



**STEPHANIE AREZES  
MACEDO**

**EFEITOS DO CONTEXTO VISUAL EMOCIONAL NA  
CODIFICAÇÃO E RECUPERAÇÃO DE INFORMAÇÃO  
DE ODORES CORPORAIS**

**THE EFFECTS OF EMOTIONAL VISUAL CONTEXT  
ON THE ENCODING AND RETRIEVAL OF BODY  
ODOR INFORMATION**



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Tese apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Psicologia da Saúde e Reabilitação Neuropsicológica, realizada sob a orientação científica da Doutora Sandra Cristina de Oliveira Soares, Professora Auxiliar do Departamento de Educação e Psicologia da Universidade de Aveiro.

“Whenever you feel weak, remember the things that made you strong.

Whenever you start to doubt yourself, remember those who believe in you”

## **o júri**

presidente

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**palavras-chave**

olfato, odores corporais, emoção, memória dependente do contexto.

**resumo**

Sabe-se que as condições de codificação e recuperação influenciam a informação sensorial armazenada e a sua recapitulação. No entanto, pouco se sabe acerca de tais processos ao nível do olfato. No presente estudo, focamos na singularidade dos odores corporais, os quais, à semelhança das impressões digitais, permitem a identificação de uma pessoa específica, ao associar a sua apresentação a contextos emocionais negativos ou neutros. Um total de 125 participantes (68F) foram expostos a um odor corporal (BO) de um indivíduo masculino enquanto viam um vídeo de crime ou neutro (fase de codificação), sendo-lhes posteriormente pedido que reconhecessem o BO alvo numa condição visual congruente ou incongruente (fase de recuperação). Os resultados indicam que os vídeos de crime foram avaliados como mais vívidos, desagradáveis e ativadores quando comparados com os vídeos neutros, tanto na codificação como na recuperação. Para além disto, em termos de avaliação subjetiva dos BOs, a intensidade e a ativação dos odores permitem a distinção entre o alvo e os distratores quando era apresentada informação criminal congruente na codificação e recuperação. Por fim, os resultados em termos de acertos não foram significativamente diferentes da probabilidade de acertar ao acaso. Estes resultados poderão clarificar como é que as memórias olfativas são processadas em situações emocionais.

**keywords**

olfaction, body odors, emotion, context-dependent memory.

**abstract**

Encoding and retrieval conditions are known to influence the sensory material stored and its recapitulation. However, little is known about such processes in olfaction. Here, we capitalized on the uniqueness of body odors which, similarly to fingerprints allow for the identification of a specific person, by associating their presentation to a negative or a neutral emotional context. A total of 125 receivers (68F) were exposed to a male body odor (BO) while watching either criminal or neutral videos (encoding phase) and were subsequently asked to recognize the target BO within either a congruent or an incongruent visual context (retrieval phase). The results showed that criminal videos were rated as more vivid, unpleasant and arousing than neutral videos both at encoding and retrieval. Moreover, in terms of BO ratings, we found that odor intensity and arousal allow to distinguish the target from the foils when congruent criminal information is presented at encoding and retrieval. Finally, the accuracy performance was not significantly different from chance level for either condition. These findings elucidate how olfactory memories are processed in emotional situations.

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## Introduction

Despite the reduced attention for olfaction in human perception (McGann, 2017), its role in episodic memory has long been investigated. It has even become paradigmatic to refer to the “Proust effect” to present the ability of odors to allow us to relive memories from our past (Chu & Downes, 2002; Herz & Schooler, 2002; Willander & Larsson, 2006). If an odor, like the odor of the Proustian madeleine dipped in the tea, is contextual to the encoding of a specific event (e.g., Sunday mornings at Proust aunt’s house; Proust, 1913 in Jellinek, 2004), then such odor can later constitute a cue for the retrieval of that memory. So far, a wealth of behavioral studies demonstrated that memory performance improves when odors congruent with the to-be-retrieved information are present at encoding (Ball, Shoker, & Miles, 2010; Herz, 1997; Parker & Gellatly, 1997; Parker, Ngu, & Cassaday, 2001; Schab, 1990; Schwabe, Böhringer, & Wolf, 2009; Smith, Standing, & Man, 1992; Wiemers, Sauvage, & Wolf, 2013). Furthermore, successful retrieval of odor-congruent information seems to be associated with the reactivation of the brain state present at encoding (Reichert et al., 2017). Specifically, many emotional odor-triggered memory effects are underlined by the close anatomical connections between olfactory areas and limbic centers devoted to the processing of emotional (e.g., amygdala) and memory (e.g., hippocampus) information (Saive, Royet, & Plailly, 2014; Wilson, Best, & Sullivan, 2012).

The majority of the available studies have now considered how contextual odors modulate the accurate retrieval of information. However, in few instances it has been investigated how odor memory can be modulated by the presence of contextual information. In a review, Herz and Engen (1996) report that the emotional context in which an odor is first encountered influences the memory for that odor. For example, an odor that is perceived as pleasant may be first experienced in a pleasant context. This effect is in line with the evidence showing that emotional contexts produce more accurate retrieval performances as compared to non-emotional contexts (e.g., Buchanan, 2007; Kensinger, 2007; Ochsner, 2000), perhaps in virtue of the greater attentional resources captured by salient information (Yiend, 2010), as in the case of emotional vs. neutral processing. It is indeed common that when the contextual information of a to-be-retrieved memory is highly arousing, then memory accuracy is significantly improved (Dolcos, LaBar, & Cabeza, 2005; Holland & Kensinger, 2012; Libkuman, Stabler, & Otani, 2004). However, when encoding occurs

during emotional arousal (Burke, Heuer, & Reisberg, 1992; Christianson & Loftus, 1991; Reisberg & Heuer, 1992), in particular when the arousal has a negative connotation, such memory boost can be confined to gist but not to detailed information (Adolphs, Tranel, & Buchanan, 2005; Houston, Clifford, Phillips, & Memon, 2013). Moreover, another factor that is known to have an impact in the accurate identification of encoded information is the emotional congruency between encoding and retrieval contexts, which influences the sensory material stored and its recapitulation. In previous studies manipulating context congruency, individuals could more accurately retrieve information when the context presented at encoding was reinstated (Schwab et al., 2009; Smith et al., 2014). In olfactory contexts, these mechanisms are still under investigation.

Perceptual complexity (or informational load) is a key variable in determining the ability to retain details about objects (Eng, Chen, & Jiang, 2005). Albeit this basic property has been extracted by using visual stimuli, it is likely to be translated to the olfactory domain. Olfactory stimuli, and particularly of BOs, which are unique mixtures of hundreds of chemical compounds (Zeng et al., 1991) comparable to fingerprints (Penn et al., 2007), are inherently complex and, as other odors, associated with poor semantic representations (Olofsson et al., 2014). It is then expected that memory for complex olfactory stimuli, such as BOs, may suffer in identification accuracy (Cain, 1979), and particularly when the context in which the encoding occurs is incongruent to the contextual features at retrieval. Furthermore, despite the fact that the majority of the BO effects reported occur below conscious control (Lundström & Olsson, 2010; Parma et al., 2017), the ability to explicitly report the perceptual features of the BO related to danger (i.e., disease signals) may reveal the participants' ability to distinguish specific perceptual features in the encoded BO (Olsson et al., 2014). Contrarily to the prediction that arousal may hamper identification accuracy for BOs, two recent studies from our laboratory presented BOs while participants watched criminal and neutral videos. The results showed an enhanced memory performance for target BOs that were encoded under the arousing condition (Alho et al., 2015). However, the effects seemed to be short-lived (15 mins; Alho et al., 2016) and no emotional manipulation was performed at retrieval. In previous studies (e.g., de Groot, Semin and Smeets, 2014), the emotional context is manipulated to induce different emotional states in the donors, namely to directly affect body odor production. In the mentioned study, receivers were randomly

presented with fear sweat and neutral sweat while watching threatening and non-threatening videos that confirmed or contradicted the olfactory information.

