RUNNING HEAD: PHEROMONES AND EMOTIONS

Behavioural responses, Mood changes and Psychophysiological effects of *androstadienone*: Increased emotional sensitivity?

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Abstract

Scientific evidence for possible effects of human pheromones is still scarce and under dispute, even if generally accepted by the layman. In two experiments we tested the emotional effects of exposure to a putative human pheromone, *androstadienone*, on female participants, using psychophysiological parameters together with verbal affective ratings. In the first study, a controlled social interaction was used to examine possible effects of *androstadienone* on flirting behaviour. In general, no differences between the experimental and the control group were obtained; instead a heightened flirting behaviour was associated with the fertile phase of the menstrual cycle.
In the second experiment, effects of *androstadienone* on peripherical psychophysiological measures were scrutinized. Sixty-four female participants were exposed to a series of emotional pictures while their skin conductance, heart rate, and the startle reflex were monitored. The main difference obtained between groups was that the experimental group presented larger modulation of the startle reflex as a function of the valence (positive vs. negative) of the pictures. One possible explanation is that *androstadienone* increases the sensitivity to emotional material.

Keywords: Pheromones, *androstadienone*, autonomic responses, startle reflex, emotional sensitivity, mood.

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The existence of inborn mechanisms to promote approach to the opposite sex makes sense from an evolutionary perspective, although the irrational character frequently observed in human choices on that topic is sometimes surprising. For centuries, and long before Shakespeare's Romeo and Julia, literature has described and tried to make sense of the matters of passion. In fact, the possibility of explaining the mysteries of human attraction in a simple formula is a tempting goal.

Human pheromones have been a popular candidate for that endeavour in the last decades. "Explain love and attraction with basic chemical principles" – what a discovery! Since Karlson and Luscher (1959) introduced the concept of pheromones, fifty years ago, many attempts have been made to replicate on human beings what was observed in other mammalians. The authors defined pheromones as "airborne chemical signals produced by an individual of a species that trigger neuroendocrinal responses underlying behaviour, or development in another individual of the same species" (Karlson & Luscher, 1959). This triggering function has been observed in many other species. Sometimes an immediate response is elicited within seconds or minutes, as in the case of the release of *androstenon* by male pigs causing a freezing response of the female that makes possible the penetration (Melrose, Reed, & Patterson, 1971), other times the process is slower, like the abortive effect that the smell of the urine of an unknown male rat has on a pregnant female, known as the Bruce effect (Bruce, 1959). The first case, an immediate response triggered by the so called releasing pheromones, has not been observed in humans and it is unlikely that it would be. However, some evidence has been claimed for a priming effect in humans. The most known example is the synchronization of the menstruation cycle by women that live together during

several months, also known as the menstrual synchrony, the dormitory effect or McClintock effect (McClintock, 1971); for a review see (Wyatt, 2003).

Nevertheless, the existence of direct stimulus–response associations in humans is less plausible and does not fit the relatively well controlled processing taking place at the frontal lobe. More interesting might be the two other classes of pheromones that have been described in the literature: Signal pheromones, in which some information is transmitted to the other individual, for example about genetic compatibility/incompatibility (e.g., Wedekind & Furi, 1997) and the so called modulator pheromones (Jacob & McClintock, 2000), responsible for changes in the processing of ongoing information, for example giving some stimuli more or less salience in specific situations. In humans, the most known phenomenon claimed to be caused by a signal pheromone, is the observed preference for t-shirts with body smell of the opposite sex with a *human leutocyte antigen* (HLA) composition that can be considered healthier (i.e., different from the partner) (Wedekind & Furi, 1997).

Nowadays a well accepted idea is the influence, in a subtle and often non-conscious way, of non-verbal information on our moods, emotions and behaviour within social context. What still is to be proven is that at least part of that information can be ascribed to chemical substances, that through our evolution, and before other more conscious and controlled mechanisms have been developed, has been used in order to maximize the potential reproduction of the human species.

If the exposure to pheromones can cause changes in the way emotional information is processed, than these effects should be studied in the three response output systems (Lang, 1978). Firstly, there might be mood effects that are consciously perceived, albeit not consciously attributed, and that can be verbally reported. Secondly, there might be behavioural responses with enough intensity to be observed by others.

Thirdly, and probably more interesting because it is less influenced by social desirability, is the possibility of observing these effects in the patterns of the psychophysiological components of the emotional responses, in general automatic processes that occur independently of our awareness.

