ($B10 = 4.82$), the fifth ($B10 = 3.23$), the tenth ($B10 = 10.06$), and the sixteenth ($B10 = 4.64$). Regarding the other trials, Bayes factor did not confirm for $H1$ (for the eight trial $B10 = 1.6$, for the fourteenth trial $B10 = 1.09$, for the fifteenth trial $B10 = 1.83$).

Classical Pearson correlations showed that the total score in odor discrimination correlated positively with digit span ($r = .19$, $p = .017$), semantic memory ($r = .34$, $p < .001$), mindset ($r = .18$, $p = .023$) and negatively with age ($r = -.42$, $p < .001$) and response time ($r = -.16$, $p = .021$) (Table 6, Figure 3). Additionally, correlation plot between semantic memory and age is presented in Figure 4.

Bayesian Pearson correlations' results are presented in Table 7. Bayes factor obtained in the Bayesian Pearson correlation analyses indicates evidence for the hypothesis about a positive correlation

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**TABLE 4** Descriptive statistics of participants’ demographics and performance in all the presented tests

| Variable                     | M     | SD    | Range  |
|------------------------------|-------|-------|--------|
| **Demographics**             |       |       |        |
| Age (years)                  | 37.7  | 17.6  | 18–86  |
| Gender (M/F)                 | 48/112|       |        |
| **Sensory**                  |       |       |        |
| Odor discrimination          | 12.19 | 2.40  | 4–16   |
| **Cognitive predictors**     |       |       |        |
| Executive functions          |       |       |        |
| Digit span                   | 7.62  | 1.9   | 3–13   |
| Semantic memory              | 6.66  | 0.8   | 3–7    |
| General knowledge            | 6.3   | 1.1   | 2–8    |
| **Noncognitive predictors**  |       |       |        |
| Optimism                     |       |       |        |
| Life-orientation test revised| 16.39 | 3.1   | 4–24   |
| Self-efficacy                | 2.93  | 0.4   | 1.2–3.8|
| General self-efficacy        | 3.65  | 0.8   | 1.75–5.75|
| Mindset                      |       |       |        |
| Mindset quiz                 | 23.67 | 3.79  | 11–30  |

**TABLE 5** Classical ANOVA for the position of the target odor and the final outcome in odor discrimination

| Number of trial | F    | p     | Bonferroni p |
|-----------------|------|-------|--------------|
| 1               | 1.02 | .364  | –            |
| 2               | 4.66 | .11   | 1 vs. 3; $p = .18$ |
| 3               | 2.42 | .092  | –            |
| 4               | 2.49 | .086  | –            |
| 5               | 4.14 | .18   | 2 vs. 3; $p = .041$ |
| 6               | 1.2  | .304  | –            |
| 7               | 1.8  | .169  | –            |
| 8               | 3.37 | .037  | 2 vs. 3; $p = .038$ |
| 9               | 1.79 | .17   | –            |
| 10              | 5.57 | .005  | 2 vs. 3; $p = .006$ |
| 11              | 2.74 | .068  | –            |
| 12              | 1.1  | .336  | –            |
| 13              | 0.39 | .679  | –            |
| 14              | 3.04 | .051  | 2 vs. 3; $p = .045$ |
| 15              | 3.87 | .023  | 2 vs. 3; $p = .029$ |
| 16              | 4.54 | .12   | 2 vs. 3; $p = .024$ |

Abbreviation: ANOVA, analysis of variance.
between odor discrimination and semantic memory. Specifically, \( B_{10} = 1980 \), which means that the data are 1,900 times more likely to occur under this hypothesis than under the hypothesis \( H_0 \) (see Figure 5a) and the obtained evidence was robust, with Bayes factor staying above 1,000 (Figure 5b).

Eventually, the total score in odor discrimination correlated positively but weakly to digit span \( (B_{10} = 3.27) \) and mindset \( (B_{10} = 2.58) \) but the robustness of this evidence was anecdotal.

In case of other variables, Bayes factor did not confirm the \( H_1 \) (see Table 7) and, while analyzing \( B_01 \) to understand whether there was any evidence for \( H_0 \), life orientation, general self-efficacy and self-esteem were found to be unrelated to the total score in odor discrimination, with \( B_01 \) providing evidence for the lack of correlation \( (B_{01} \text{ for life orientation} = 4.26, B_{01} \text{ for general self-efficacy} = 23.77, B_{01} \text{ for self-esteem} = 3.63) \).

\[ \text{TABLE 6 Classical Pearson one-way correlation with the total score in odor discrimination} \]

|                         | Odor discrimination |
|-------------------------|---------------------|
| Digit span              | .19*                |
| Semantic memory         | .33**               |
| Life orientation test revised | .07         |
| General self-efficacy   | -.12                |
| Mindset                 | .18*                |
| Self-esteem             | .08                 |
| Response time           | -.16*               |
| Sex                     | -.12                |
| Age                     | -.42**              |

Note: *\( p < .005 \); **\( p < .001 \).