Instead, in the present study, we use the same BOs and manipulate the emotional context to which participants are exposed. We used a methodology similar to that applied in our previous studies (Alho et al., 2015; Alho et al., 2016), but we manipulated the emotional context not only at encoding (as previously done), but also at retrieval. Thus, we exposed two groups of participants to congruent visual contexts [either neutral (group N-N) or criminal (group C-C)], and two different groups of participants to incongruent visual contexts [either starting with a neutral (group N-C) or criminal (group C-N) video]. Subsequently, participants were asked to recognize, among five possible options, the BO to which they had been exposed at encoding. After having smelled each of the BO items, which included the encoded BO and the four foils, participants were asked to explicitly rate perceptual features (i.e., intensity, pleasantness and arousal) of each BO and finally select the target BO presented at encoding.

We expect the accuracy identification performance at retrieval to be maximal for the congruent groups (N-N and C-C), in line with the idea that emotional congruency between contexts at encoding and retrieval boosts memory performance (Schwab et al., 2009; Smith et al., 2014). Furthermore, in light of the ability to explicitly report perceptual differences related to danger signals (Olsson et al., 2014), we hypothesize that participants exposed to congruent contextual information at encoding and retrieval may have more attentional resources to differentiate the target BO and foils based on either odor intensity or arousal. These effects should be maximal in the C-C group, in virtue of the exposure to danger information (Li, Moallem, Paller, & Gottfried, 2007; Parma, Ferraro, Miller, Åhs, & Lundström, 2015).

## **Materials and Methods**

All the experimental procedures of this study were approved by the scientific council of the University of Aveiro, and were in accordance with the Declaration of Helsinki and the standards set by the American Psychological Association. Written informed consent was obtained from all the individuals enrolled in the study and they were rewarded with course

credits. Below, we will separately report the materials and methods for the BO collection and the body odor transmission part of the study.

## **Body Odor Collection**

### **Donors and collection procedure.**

BO samples were collected from the armpits of 25 healthy male university students, aged between 17 and 29 years ( $M=21.4$ ,  $SD=2.6$ ) that volunteered to participate. Selected donors were reported to be healthy, not to suffer from any type of physical, metabolic or mental disease, non-smokers and heterosexual (Martins et al., 2005). To ensure the quality of the collected BOs, participants followed dietary and hygienic restrictions since the day before the collection (e.g., Alho et al., 2015; Parma et al., 2017). Previously to the BO collection, each participant was given a kit with the necessary material. These included a ziplock bag containing two cotton disks (*Laboratoires Mercurochrome*; identified with a L and a R, that should be placed on the left and right armpits, respectively), a hypoallergenic fragrance-free body shower gel (*A-Derma Avoine Rhealba*), a portion of medical adhesive tape (to hold the cotton disks and prevent displacements), and a paper towel and a white cotton t-shirt (*SportZone*), packed separately. In order to ensure that the t-shirts were clean and fragrance-free, which could damage the quality of the collected BOs, these were washed with a fragrance-free detergent (*ECOS*, earth friendly products) and water (Alho et al., 2015; Heckmann, Teichmann, Pause, & Plewig, 2003). Oral and written instructions were given regarding the BO collection procedure and a written informed consent (Appendix A) was signed by each donor, as well as a sociodemographic questionnaire (Appendix B). Therefore, on the BO collection day, using the materials provided in the kit, donors had to shower with the body shower gel drying their bodies with the paper towel and posteriorly securing the cotton disks on the respective armpits with the medical adhesive tape. Next, they wore the t-shirt to prevent displacements of the disks. The collection was always done during the morning, placing the cotton disks at 9:00AM and removing them four hours later (1:00PM). Subsequently, the disks were removed and carefully sealed in the ziplock bag and frozen at a temperature of  $-20^{\circ}\text{C}$ . All donors were debriefed and the compliance to the procedures was verified. Course credit reward was provided upon completion of the donation procedures.

## Body Odor Transmission

### Receivers.

The original sample was composed of 171 participants (94 F). The receivers included in the final sample were all those who: i) reported not to have health issues or undergoing drug treatment known to be related to olfactory alterations (excluded N=18), ii) reported to be heterosexual (excluded N=3), iii) scored at the 16-item Sniffin' Sticks Identification test above the cut-off of 11 (excluded N=24), iv) reported to be younger than 35 (excluded N=1), v) did not show emotional dysregulation in the range of clinical anxiety (STAI > 55, excluded N= 16) and depression (BDI > 19, excluded N=2). The final sample included 125 receivers (68F) between the ages of 17 and 31 (M=21.6, SD=2.99). The sample was divided into four groups, each of which was administered one experimental condition in line with a between-subject design. Specifically, a group was presented with a neutral video at encoding and retrieval (N-N), a group was presented with a criminal video at encoding and retrieval (C-C) and two groups were presented with an emotional-incongruent video at encoding and retrieval (N-C or C-N). No significant socio-demographic, olfactory identification skills or anxiety trait and depressive mood differences - known to contribute to altered olfactory and/or memory processing - were revealed across groups. Please refer to Table 1 for details.

Table 1

#### *Sample description*

	N-N N=27	C-C N=34	N-C N=30	C-N N=34	p- value	N
Age	21.8 (3.17)	21.5 (3.03)	21.2 (3.56)	21.9 (2.72)	0.845	125
Sex: Female	55.6%	55.9%	50.0%	55.9%	0.958	125
Contraception: No	52.6%	44.8%	55.6%	44.0%	0.838	91
Smoking: No	81.5%	88.2%	90.0%	70.6%	0.187	125
OdorID	13.0 [12.0;14.0]	13.0 [12.0;13.0]	12.0 [11.0;13.0]	13.0 [11.2;14.0]	0.055	125
STAI Trait	39.0 (10.1)	36.8 (7.01)	37.0 (9.82)	37.1 (9.81)	0.785	117
BDI	5.67 (4.84)	4.57 (2.98)	5.87 (4.64)	6.50 (5.12)	0.407	117

*Note.* Group combination based on the emotional context presented at encoding – context at retrieval; N = neutral, C= criminal. OdorID = 16-item Sniffin' Sticks identification test; STAI Trait: Trait anxiety measure; BDI = Beck Depression Inventory.