The main purpose of the two studies to be presented below is to test these possible influences. In the first experiment, a social situation with pairs of male-female participants was manipulated in order to see if there were any effects of pheromone exposure in the flirting behaviour during their interaction. In the second study, psychophysiological responses were registered while participants were exposed for different categories of emotional pictures. In both studies, half of the group was exposed to *androstadienone* while the other half received a non-active control substance.

The choice of *androstadienone*, a steroid that has been isolated from the human skin (Preti & Wysocki, 1999), was mainly due to the fact that *androstadienone* has gathered evidence for several characteristics that are necessary conditions for a substance to be considered a pheromone. First, *androstadienone* exists in humans, and although it has been found in women, it has been obtained in larger concentrations on men (Hummel, Krone, Lundström, & Bartsch, 2005). Secondly, effects on other human beings have been observed. For example, positive mood changes have been found in women after exposure to *androstadienone* (Lundström, Gonçalves, Esteves, &Olsson, 2003). Third, there is evidence for a sex-specific differentiation in the hypothalamic activation of male and female participants, with only female being activated by this "male pheromone" (Savic, Berglund, Gulyas, & Roland, 2001). Furthermore, and not surprisingly giving these results, *androstadienone* is the most used and the best candidate to be a male pheromone. However, to our knowledge, empirical evidence for behavioural changes has not been attained.

Experiment 1

That our behaviour is dependent on the social context is a well known fact, for example, the way we can adapt our conduct in social interactions in order to give a positive impression. Nevertheless, can we manipulate this effect chemically? Can the exposure to a putative human pheromone change our overt behaviour? Can this effect, albeit discreet, be observed by others?

In our daily life, one of the ways to interact with members of the opposite sex is flirt. Difficult to define it scientifically, the class of behaviours generally called "flirt" can be observed observe in social interactions around us. Could it be so that pheromones can, at least in part, facilitate flirt behaviour? The aim of the first study was to test this hypothesis.

Participants were randomly distributed between two groups, one was exposed to *androstadienone* and the other one to the oil used to dilute the concentration of *androstadienone* (propanediol). Furthermore, as the phase of the menstruation cycle might be relevant to possible effects of this kind, for example Lundström, McClintock and Olsson (2006), have shown that women have better sensibility to some odours during the fertile phase, information about the phase of the menstrual cycle was gathered. As it has been shown that this modulation tends to disappear when women are using hormonal contraceptives (Grammer, 1993), only women that were not taken hormonal contraceptives were enrolled.

Method

Participants

Sixty-five male and 65 female, aged 19-34 (mean 23 years), were randomly assigned to the experimental group (exposure to *androstadienone*) (n = 32) or the control condition (n = 33). None of the women were taking hormonal contraceptives

and reported a normal menstrual cycle. Data on their menstrual were collected (see Table 1). All described themselves as heterosexual, and considered to have normal odour capacity.

Materials

Androstadienone was obtained from Steraloids INC. (catalogue number A570) with a purity of 98%. It was diluted at a university chemical laboratory in mineral oil (1.2 propanediol), in order to obtain a concentration of 250 micro M concentration of *androstadienone*. An odour mask, consisting in clove oil with 98% purity, was added to the solution. The control substance consisted on only propanediol and clove oil. Both solutions were prepared in identical vials and distributed in small identical bottles by a chemist, coding the two solution with A and B, and revealing the code only after the experiment was concluded.

For the examination of flirting behaviour, an observation sheet was elaborated based on the different behaviour referred in the literature. (e.g., Grammer, Kruck & Magnusson, 1998; Moore, 1985).The behaviours were: Primping, Coy smile, Illustrator, Head tilt, Synchronization of movements, Hair flip, Object caress, Lean toward other, Brushing, Aid solicitation, Space maximization, Automanipulations, Head akimbo, Look up, Open body position, and Eye contact. Furthermore, the observer had to evaluate other behaviours that could be informative about possible effects of *androstadienone*. By means of visual analogue scales also evaluated, the degree of fun that participants seemed to have, how much they focused on the task and on the other person, if they showed a dominating attitude, and their level of mutual attraction and collaboration.

Procedure

Participants were randomly assigned to the experimental group (exposed to *androstadienone*) or the control condition. Pairs of two (one man and one woman) were formed, and instructed by two double-blind female experimenters to perform two collaborative tasks. The first task consisted on a "guess game", in which one of the pair of participants had to deduce the name of a known person by asking several yes and no questions. After correct identification, the participants changed roles and the procedure was repeated for 10 minutes. The second task was an exercise based on the prisoner's dilemma. During 10 minutes the pair had to discuss the solution of the dilemma. The pairs were left alone in the experimental room and videotaped during both tasks.