Eventually, the Bayes factor indicated strong evidence for the negative correlation between the total score in odor discrimination and age. Specifically, \( B_{10} = 1,063,000,000 \), which means that the data are 1,063,000,000 more times likely to occur under this hypothesis than under the hypothesis \( H_0 \) and the obtained evidence was very robust, with Bayes Factor staying above 100,000.

Classic stepwise regression analysis, presented in Table 8, was carried out for age, semantic memory, digit span, response time and mindset. Results showed that, while the first model was significant \( (F_{5,154} = 9.35, p < .001) \) and explained 21% of variability \( (\text{Adj. } R^2 = .21) \), the best model was much stronger \( (F_{2,157} = 21.78, p < .001) \), with semantic memory \( (\text{Adj. } R^2 = .21, p = .007) \) and age \( (\text{Adj. } R^2 = -.35, p < .001) \) as the only predictors and also explained 21% of variability \( (\text{Adj. } R^2 = .21) \) (Table 8). Durbin–Watson test \( d \) was, in case of all five models, equal 2.1.

Comparing Bayesian factors presented in Table 9, it can be noticed that the value of \( B_{10} \) is relatively high for all presented models but the highest for the model consisted of semantic memory and age \( (B_{10} = 2587e6) \). This model is 16 times more probable to occur than the other models \( (BM = 16.684) \). Its a posteriori probability is the highest as compared to other models \( (PM/data = 0.22) \), which demonstrates its superiority. The least probable model was the one containing mindset \( (BM = 0.648) \). Prior inclusion probabilities are presented in Figure 6. The descriptive statistics of all model components, together with B inclusion and credible intervals are presented in Table 10.

4 | DISCUSSION

The main objective of this study was to investigate which components among a range of cognitive and noncognitive factors contribute to odor discrimination and to which extent. Overall, the present results
demonstrate a significant impact of semantic memory and age on odor discrimination performance. On the contrary, executive functions together with noncognitive factors and response time were not strong predictors of odor discrimination performance.

A robust relationship between odor discrimination and cognitive performance has been demonstrated before. For example, Hedner et al. (2010) showed that the cognitive impact, measured by executive functions and semantic memory was strongest in odor discrimination as compared to other olfactory functions. In the present study, by means of Bayesian statistics, we demonstrated that while executive functions were a relatively weak predictor of odor discrimination, semantic memory allowed to predict this olfactory function with a high level of certainty. One plausible explanation of this strong dependence between semantic memory and odor discrimination can be the functions of semantic memory. Semantic memory is a component of long-term memory containing the continuous representation of our knowledge—concepts, objects, facts, together with words and their meaning (Tulving, 1983). Simply put, semantic memory provides meaning to the sensory experience (Hodges, Salmon, & Butters, 1991). In the process of odor discrimination, access to the representation of odors that the participant is asked to compare appears as a fundamental issue. If an odorant is unfamiliar to the participant, they may have a less differentiated representation (Rabin, 1988), leading to impaired discriminative performance (Stevenson & Mahmut, 2013). Thus, impairment of semantic memory can result from a lack of access to item knowledge from a particular sensory modality of input, or actual loss of central representational knowledge (Shallice, 1988). As a matter of fact, this impairment has been noted in case of neurodegenerative diseases, such as Alzheimer’s (Saykin et al., 2018) or Parkinson’s disease (Blundo, Weis, & Antonini, 2016) that are also associated with odor discrimination impairment.

Indeed, odor discrimination was shown to be the best predictor of the future development of Parkinson’s disease (Haehner et al., 2007). Along the same line of thought, studies on nonclinical samples confirm the relationship between olfactory and cognitive components. Deficits in higher-order olfactory abilities, namely odor discrimination and odor identification were found to be associated to the impairment in cognitive abilities, including memory, language, and

![Age vs Semantic Memory](image)

**FIGURE 4** Classic Pearson correlation between semantic memory and age

|                         | r  | BF10  |
|-------------------------|----|-------|
| Digit span              | .19| 3.27  |
| Semantic memory         | .33| 1,979.98|
| Life orientation test revised | .07| 0.24  |
| General self-efficacy   | -.12| 0.04  |
| Mindset                 | .18| 2.58  |
| Response time           | -.16| 1.6   |
| Self-esteem             | .08| 0.28  |
| Age                     | -.42| 1,063,000,000 |

**TABLE 7** Bayesian Pearson one-way correlations with the total score in odor discrimination. BF10 value presents the support for the alternative Hypothesis H1
executive functions (de Guise et al., 2015; Fagundo et al., 2015; Hedner et al., 2010; Westervelt, Ruffolo, & Tremont, 2005).

In agreement with a number of studies, age exhibited a strong negative influence on odor discrimination performance (e.g., Doty & Kamath, 2014; Hulshoff Pol, Hijman, Baaré, van Eekelen, & van Ree, 2000; Kaneda et al., 2000; Schiffman & Pasternak, 1979; Stevenson, Mahmut, & Sundqvist, 2007). Importantly, age-related deficits in odor recognition may be a reflection of greater difficulties in tasks related to semantic memory, such as recalling odor knowledge or names than in the weaker ability to perceive the involved odors (Larsson, Öberg, & Bäckman, 2006).