### **Experimental stimuli.**

The previously collected BOs were presented in odor-free glass jars and constituted the target and foil odor stimuli (Alho et al., 2015; Alho et al., 2016). BOs were thawed at least one hour before testing and placed in the glass jars, always using disposable gloves when handling the samples. In order to prevent any investigator interference on the target position in the lineup, a double-blind procedure was used. As visual contextual stimuli, one-minute audio-visual presentations (video clips) were used (the same as in Alho et al., 2015). Five of these were rated as emotionally neutral (e.g., couple walking by the sea) and five as arousing, given the criminal nature of the images portrayed (e.g., domestic violence). All receivers watched the video clips on the same computer monitor (DELL E198FP, 1280x1024), while using headphones to minimize interferences from external noise.

### **Procedures.**

Firstly, recipients were asked to sit comfortably in front of the computer and completed the informed consent (Appendix C), a sociodemographic questionnaire (Appendix D), a Visual Analogue Scale (VAS) rating their perceived stress (Appendix E) and the STAI State questionnaire (Appendix F). Next, they watched a one-minute audio-visual clip of an event involving a man and a woman, being informed that the BO belonged to the man present in the video clip. The target BO was presented continuously during the video clip in wide-mouth jars, which the receivers held under their noses with their dominant hand. Receivers were instructed to breathe naturally through their noses and to close the jar after the video clip ended. Subsequently, receivers were asked to rate the video clip in terms of vividness, pleasantness and arousal (Appendix G), and completed a VAS rating their perceived stress, the STAI Trait (Appendix H) and the Beck Depression Inventory (BDI) (Appendix I). This was done to allow a 15-min break from the target BO presentation and the retrieval phase. Receivers watched a new video clip (no odor presentation) and were unaware that they would have to perform a recognition task. The task included 5 glass jars (one target BO and four foils) aligned horizontally and the receivers were instructed to identify the odor of the man whose BO they smelled during the first video clip presentation. This five-alternative, forced-choice, target-present procedure was chosen in order to obtain a high power and bias-free measure of the identification performance. Thus, receivers were

given instructions to smell each BO at a time, from left to right, with no time restriction to smell but without the chance to resample previous BOs. Between smelling each BO, receivers also had to complete a VAS rating on the odor's intensity, pleasantness and arousal (Appendix J). The position of the BO in the lineup was counterbalanced. Next, they rated the second video clip in terms of vividness, pleasantness and arousal, and completed a VAS assessing their perceived stress and the STAI State. As a last task, receivers completed the 16-item Sniffin' Sticks identification test, and were debriefed and rewarded with course credits.

### **Dependent Variables and Data Analysis**

All data were analyzed using *R* with the *lme4* package (Bates, Mächler, Bolker, & Walker, 2014). To determine whether the movies were effective in inducing different emotional contexts, we performed separate linear mixed models (LMMs) to analyze the subjective emotional ratings (vividness, pleasantness, arousal) of the receivers when watching the videos and the perceptual features of the body odors as rated by the receivers (intensity, pleasantness, familiarity). The LMMs used for these analyses included the subjective emotional ratings as dependent variable, the Subject ID as a random factor and Group (4 levels) as the between-subject predictor and for the BO, whether the odor was a target or a foil (2 levels). *Anova* results were retrieved from the LMM models via the *anova* function. Post-hoc contrasts were run via the function *glht* of the *multcomp* package (Hothorn, Bretz, & Hothorn, 2009), following the Tukey method and the Bonferroni correction, which adjust for multiple comparisons. Results reported include the mean (M) and standard deviations (SD), as well as the betas of the models in the tables. A ROC curve analysis was performed via the *klaR* package (Roever et al, 2006) using the Naïve Bayes machine learning algorithm, which assumes that the presence of a particular feature in a class (e.g., target in the C-C) is unrelated to the presence of any other feature (e.g., emotional context at encoding, emotional context at retrieval, perceptual information of the odor). Results are visualized via the *ROCR* package (Sing, Sander, Beerenwinkel, & Lengauer, 2005). ROC curves plot the performance of binary classifiers by graphing true positive rates (TPR) versus false positive rates (FPR), with cutoff value from 0 to 1. The closer the curve is to the top-left corner of the graph (the smaller the area above the curve), the better the



performance of the model. In a ROC curve, we can compare the performance of a classifier with that of a random guess that would lie at a point along a diagonal line running from the origin (0, 0) to the point (1, 1; this line is sometimes called the line of no-discrimination). Anything to the left of this line indicates a better prediction, and anything to the right indicates a worse prediction than chance discrimination. The best possible prediction performance would be denoted by a point at the top-left of the graph at the intersection of the x and y axis (perfect classification). The Area Under the Curve (AUC) is the space in the graph that appears below the ROC curve, and it is a value between 0 and 1. The closer the value of AUC is to 1, the better the performance of the classification model. In all instances, the significance level is set at  $p < .05$ .

## Results

### **Criminal videos were rated as more vivid, unpleasant and arousing than neutral videos both at encoding and retrieval**

As expected, receivers rated the criminal videos and the neutral videos as significantly different. Indeed, the criminal videos were rated as more vivid either at encoding (C-C:  $M=5.86$ ,  $SD=2.39$ ; C-N:  $M=5.94$ ,  $SD=2.19$ ) or retrieval (C-C:  $M=5.95$ ,  $SD=1.76$ ; N-C:  $M=5.56$ ,  $SD=2.97$ ) when compared to the neutral videos. Please, refer to Figure 1, Panel A, for a visualization. Similarly, in terms of arousal, the criminal videos were once again considered to be significantly more arousing when presented at both encoding (C-C:  $M=5.67$ ,  $SD=2.56$ ; C-N:  $M=5.17$ ,  $SD=2.34$ ) and retrieval (C-C:  $M=5.98$ ,  $SD=2.26$ ; N-C:  $M=5.88$ ,  $SD=3.01$ ; please see Figure 1, Panel C). In line with this, the criminal videos were rated at encoding (C-C:  $M=1.61$ ,  $SD=2.15$ ; C-N:  $M=1.50$ ,  $SD=1.44$ ) and retrieval (C-C:  $M=1.48$ ,  $SD=1.90$ ; N-C:  $M=1.88$ ,  $SD=1.70$ ) as less pleasant (see Figure 1, Panel B). In summary, the criminal videos were rated as more vivid, arousing and unpleasant by receivers, either at encoding or retrieval in comparison to the neutral videos.