The videotapes were analyzed afterwards by two raters (one male, one female that were not involved in the data collection phase) on non-verbal signs of flirting behavior using the predefined list. The frequency of specific behaviors (e.g., object caress, lean toward the other) was registered, and the subjective ratings (e.g., focus on task, attraction to the other) were also collected by means of visual analogue scales. The two observers did this analysis independently of each other.

Results

Data from the two observers were merged into one database. In general, the degree of concordance was acceptable ($r = .69$); with the exception of the category "head tilt" which showed clear divergent evaluations; therefore this behavior was excluded.

Because some of the variables had different metrics (objective frequency of behaviors and subjective evaluations), standardized Z scores were calculated and used in all the statistical analyses.

In order to analyze the existence of differences in flirtatious behavior between the experimental group and the control group, as a function of sex of the participant and

menstrual cycle phase, a MANOVA (Sex *x* Menstrual cycle phase *x* Exposure condition) was performed on all flirt behaviours (see Table 2).

Main effects of Sex and Menstrual phase were obtained (F (1,128) = 2.96 and 2.46, respectively), and post-hoc tests revealed that three flirt behaviors differed significantly ($p<.05$) between the sexes: Whereas hair flip were unusual among men, space maximization was a typical male behavior. The fertile phase of the menstrual cycle was for the couples associated with significantly higher flirting behaviors (synchronization, auto manipulations, and head akimbo) and also statistical tendencies for higher flirting behaviors in the case of primping and brushing). Only aid solicitation was lower in the sexual phase. Exposure to *androstadienone* was associated with mixed effects: significantly less synchronization and head akimbo were observed, whereas frequency of illustrations was increased. Interestingly, we also found a tendency for *androstadienone*-exposed couples to solicit more aid. The only significant two-way interaction observed stated that *androstadienone* depressed the increase in head akimbo that was observed for couples in the fertile phase. MANOVAs for each sex with post-hoc pairwise testing of individual flirt variables showed that it was primarily the women that contributed to the above effects.

As different behavioural patterns were observed for the flirting behaviours; separate factor analyses were run for each sex. Principal component analysis for flirting behaviours of women is seen in Table 3 (left side). Factor scores were submitted to a MANOVA. Menstrual phase and Exposure condition tended both to matter (both *p*'s = .07). Post-hoc tests indicated that phase tended to differ for Factor3 ($p=.07$) and exposure differed for Factor 1 ($p=.03$).

A principal component analysis of male flirting behaviour contributed to a different result (Table 3, right) indicating that flirting differs between men and women.

The factor scores were submitted to a MANOVA. For women, menstrual phase tended to matter (p = .07), but no effect was found for Exposure (p = .66). Post-hoc tests indicated that menstrual phases differ significantly for Factor 3 (p = .008), no other significant differences were found.

For the qualitative judgments, the MANOVA indicated a main effect of menstrual phase, albeit marginally significant (p=.06). Contrary to recent results showing an association between *androstadienone* and increased attraction in a speed dating set up (Saxton, Lyndon, Little, & Roberts, 2008 (Saxton, Lyndon, Little, & Roberts, 2008), in the present study, attraction as judged by the observers was nominally lower in couples that were exposed to *androstadienone*.

Discussion

Based on a general assumption about the possible role of pheromones on approach behavior facilitation in social situations, the aim of this experiment was to test the possibility that exposure to *androstadienone* could influence (i.e. boost) flirting behavior in a controlled interaction between two young adults of opposite sex. In general, our results did not support this hypothesis. The pattern of the few differences obtained between the two exposure conditions is difficult to interpret and can not be associated with a facilitation or inhibition of flirting behavior within couples. Instead, an interesting effect was obtained when taking into account the phase of the menstrual cycle of the women. The pairs whose women were in the fertile phase of the menstrual cycle showed higher frequencies on several categories of flirting behaviour (e.g., synchronicity between the couple was heightened compared to the pairs in which the women were not on the fertile phase). This pattern, congruent with what should be expected from an evolutionary perspective, is consistent with empirical data showing an

increase interest in sexuality during the fertile phase (e.g., (Graham, Janssen, & Sanders, 2000).

Although possible changes due to *androstadienone* could not be conveyed through overt behaviour observable by others, the possibility that there were some effects on the emotional processing of the participants could not be ruled out. In that case, psychophysiological measures can be considered the treatment of choice to detect these subtle variations. Therefore, in Experiment 2 changes in the pheripheral nervous system were recorded.