Interestingly, target’s odor position facilitated the correct choice in odor discrimination process always in the same way. When the target odor was presented as the last of the three pens, participants were more successful at indicating it, what can be probably due to recency effects (Miles & Jenkins, 2000). Even though, the influence of the target odor position was noticed only in case of several trials, it should be considered in the future studies.

On the other hand, the two investigated groups did not vary in terms of their final score in odor discrimination. In the light of the previous finding, the target odor’s position appears to facilitate the final outcome only when presented as the last while the amount of the response time does not cause any difference in the task completion. Here, we are first to show that controlling for the response time appears unnecessary while conducting the odor discrimination task.

Even though, some studies demonstrated that depression is related to the impairment in odor discrimination performance (Atanasova et al., 2010; Croy et al., 2014), the present study, conducted on a relatively big sample, showed that none of the noncognitive components related to depression predicted the final outcome in this task. On the contrary, in both classic and Bayesian regression analyses, the model containing mindset was the weakest among all. This result can be explained in at least two different ways. On the one hand, the decrease in odor discrimination performance in depressed participants might be rather a consequence of reduced olfactory attention and decreased olfactory bulb volume (Croy & Hummel, 2017) than of a combination of noncognitive factors. On the other hand, while some studies indicated impairment of odor discrimination in depression (Atanasova et al., 2010; Croy et al., 2014), a number of others showed that normosmic controls

| Variables       | 1 | VIF | 2 | VIF | 3 | VIF | 4 | VIF |
|-----------------|---|-----|---|-----|---|-----|---|-----|
| Mindset         | 0.2| 1.16|   |     |   |     |   |     |
| Digit span      | 0.6| 1.19| 0.6| 1.18|   |     |   |     |
| Response time   | -0.1| 1.08| -0.11| 1.03| -0.11| 1.02|   |     |
| Semantic memory | 0.16**| 1.36| 0.17*| 1.34| 0.19*| 1.17| 0.21*| 1.15 |
| Age             | -.34**| 1.22| -.35**| 1.15| -.35**| 1.15| -.35**| 1.15 |

Note: *p < .005; **p < .001.
Abbreviation: VIF, variance inflation factor.

### Table 8

| Models comparison | P(M)       | P(M(data)) | BF M | BF 10 | R² |
|-------------------|------------|------------|------|-------|----|
| Null model        | 0.167      | 8.521e-7   | 4.260e-66 | 6 - 6| 1  | 0  |
| Semantic memory plus age | 0.017 | 0.22 | 16.684 | 2.587e + 6 | .217 |
| Response time plus semantic memory plus age | 0.017 | 0.136 | 9.316 | 1.600e + 6 | .229 |
| Response time plus digit span plus mindset plus semantic memory plus age | 0.167 | 0.115 | 0.648 | 134,675.507 | .233 |
| Response time plus digit span plus semantic memory plus age | 0.033 | 0.086 | 2.738 | 504,629.663 | .232 |

### Table 9

![Figure 6](image-url)
TABLE 10  Bayesian stepwise regression, descriptive statistic. P(incl) illustrates prior inclusion probability of individual components while P(incl|data) demonstrates posterior inclusion probability for each individual component. BF_inclusion represents the change from prior to posterior inclusion odds

| Coefficient               | Mean  | SD    | P(incl) | P(incl|data) | BF_inclusion | 95% credible interval Lower | Upper |
|---------------------------|-------|-------|---------|----------|--------------|----------------------------|-------|
| Intercept                 | 12.17 | 0.17  | 1.00    | 1.00     | 1.00         | 11.85                      | 12.49 |
| Age                       | −0.05 | 0.01  | 0.50    | 1.00     | 2,479.21     | −0.07                      | −0.03 |
| Total time to take the decision | −0.01 | 0.01  | 0.50    | 0.49     | 0.95         | −0.03                      | 0.00  |
| Digit span                | 0.04  | 0.08  | 0.50    | 0.39     | 0.64         | −0.06                      | 0.22  |
| Mindset                   | 0.03  | 0.12  | 0.50    | 0.31     | 0.45         | −0.24                      | 0.34  |
| Semantic memory           | 0.21  | 0.15  | 0.50    | 0.78     | 3.48         | 0.00                       | 0.47  |

did not differ from patients with depression (Negoias et al., 2010; Kamath et al., 2018; Pollatos et al., 2007; see: Rochet, El-Hage, Richa, Kazour, & Atanasova, 2018).

The present study is not free from limitations. Out of all information regarding three odorants presented in each single trial of the odor discrimination test, only the position of target odor was coded. Thus, it was not possible to obtain the information about the impact of individual odors on the odor discrimination performance. Future studies should further investigate this issue.

The aim of the present study was to determine the relative predictive value and the extent to which a range of cognitive and non-cognitive variables impact odor discrimination performance. We conclude that odor discrimination performance is strongly and to a large extent predicted by semantic memory and age while the influence of noncognitive factors, even those related to depression, is less pronounced. In turn, considering the reflection of cognitive abilities on methodological elements of the procedure of the odor discrimination task, the influence of the target odor position should be considered in future studies. Controlling for the response time in this kind of task appears not to be highly significant.

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CONFLICT OF INTEREST
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