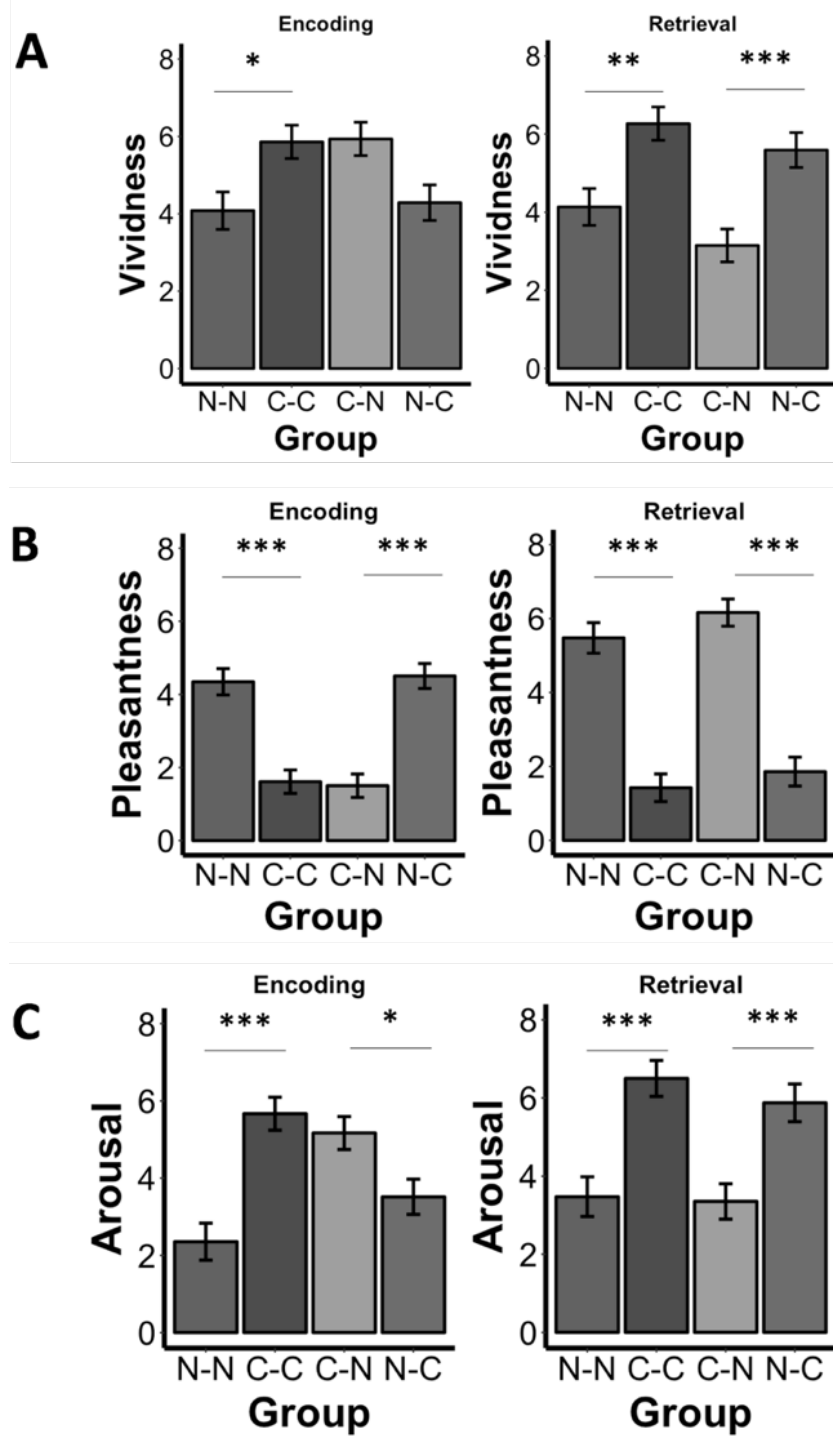


Figure 1. Subjective video ratings in terms of Vividness (A), Pleasantness (B) and Arousal (C) at encoding and retrieval. Note.  $*=p<.05$ ;  $**<p<.01$ ;  $***<p<.001$ .

### **Odor intensity and arousal allow to distinguish the target from the foils when congruent criminal information is presented at encoding and retrieval**

The LLM revealed a main effect of Group [ $F(1,121)=3.28, p=.02$ ] and Target/Foil [ $F(1,121)=9.12, p=.003$ ], using intensity as dependent variable, suggesting that the intensity of the BOs, as expected from naturally produced stimuli, would differ across groups (C-C > C-N > N-C) and targets and foils (targets being more intense than foils). However, the interaction did not reach the significance level [ $F(3,121)=2.08, p=.11$ ]. Post-hoc analyses revealed that only in the case of the C-C group, the intensity of the BO was significantly greater for the target as compared to the foils (C-C<sub>target</sub>:  $M=6.90, SD=2.14$ ; C-C<sub>foils</sub>:  $M=5.23, SD=1.70, p<.05$ ). Please refer to Figure 2, Panel A, for a visual representation. In accordance, a main effect of Target/Foil [ $F(1,121)=2.63, p<.001$ ] was found when using arousal as dependent variable. Post-hoc analyses also indicated that in the C-C group, the arousal of the BO was significantly greater for the target in comparison with the foils (C-C<sub>target</sub>:  $M=5.97, SD=2.14$ ; C-C<sub>foils</sub>:  $M=4.25, SD=1.73, p<.001$ ) as you can see in Figure 2, Panel C. The interaction did not reach the significance level [ $F(3,121)=2.63, p=.05$ ], however, a statistical trend is reported. As evident from Figure 2, Panel B, no significant main effects in pleasantness were reached, neither for Group [ $F(3,121)=1.28, p=.28$ ] nor for Target/Foil [ $F(1,121)=0.67, p=.41$ ]. However, in accordance to what was expected and in line with the previously presented information, the target was rated as less pleasant than the foils in the congruent groups (N-N<sub>target</sub>:  $M=2.15, SD=1.74$ ; N-N<sub>foils</sub>:  $M=3.10, SD=1.47$ ; C-C<sub>target</sub>:  $M=2.66, SD=2.50$ ; C-C<sub>foils</sub>:  $M=2.92, SD=1.27$ ).