Experiment 2

Considering the possibility that *androstadienone* could influence mood and the emotional responding of the participants in other ways than through overt behaviour, Experiment 2 expanded the dependent measure repertoire to the two other systems generally used to evaluate emotional responses: psychophysiological changes and verbal evaluations (cf. Lang, 1978). Thus, the aim of the second experiment was to test possible effects of *androstadienone* on psychophysiological measures (heart rate, skin conductance, and startle reflex modulation) and mood changes (verbal evaluation). In order to evoke emotional reactions, the picture viewing paradigm was used, i.e. a series of emotional pictures was presented while their psychophysiology was monitored. Furthermore, participants had to evaluate the emotional content of the pictures, as well as their own mood before and after the experiment. Similar to Experiment 1, half of the participants were exposed to *androstadienone* while the others represented the control condition.

Method

Participants

Sixty-four female participants (mean age 22.32 years) were randomly assigned by two double-blind male experimenters to the experimental group (exposed to *androstadienone*) or a control condition. Participants were mainly college students, almost all considered themselves heterosexual (there were two bisexuals, one in each group), and referred no olfactory problems. They were paid 5 euro for their participation.

Materials

Odour solutions. Androstadienone was obtained from Steraloids INC. and prepared in a similar way as the procedure used in Experiment 1, as well as the control substance. Once again, a double-blind procedure was implemented, the code for which substance was the putative pheromone was unknown not only for participants but for the all research team until the initial statistical analysis of the data was completed.

Emotional pictures. Twenty-five pictures taken from the International Affective Picture System (IAPS, (Lang, Bradley, & Cuthbert, 2008) were used. The pictures were chosen depending on their affective valence (positive, negative and neutral), with the particularity that all emotional images depicted human social interactions. Two categories of positive pictures were used: erotica and affiliative social interactions between heterosexual couples, five exemplars of each. The same total number of negative pictures (10) was used, illustrating scenes of violence targeting humans (e.g., men attacking women). Finally, five neutral pictures, representing household objects, were also selected. Each picture was exposed for 6 seconds, with an inter-stimulus-interval of about 10 seconds, and the order of presentation was randomized. E-Prime was used for the presentation of the visual stimuli and registration of the verbal ratings.

Verbal ratings. To evaluate the affective valence, the arousal, and the degree of control/dominance experienced by the participants while viewing the images, the Self-

Assessment Manikin (SAM; (Bradley & Lang, 1994) was used. These verbal ratings are 9-point pictorial scales, with a happy/pleasant humanoid at one end and a sad/unpleasant at the other extremity for the affective valence scale. For the arousal scale, the range went from calm to an excited drawing; and for the dominance scale the extremities show a little or a big humanoid, corresponding to low or high control of the situation/picture. High scores indicate higher positive valence, higher arousal, and more dominance. Being a measure very easy to implement, and not depending upon language (avoiding the resulting translation problems), SAM was the measure chosen. Furthermore, it is widely used, and has previously shown to have good psychometric qualities, namely convergent validity (Bradley & Lang, 1994).

To evaluate mood, both before and after the experiment, a questionnaire consisting of eight visual analogue scales was used in order to test possible mood changes due to *androstadienone*. Participants had to place a mark on a 10 cm horizontal line, according to how much they were feeling the following eight different "moods": social, open, heavy, focused, sensual, energetic, angry, and relaxed. Visual analogue scales have been used in previous research about pheromones (e.g., (Jacob & McClintock, 2000)), and the chosen adjectives are the same used before by our research group (e.g., (Olsson, Lundstrom, Diamantopoulou, & Esteves, 2006)

Psychophysiological measures. All measures were recorded continuously during the experimental session using MP100 Biopac Hardware (Biopac Systems, Santa Barbara, CA, USA) with a 1000 HZ sampling rate, and analyzed with *Acknowledge* 3.7.2 software (Biopac Systems, Santa Barbara, CA, USA).

Skin conductance responses (SCRs), considered a direct measure of the general sympathetic nervous system activity (e.g., (Dawson, Schell, & Filion, 2000), were recorded by means of two surface Ag/AgCL electrodes, filled with K-Y lubricating

jelly, with a diameter of 0.8 mm, and placed on the second phalanx of the index and middle fingers of the left hand. SCRs were defined as the largest response initiated in the interval 1-4 seconds after stimulus onset. In order to normalize the distribution, SCR values were log transformed [log (SCR + 1)] before the statistical analysis.