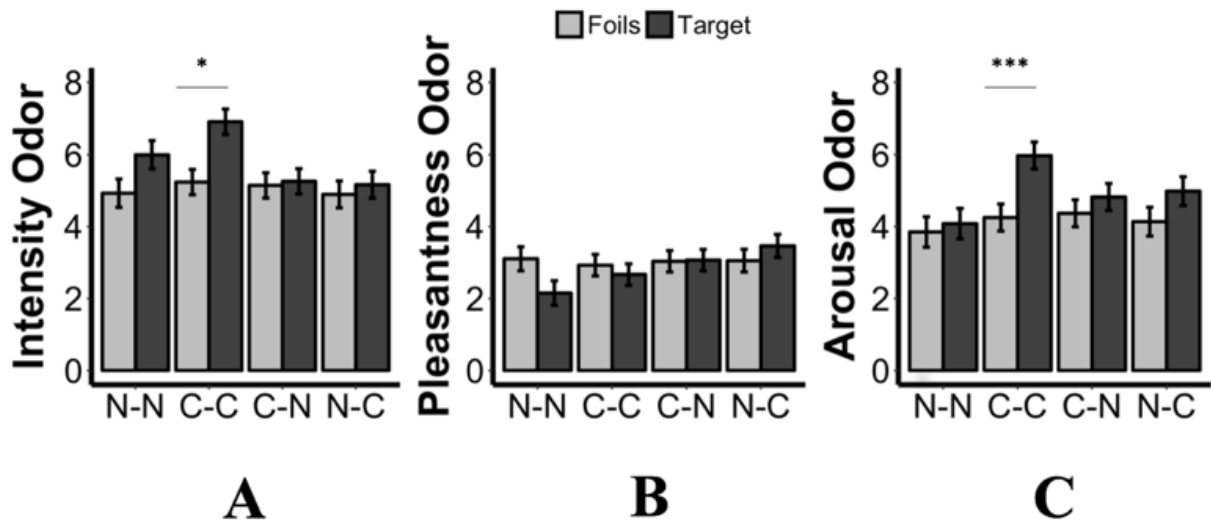
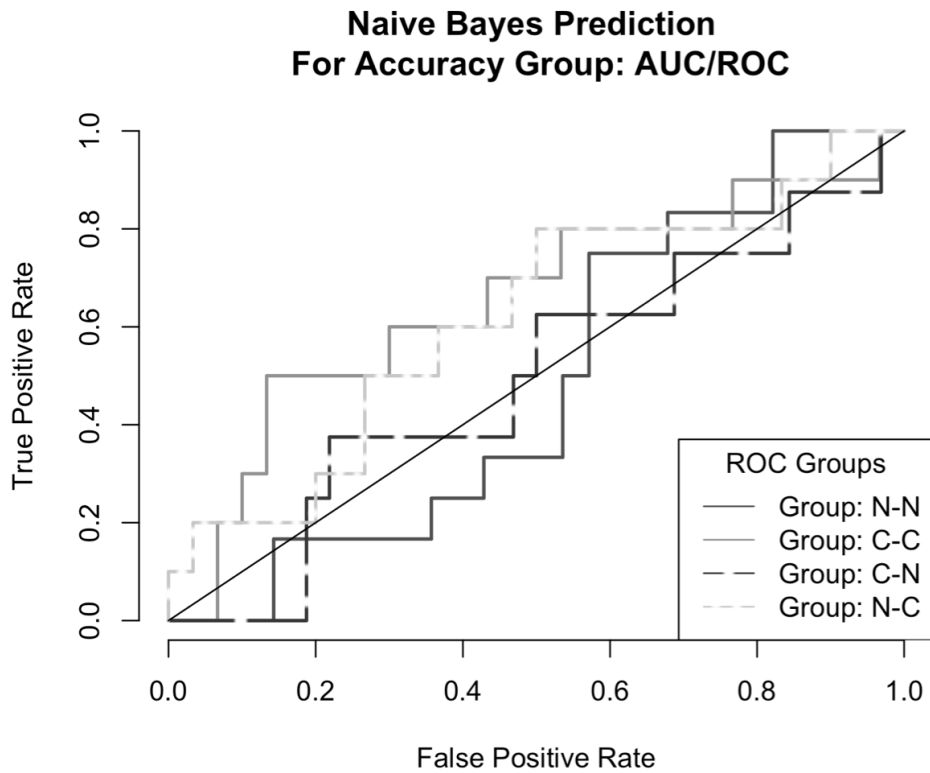


Figure 2. Subjective BO ratings in terms of Intensity (A), Pleasantness (B) and Arousal (C) for Target and Foils. Note.  $*=p<.05$ ;  $**<p<.01$ ;  $***<p<.001$ .

### Identification accuracy is at chance level for all groups

The results from the Naïve Bayes machine learning algorithm run on a training set (70% of the observations) and validated on the remaining 30% of the observations indicate that the accuracy performance is not significantly different from chance level (the black diagonal line). The predicted performance in order of accuracy is the following: C-N (59% of correct recognitions); C-C and N-N (55%); and N-C (50%) (see Figure 3).



*Figure 3.* ROC curves based on the accuracy of BO identification for each group based on the Naïve Bayes prediction algorithm.

### **Discussion**

The purpose of the present study was to further the understanding of how odor memory can be modulated by the presence of emotional contextual information. By presenting criminal and neutral videos, we created different emotional contexts within which a BO was encoded and subsequently retrieved. The analysis of the subjective ratings of the videos revealed that we were able to induce different emotional experiences in the receivers. Indeed, criminal videos were rated as more vivid, unpleasant and arousing than neutral videos, both at encoding and retrieval.

With respect to the accuracy identification performance, we hypothesized that it would be maximal for congruent groups, however, our results did not corroborate this hypothesis. Indeed, the accuracy performance for each prediction was not significantly different from chance level. Despite some differences, the identification performance is

similar for all groups, suggesting that even the emotional quality of the context may not facilitate the accurate retrieval of an encoded BO information. One aspect contributing to this finding is that better odor identification is achieved when a verbal label can be paired with the odor. In other words, more namable odors lead to better recognition performances (Jönsson, Möller, & Olsson, 2011). Thus, complex and hard to verbalize stimuli, such as BOs, may lead to impairments in the accuracy performance (Cain, 1979).

If this was generally true, it would go against the evidence produced by Alho and colleagues (2015, 2016), who revealed a facilitation effect in the identification of the BO paired with a criminal video, with a recognition delay of up to 15 minutes. Indeed, a methodological change implemented in the present study may have increased the difficulty of the recognition task when compared to Alho et al. (2015, 2016), and consequently reduced the accuracy performance. At retrieval, receivers immediately identified the target BO and only rated the perceptual features of the BOs after the identification (Alho et al., 2015), whereas in the present study receivers only identified the target BO after providing the ratings to all the BOs included in the lineup. As a result, the time passed between encoding and retrieval may be slightly longer than 15 mins, and in line with the findings by Alho et al. (2016), incrementing the delay between encoding and retrieval has a disruptive effect in the accuracy of the identification performance.

Furthermore, we cannot exclude that focusing on the ratings of the perceptual features of all the BOs in the lineup may have interfered with the ability to identify the target BO. If so, such interference effects were not able to disrupt the perceptual analysis of the BOs, whether target or foils. We hypothesized that the exposure to congruent contextual information at encoding and retrieval would facilitate the identification of the target BO over the foils, based on either odor intensity or arousal. Indeed, this hypothesis was confirmed. Receivers included in the C-C group, possibly due to the exposure to danger information (Li et al., 2007; Parma et al., 2015), were able to differentiate the target BO, rating it as significantly more intense and arousing than its foils. These results are in line with previous findings which indicate that we are able to explicitly report perceptual differences related to signals of danger embedded in BOs (Olsson et al., 2014). In fact, the congruent negative arousing context in the C-C group may have communicated the existence of threatening information inducing an increased attentive state, which consequently facilitated the detection of the target and is reflected in the intensity and arousal ratings. One might then

speculate that possibly instructing the receivers to focus on the BO intensity and arousal at encoding may facilitate an accurate retrieval of the BO information. Furthermore, even asking at retrieval to think of the intensity and arousal of the odor before selecting the target BO may improve identification accuracy. At present, these potential sensory-based strategies to improve odor memory accuracy are only hypothetical, but they set the stage for future studies on the topic.

As for most studies, also the present one is not free from limitations. Due to the target's statistically significant subjective ratings in terms of intensity and arousal in comparison to foils, besides collecting subjective ratings as in the present study, future studies should also collect physiological measures (e.g., heart rate, skin conductance) to investigate if the target BO in fact caused somatic alterations in receivers, even if they do not correctly explicitly recognize the target BO. Additionally, it would be interesting to study the effect of anxiety BOs collected in anxiety contexts in the BO recognition accuracy. Previous findings indicate that this type of BOs can lead the receivers to feel the same emotion as the donors, a condition that could possibly exploit emotional contagion and lead to a better performance in odor recognition (de Groot, Smeets, Kaldewaij, Duijndam, & Semin, 2012). Furthermore, we only contrasted negative and neutral emotional stimuli, not allowing to disentangle valence/arousal differences in memory retrieval, for which a positive condition would be required.

Taken together, these results confirm the dissociation between the ability to identify odors and to describe their perceptual features, and extend it to the BO domain. This difference supports the idea that despite the fact that we are able to discriminate BOs based on features such as intensity and arousal, we may not be able to correctly identify them, irrespective of the emotional context in which they are encoded or retrieved. In the effort of providing insights on how to promote strategies to improve BO identification accuracy, we highlight that even a slight increase in the delay between encoding and retrieval highly disrupts BO identification, and that focusing on perceptual features of the BO such as intensity and arousal may constitute a strategy to improve BO identification.

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## **Appendices**

## Appendix A

### Consentimento informado

No âmbito do desenvolvimento da Tese de Mestrado em Psicologia da Saúde e Reabilitação Neuropsicológica, que se encontra a decorrer na Universidade de Aveiro, orientada pela Professora Dr.<sup>a</sup> Sandra Soares, pretende-se recolher odores corporais de participantes voluntários. A recolha de odores corporais será realizada num único momento em contexto académico.

Todos os procedimentos e instruções foram expostos oralmente e/ou por escrito. Os dados recolhidos serão usados unicamente para fins de investigação e em momento algum será divulgada a identificação do voluntário.

Eu, \_\_\_\_\_, declaro que fui informado(a) acerca dos objetivos da recolha de odores corporais e dos procedimentos que serão realizados, comprometendo-me a cumprir as instruções fornecidas.

Compreendi as instruções e aceito, de livre e espontânea vontade, participar no estudo podendo, a qualquer momento, desistir do mesmo.

Data: \_\_\_\_\_

Assinatura:

\_\_\_\_\_

## Appendix B

### Formulário

#### Questões Demográficas e de Saúde

Por favor, responda às seguintes questões com sinceridade. Os dados recolhidos são confidenciais e, em momento algum, serão divulgados.

- Depois de ter lido as instruções que lhe foram fornecidas no Kit de participante, seguiu as seguintes regras?

Comeu alho, cebola ou comidas picantes? Sim \_\_ Não \_\_

Fumou durante o período de preparação? Sim \_\_ Não \_\_

Bebeu bebidas alcoólicas? Sim \_\_ Não \_\_

Tomou banho com o gel fornecido no seu kit? Sim \_\_ Não \_\_

Usou desodorizante/ perfume/ loções corporais ou outro tipo de hidratante ou produto para o corpo? Sim \_\_ Não \_\_

- Qual é a sua idade? \_\_\_\_\_

- Lateralidade: Dextro(a) \_\_ Canhoto(a) \_\_ Ambidextro(a) \_\_

- Qual é a sua Língua Materna? \_\_\_\_\_

- Qual é a sua raça? Caucasiana \_\_ Negra \_\_ Asiática \_\_ Outra \_\_

- Tem algum problema de saúde? De entre as seguintes hipóteses, assinale a(s) que se adequam a si:

Diabetes \_\_

Epilepsia \_\_

Endometriose \_\_

Doença de Addison \_\_

Problemas renais \_\_

Problemas da tiróide \_\_

Deficiências vitamínicas/minerais (ex: zinco, cálcio...) \_\_

Fibrose Cística \_\_

Cancro \_\_

Outra doença não listada. Qual? \_\_\_\_\_

7. Está a tomar alguma medicação (medicação prescrita, suplementos vitamínicos ou outros)? Em caso afirmativo, indique os nomes dos medicamentos que está a tomar.

---

---

8. É fumador(a)? Se sim, quantos cigarros fuma por dia e com que frequência?

---

9. Qual é a sua orientação sexual? Heterossexual \_\_\_ Homossexual \_\_ Bissexual\_\_



## Appendix C

### Consentimento Informado

No âmbito do desenvolvimento da Tese de Mestrado em Psicologia da Saúde e Reabilitação Neuropsicológica, que se encontra a decorrer na Universidade de Aveiro, orientada pela Professora Dr.<sup>a</sup> Sandra Soares, será realizada uma tarefa em laboratório que tem como objetivo principal investigar a importância dos odores no nosso dia-a-dia.

Todos os procedimentos e instruções foram expostos oralmente e/ou por escrito. Os dados recolhidos serão usados unicamente para fins de investigação e em momento algum será divulgada a identificação do voluntário.

Eu, \_\_\_\_\_, declaro que fui informado(a) acerca dos objetivos do estudo e dos procedimentos que serão realizados, comprometendo-me a cumprir as instruções fornecidas.

Compreendi as instruções e aceito, de livre e espontânea vontade, participar no estudo podendo, a qualquer momento, desistir do mesmo.

Data: \_\_\_\_\_

Assinatura:

\_\_\_\_\_

Pretende ter acesso aos resultados deste estudo? Sim \_\_\_ Não \_\_\_

Em caso afirmativo, deixe o seu email no espaço abaixo

\_\_\_\_\_

## Appendix D

### Formulário

#### Questões Demográficas e de Saúde

Por favor, responda às seguintes questões com sinceridade. Os dados recolhidos são confidenciais e, em momento algum, serão divulgados.

1. Em relação às regras que lhe foram dadas:
  - a. Fumou, bebeu álcool ou café? Sim \_\_\_ Não \_\_\_
  - b. Está a usar perfume? Sim \_\_\_ Não \_\_\_
2. Idade: \_\_\_\_\_
3. Sexo: Masculino \_\_\_ Feminino \_\_\_
4. Lateralidade: Dextro(a) \_\_\_ Canhoto(a) \_\_\_ Ambidextro(a) \_\_\_
5. Qual é a sua Língua Materna? \_\_\_\_\_
6. Qual é a tua raça? Caucasiana \_\_\_ Negra \_\_\_ Asiática \_\_\_ Outra \_\_\_
7. Tem algum problema de saúde? Em caso afirmativo indique qual ou quais.  
\_\_\_\_\_
8. Está a tomar alguma medicação (medicação prescrita, suplementos vitamínicos ou outros)? Em caso afirmativo, indique os nomes dos medicamentos.  
\_\_\_\_\_
9. É fumador(a)? Se sim, quantos cigarros fuma por dia e com que frequência?  
\_\_\_\_\_
10. Qual é a tua orientação sexual? Heterossexual \_\_\_ Homossexual \_\_\_ Bissexual \_\_\_

#### Apenas para as mulheres:

11. Suspeita de que possa estar grávida? Sim \_\_\_ Não \_\_\_
12. Já alguma vez esteve grávida ou deu à luz? Sim \_\_\_ Não \_\_\_
  - \* Se sim, **quando e como** é que a gravidez terminou? Selecione a opção: Nascimento \_\_\_ Aborto Espontâneo \_\_\_ Aborto provocado \_\_\_
  - \* Se já teve um filho, amamentou-o? Sim \_\_\_ Não \_\_\_  
Se já parou de o amamentar, quando é que isso aconteceu (indique o mês e o ano) \_\_\_\_\_
13. Está a usar atualmente algum contraceptivo oral (pílula)? Sim \_\_\_ Não \_\_\_
  - \* Se sim, qual a marca? \_\_\_\_\_
  - \* Se não, já usou algum contraceptivo oral nos últimos 12 meses? Sim \_\_\_ Não \_\_\_  
Se sim, que marca usou e quando parou? \_\_\_\_\_
14. Qual foi o primeiro dia da sua menstruação mais recente? \_\_\_\_\_
15. Qual é a duração média do seu ciclo menstrual? (Conte desde o primeiro dia de menstruação até à véspera do primeiro dia do ciclo menstrual seguinte).  
\_\_\_\_\_

**Appendix E**  
**Visual Analogue Scale (VAS)**

DATA: \_\_\_\_\_

HORA: \_\_\_\_\_

**NÍVEIS DE STRESS**

Muito stressado (10)

Nada stressado (0)



## Appendix F

### QUESTIONÁRIO DE AUTO-AVALIAÇÃO

Self-Evaluation Questionnaire

Desenvolvido por Charles D. Spielberger

STAI Form Y-1

INSTRUÇÕES: Em baixo tem uma série de frases que são habitualmente utilizadas para descrever pessoas. Leia cada uma delas e assinale com uma cruz (X) o algarismo da direita que melhor indica **como se sente neste momento**. Não há respostas certas ou erradas. Não demore muito tempo com cada frase; responda de modo a descrever o melhor possível a maneira **como se sente agora**.