Standard Lead II disposable electrodes were used for electrocardiographic data. Two Ag/AgCl electrodes, 4 mm diameter and already prepared with electrolyte paste, were attached to the left and right forearms and a third one on the left ankle. Changes in heart rate from baseline were analyzed for the 6 seconds picture exposure.

Eyeblink responses were recorded from the orbicularis oculi muscle. Raw EMG signals were amplified and band pass filtered 90-1000 Hz online and afterwards rectified and integrated using the *Acknowledge* software. Blink magnitude peak in the interval 20-170 ms after onset was scored for each probe acoustic stimulus. Following the usual procedure, the raw values were standardized (Z-scores) and transformed to T-scores (e.g., (Levenston, Patrick, Bradley, & Lang, 2000). In order to elicit the startle reflex, acoustic startle probes (white noise presented at 95 Db, 50 ms duration, and instantaneous rising time) were presented binaurally in 80 percent of the trials, i.e., 20 of the 25 pictures, either 2000, 2500 or 3500 ms after picture onset. Another five probes were presented during the inter trial interval.

Procedure

Depending on their experimental condition, which was previously randomized, and after the initial introduction and the signature of the informed consent, the solution was administered by smearing the upper lip with either *androstadienone* or the control oil. Afterwards participants had to fill the mood analogue scales for the first time, were sited in an armchair in front of the screen, and the electrodes were attached. They were instructed to look at the pictures the entire time they were exposed on the screen, and to

ignore the acoustic noises presented via headphones. They were also instructed about the SAM scale and the way they should give their answers using the keyboard by pressing the 1 to 9 keys. After the experiment, participants had to fill again the mood rating scales, and finally a discrimination test was performed. To ensure that participants could not discriminate the two solutions, they were asked to smell three different small bottles containing these two solutions (e.g., two bottles with A and one with B) and to identify the solution with a different smell form the other two. This procedure was repeated nine times (cf. Lundstrom, Gonçalves, Esteves, & Olsson, 2003).

Results

Subjective evaluations of the emotional pictures

In order to test the possibility that exposure to *androstadienone* could change the way emotional pictures were perceived, 2x4 mixed ANOVAs were performed separately for the three dimensions of the SAM evaluations. Experimental condition was a between-subject factor and Emotional category (violence, neutral, erotic and affilative) was a repeated measure.

For the affective valence, as expected, participants rated the violence pictures more negatively, pleasant pictures (both erotica and affiliative) more positively, and the neutral in between, as expressed by a main effect of Emotional category, $F(3,174) = 290.07$, $p<.0001$ (see Figure 1). No other significant effects were obtained, although there was a tendency for an interaction, $F(3,174) = 2.26$, $p=.08$, and as it can be seen in Figure 1, the experimental group rated the violence pictures less negatively than the control group.

The analysis of the arousal and dominance ratings showed only main effects of Emotional category, $F(3,174) = 56.15$, and 39.76, $p<.0001$, respectively. Neutral

pictures were those that evoked lower arousal and the violence and erotic images were classified as more intense (see Figure 2). Regarding the dominance dimension of emotions, violent pictures were associated with less control compared to the three other categories (see Figure 3).

To analyse if there could be a subtle effect of the experimental manipulation in the time participants took to evaluate the pictures, a similar ANOVA, 2x4, was conducted for the viewing times. Again, only the Emotional category differentiate the responses, F (3,174) = 7.93, and 39.76, p<.0001, being the erotic pictures those that took longer viewing time and the neutral ones associated with the quickest evaluation responses (see Figure 4).

Mood

To investigate possible mood effects of the exposure to *androstadienone*, a score was computed subtracting the first answer from the second one for the eight visual analogue scales. Positive values implied that the second evaluation was higher than the first one, i.e., that there was a shift towards a more intense evaluation of that emotional state. Negative values indicate the reverse. Experiment and control groups were compared by means of independent t-tests on the eight adjectives. No difference reached the .05 level of significance; however, two unexpected tendencies (p<.10) were observed: Participants submitted to *androstadienone* considered themselves as more angry after the exposure, while the control group felt more sensual (see Figure 5).

Psychophysiological measures

Regarding Skin Conductance Responses (SCRs), a 2x 3 ANOVA was performed on SCR magnitude, collapsing the two positive categories (erotic and positive affect) in order to compare positive, negative and neutral pictures as a function of experimental condition. No effects were obtained at .05 significance level; however, there was a

tendency for a main effect of Experimental condition, F (2,98) = 2.97, p<.06. In general, the means for SCRs to in the Experimental group were lower than the means of the Control group see Figure 6).

Finally, a 2x4 ANOVA was performed to analyse possible effects of *androstadienone* on the modulation of the startle reflex. A main effect of Emotional category was observed, F (3,129)=6.17, p<.001. The expected inhibition of the reflex, when the acoustic probe was elicited, while participants viewed positive pictures was observed; however, no effect of the experimental condition and no interaction were found. In order to better explore the differences on startle reflex between positive and negative pictures, which is a very robust effect replicated with different kinds of stimuli and, that also has been obtained with odour stimuli (e.g. (Ehrlichman, Brown, Zhu, & Warrenburg, 1995), a new 2x2 ANOVA was run with the Exposure condition and Emotional content (positive vs. negative) as variables. Again, the main effect of Exposure condition emerged, F (1,43) = 9.04, p<.01, but most relevant, there was an significant interaction between these two factors, F (1,43) = 4.40, p<.05. As it can be seen in Figure 7, the differentiation between positive and negative pictures, with smaller responses to pleasant stimuli, is clearer in the group submitted to *androstadienone*.

Discussion

The aim of Experiment 2 was to investigate possible effects of androstadienone in the processing of emotional pictures when compared to a control group. Using both pleasant and unpleasant images, we scrutinised whether: a) emotional stimuli could be perceived in a different way, as reflected by participant's verbal evaluations, b) the psychophysiological pattern of responding to the pictures could be different, and c) self-reported mood could be influenced by the experimental manipulation.

In general, differences attributable to the putative pheromone were small and somehow contradictory. First, there was a trend for an interaction in the valence evaluation of the pictures, with reduced differentiation in the experimental group compared to the control group that could be interpreted as inhibitory effect of *androstadienone* on emotional responding. However, the differentiation observed on the startle modulation goes on the opposite direction. Here, it seems that the exposure to the experimental substance enhances the differentiation between positive and negative stimuli, i.e., an increased sensitivity to differentiate pleasant and unpleasant emotional content. However, and unexpectedly, although not significantly, the skin conductance data could be interpreted as lower sympathetic activation in the experimental group.

General discussion

The aim of the present study was to test the possibility of emotional effects of a putative human pheromone – *androstadienone*. First, using an experimental setting that intended to be closer to a natural situation with two participants of opposite sexes, we expected to have some effects that could be observed by independent judges on flirting behaviours. However, despite some behavioural differences between male and female participants, no general effect of *androstadienone* was obtained. The second experiment aimed to test other possible outputs of emotional reactions, namely verbal evaluations and psychophysiological changes (c.f. Lang, 1978). Here a more classical experiment was run, being participants individually exposed to the putative pheromone or a control substance using the picture viewing paradigm. Although we must be careful in the interpretation of the findings, especially considering the scarce statistical support, some evidence can be said that has been obtained for a possible role of *androstadienone* as a modulator pheromone. In fact, it seems that the exposure to this putative pheromone might increase the psychophysiological sensitivity to the emotional content of the

individual. Interestingly, at the same time, that was a tendency for a reduction of the verbal discrimination. If this later effect reflects some (non-conscious) mechanism to compensate for the increased sensitivity, is a question that our data does not allow to answer. Nevertheless, it is an interesting hypothesis that deserves further scrutiny.

Another result that is puzzling is the tendency for lower skin conductance responses in the group exposed to *androstadienone*. How can we conciliate this general inhibitory effect on the sympathetic nervous system with the enhanced sensitivity to emotional information showed by the startle results? Could it be related to the focusing effect previously obtained in other studies (Lundström et al., 2003)? Unfortunately, our participants did not reveal mood changes regarding their capacity of focusing, so our data does not allow the exploration of these hypotheses; however it seems that further studies should go further testing these noticeable contradictions.

Another important effect observed in study 1 was the difference in flirting behaviour between the pairs in which the woman was in the fertile phase of the menstrual cycle, compared to those that were in the non-fertile phase. This is what should be expected from an evolutionary perspective (e.g., Graham et al., 2000), and it is interesting to note that the effects were obtained through blind observers.

Summing up, although the effects of our putative pheromone were small and with some unsolved contradictions, they seem to be an argument for *androstadienone* being a modulator pheromone. In this sense, the results are relevant and should deserve further scrutiny.

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Table 1. Experimental design and number of couples in each condition (Experiment 1).