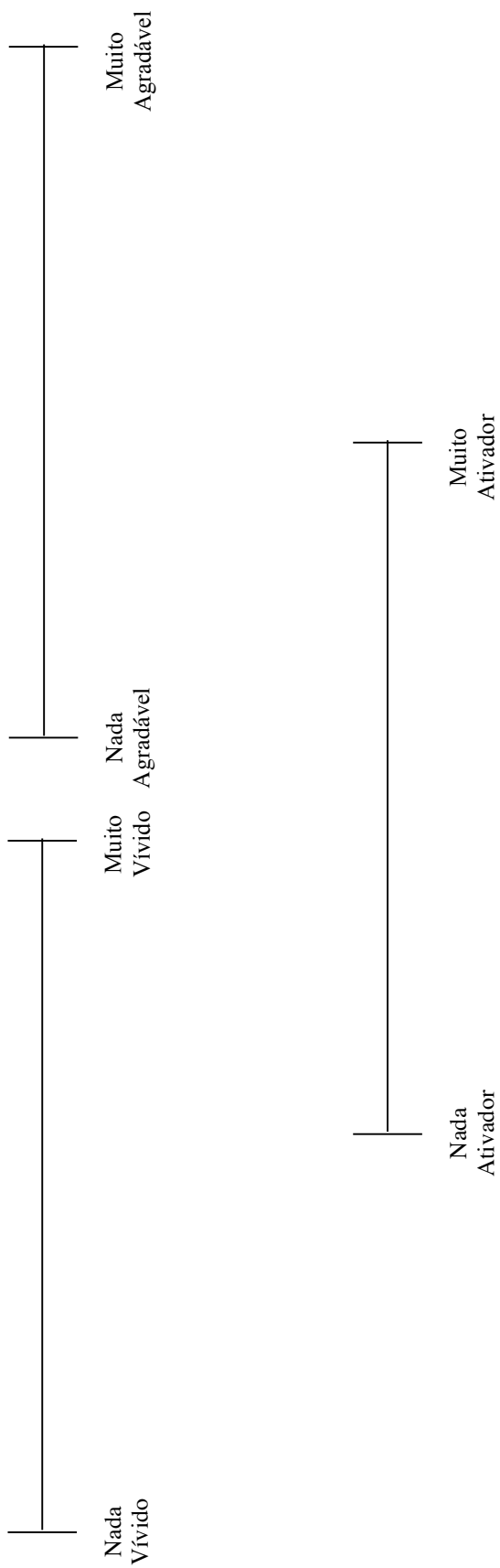
		Nada	Um pouco	Moderadamente	Muito
1.	Sinto-me calmo(a)	1	2	3	4
2.	Sinto-me seguro(a)	1	2	3	4
3.	Estou tenso(a)	1	2	3	4
4.	Sinto-me cansado(a)	1	2	3	4
5.	Sinto-me à vontade	1	2	3	4
6.	Sinto-me perturbado(a)	1	2	3	4
7.	Presentemente, preocupo-me com possíveis desgraças	1	2	3	4
8.	Sinto-me satisfeito(a)	1	2	3	4
9.	Sinto-me amedrontado(a)	1	2	3	4
10.	Sinto-me confortável	1	2	3	4
11.	Sinto-me auto-confiante	1	2	3	4
12.	Sinto-me nervoso(a)	1	2	3	4
13.	Sinto-me trémulo(a)	1	2	3	4
14.	Sinto-me indeciso(a)	1	2	3	4
15.	Sinto-me descontraído(a)	1	2	3	4
16.	Sinto-me contente	1	2	3	4
17.	Sinto-me preocupado(a)	1	2	3	4
18.	Sinto-me confuso(a)	1	2	3	4
19.	Sinto-me firme	1	2	3	4
20.	Sinto-me bem	1	2	3	4

**Appendix G**

Avalie o filme a que assistiu

**FILME** \_\_\_\_\_

**(1)**



Avalie o filme a que assistiu

**FILME** \_\_\_\_\_

(2)

_____	_____	_____
Nada Vívido	Muito Vívido	Nada Agradável
		Muito Agradável
_____	_____	_____
Nada Ativador		Muito Ativador

## Appendix H

### QUESTIONÁRIO DE AUTO-AVALIAÇÃO

Self-Evaluation Questionnaire

Desenvolvido por Charles D. Spielberger

STAI Form Y-2

INSTRUÇÕES: Em baixo tem uma série de frases que são habitualmente utilizadas para descrever pessoas. Leia cada uma delas e assinale com uma cruz (X) o algarismo da direita que melhor indica **como se sente habitualmente**. Não há respostas certas ou erradas. Não demore muito tempo com cada frase; responda de modo a descrever o melhor possível a maneira **como se sente habitualmente**.

		Nada	Um pouco	Moderadamente	Muito
21.	Sinto-me bem	1	2	3	4
22.	Sinto-me nervoso(a) e agitado(a)	1	2	3	4
23.	Sinto-me satisfeito(a) comigo mesmo(a)	1	2	3	4
24.	Gostava de poder ser tão feliz como os outros parecem ser	1	2	3	4
25.	Sinto-me falhado(a)	1	2	3	4
26.	Sinto-me tranquilo(a)	1	2	3	4
27.	Estou “calmo(a), fresco(a) e concentrado(a)”	1	2	3	4
28.	Sinto que as dificuldades se acumulam de tal forma que não as consigo ultrapassar	1	2	3	4
29.	Preocupo-me demais com coisas que na realidade não têm importância	1	2	3	4
30.	Estou feliz	1	2	3	4
31.	Tenho pensamentos que me perturbam	1	2	3	4
32.	Falta-me auto-confiança	1	2	3	4
33.	Sinto-me seguro(a)	1	2	3	4
34.	Tomo decisões facilmente	1	2	3	4
35.	Sinto-me inadequado(a)	1	2	3	4
36.	Estou contente	1	2	3	4
37.	Passam-me pela cabeça pensamentos sem importância que me perturbam	1	2	3	4
38.	As contrariedades afectam-me de modo tão intenso que não consigo afastá-las da minha mente	1	2	3	4
39.	Sou uma pessoa firme	1	2	3	4
40.	Fico tenso(a) e perturbado(a) quando penso nas minhas preocupações e interesses pessoais	1	2	3	4