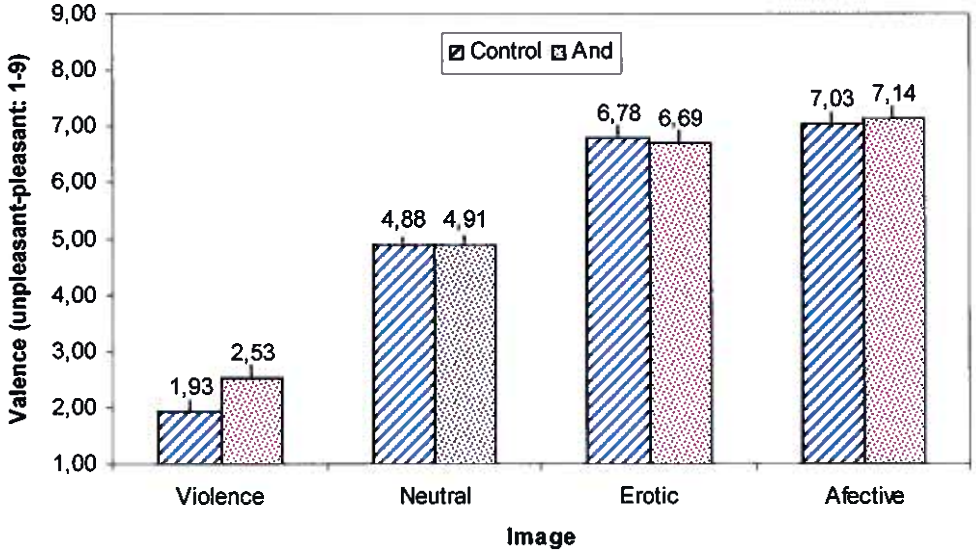
	Exposure Group	
Menstrual cycle phase	*Androstadienone*	Control
Non-fertile	14	17
Fertile	18	16

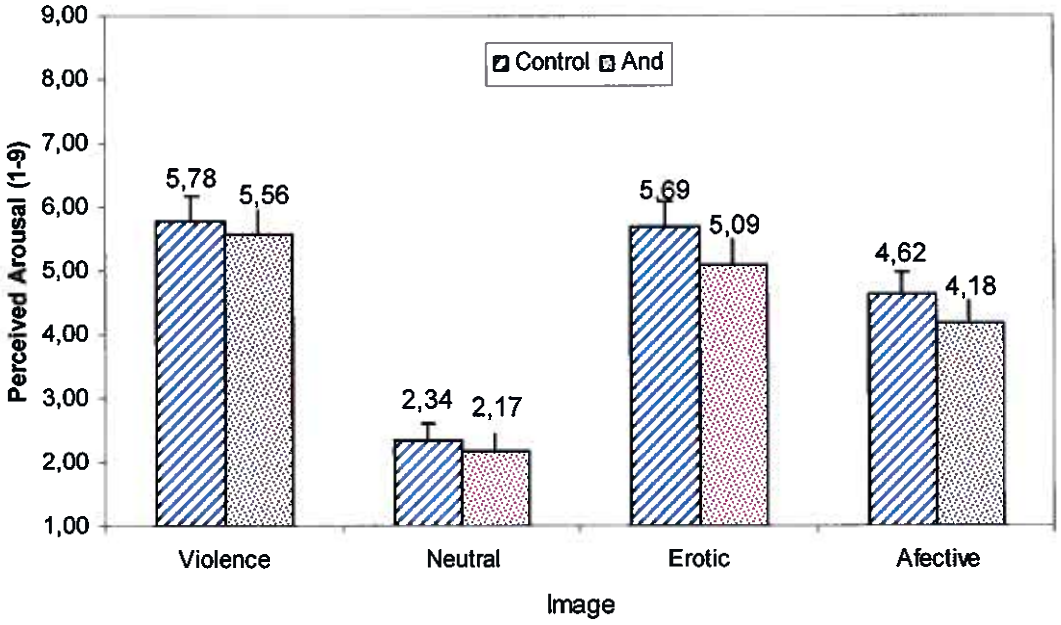
Table 2. MANOVA statistics for flirting behaviours as a function of sex of the participant, menstrual cycle phase, and exposure condition.