## Appendix I

### **INVENTÁRIO DEPRESSIVO DE BECK** **(BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961)** **(Tradução e adaptação Pedro Nobre, 2003)**

**Este questionário é composto por grupos de afirmações. Por favor leia atentamente cada grupo e escolha a afirmação que para cada grupo descreve melhor a forma como se tem vindo a sentir durante a última semana (incluindo hoje). Coloque um círculo no número correspondente à afirmação escolhida. Escolha apenas uma afirmação para cada grupo. Por favor confirme se leu todas as afirmações em cada grupo antes de responder.**

- |   |
|---|
| 0. Não me sinto triste  |
| 1. Ando "neura" ou triste   |
| 2. Sinto-me neura ou triste todo o tempo e não consigo evitá-lo             |
| 3. Sinto-me tão triste ou infeliz que não consigo suportar mais este estado |

- |  |
|--|
| 0. Não estou demasiado pessimista nem me sinto desencorajado em relação ao futuro        |
| 1. Sinto-me desencorajado em relação ao futuro   |
| 2. Sinto que não tenho nada a esperar do futuro  |
| 3. Não tenho qualquer esperança no futuro e penso que a minha situação não pode melhorar |

- |   |
|---|
| 0. Não me sinto um fracassado   |
| 1. Sinto que tive mais fracasso que a maioria das pessoas                               |
| 2. Quando analiso a minha vida passada, tudo o que noto são uma quantidade de fracassos |
| 3. Sinto-me completamente falhado como pessoa (pai, mãe, marido, mulher)                |

- |  |
|--|
| 0. Tenho tanta satisfação com as coisas como anteriormente           |
| 1. Não tenho satisfação com as coisas que me alegravam anteriormente |
| 2. Não consigo obter verdadeira satisfação seja com o que for        |
| 3. Sinto-me descontente com tudo                                     |

- |   |
|---|
| 0. Não me sinto culpado por nada em particular      |
| 1. Sinto grande parte do tempo que sou culpado      |
| 2. Sinto-me bastante culpado a maior parte do tempo |
| 3. Sinto-me sempre culpado                          |

- |   |
|---|
| 0. Não sinto que esteja a ser vítima de algum castigo |
| 1. Tenho o pressentimento que posso ser castigado     |
| 2. Penso que no futuro serei castigado                |
| 3. Sinto que estou a ser castigado                    |

- |   |
|---|
| 0. Não me sinto descontente ou desapontado comigo |
| 1. Estou desiludido comigo                        |
| 2. Estou bastante desgostoso comigo               |
| 3. Odeio-me                                       |

- |   |
|---|
| 0. Não sinto que seja pior do que qualquer outra pessoa   |
| 1. Critico-me a mim mesmo pelas minhas fraquezas ou erros |
| 2. Estou sempre a culpar-me pelas minhas próprias faltas  |
| 3. Acuso-me por tudo de mal que acontece                  |

- |  |
|--|
| 0. Não tenho quaisquer ideias de fazer mal a mim próprio                   |
| 1. Tenho ideias de pôr termo à vida, mas não seria capaz de as concretizar |
| 2. Gostaria de por termo à minha vida                                      |
| 3. Matar-me-ia se tivesse oportunidade                                     |



0. Actualmente não choro mais do que o costume
1. Choro agora mais do que o que costumava
2. Actualmente passo o tempo a chorar
3. Costumava ser capaz de chorar, mas agora não consigo, mesmo quando tenho vontade

0. Não fico agora mais irritado do que ficava
1. Fico aborrecido ou irritado mais facilmente do que ficava
2. Sinto-me permanentemente irritado
3. Já não consigo ficar irritado por coisas que me irritavam anteriormente

0. Não perdi o interesse que tinha nas outras pessoas
1. Actualmente sinto menos interesse pelos outros do que costumava ter
2. Perdi quase todo o interesse pelas outras pessoas
3. Perdi por completo o interesse pelas outras pessoas

0. Sou capaz de tomar decisões tão bem como antigamente
1. Actualmente evito tomar decisões mais frequentemente do que antes
2. Tenho mais dificuldade em tomar decisões do que anteriormente
3. Sinto-me completamente incapaz de tomar qualquer decisão

0. Não acho que tenho pior aspecto do que costumava
1. Estou preocupado porque estou a parecer velho e pouco atraente
2. Sinto que se deram modificações permanentes na minha aparência que me tornam pouco
3. Sinto que sou feio ou que tenho um aspecto repulsivo

0. Sou capaz de trabalhar tão bem como antigamente
1. Agora preciso de um esforço maior do que dantes para começar a trabalhar
2. Tenho de despender um grande esforço para fazer seja o que for
3. Sinto-me incapaz de realizar qualquer trabalho por mais pequeno que seja

0. Consigo dormir tão bem como dantes
1. Não durmo tão bem como costumava
2. Acordo cerca de 1-2 horas mais cedo do que é costume e custa-me voltar a adormecer
3. Acordo todos os dias várias horas mais cedo do que o costume e não consigo voltar a dormir

0. Não me sinto mais cansado do que o habitual
1. Fico cansado com mais facilidade do que antigamente
2. Fico cansado quando faço seja o que for
3. Sinto-me tão cansado que sou incapaz de fazer o que quer que seja

0. O meu apetite é o mesmo de sempre
1. O meu apetite não é tão bom como costumava ser
2. Actualmente o meu apetite está muito pior do que anteriormente
3. Perdi por completo todo o apetite que tinha

0. Não tenho perdido muito peso, se é que perdi algum, ultimamente
1. Perdi mais de 2,5 quilos de peso
2. Perdi mais de 5 quilos de peso
3. Perdi mais de 7,5 quilos de peso

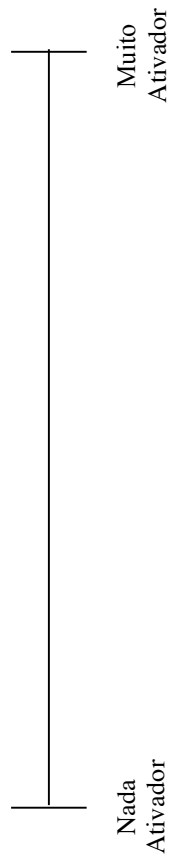
0. A minha saúde não me preocupa mais do que o habitual
1. Sinto-me preocupado com a minha saúde, com dores e sofrimento, com má disposição de estômago ou prisão de ventre ou ainda outras sensações físicas desagradáveis
2. Estou muito preocupado com a minha saúde e torna-se difícil pensar noutra coisa
3. Estou tão preocupado com a minha saúde que não consigo pensar noutra coisa

0. Não notei qualquer mudança recente no meu interesse pela vida sexual
1. Tenho menos interesse pela vida sexual do que costumava ter
2. Actualmente sinto-me muito menos interessado pela vida sexual
3. Perdi completamente o interesse que tinha pela vida sexual

**Appendix J**

Avalie o odor a que esteve exposto pela ordem apresentada

**ODOR FRASCO 1**



**ODOR FRASCO 2**



Avalie o odor a que esteve exposto pela ordem apresentada

**ODOR FRASCO 3**



**ODOR FRASCO 4**



Avalie o odor a que esteve exposto pela ordem apresentada

**ODOR FRASCO 5**