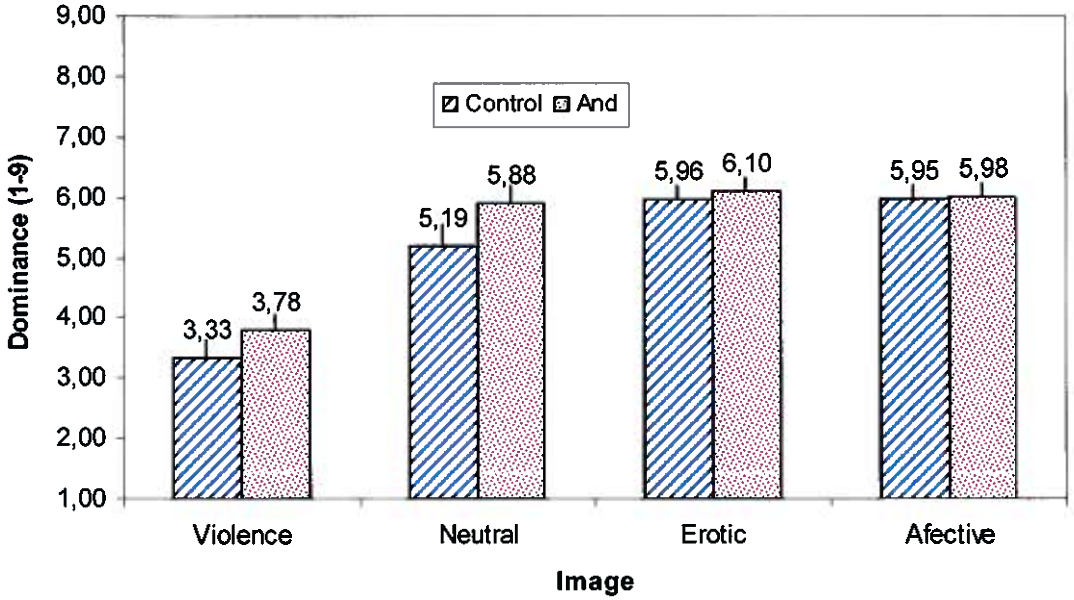
Factors	MANOVA statistics	p-value
Sex	2.96	0.001
Phase	2.46	0.004
Exposure	1.67	0.069
Sex*Phase	0.59	0.88
Sex*Exposure	0.56	0.90
Phase*Exposure	1.25	0.24

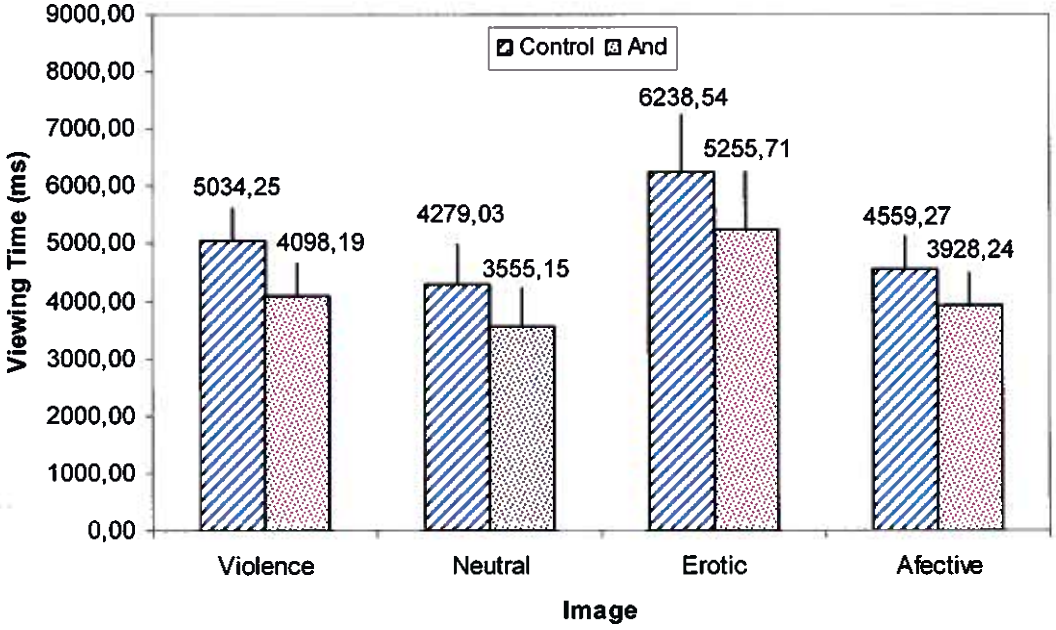
Table 3. Rotated Component Matrix derived for flirting behavior scores for women and men (Experiment 1).

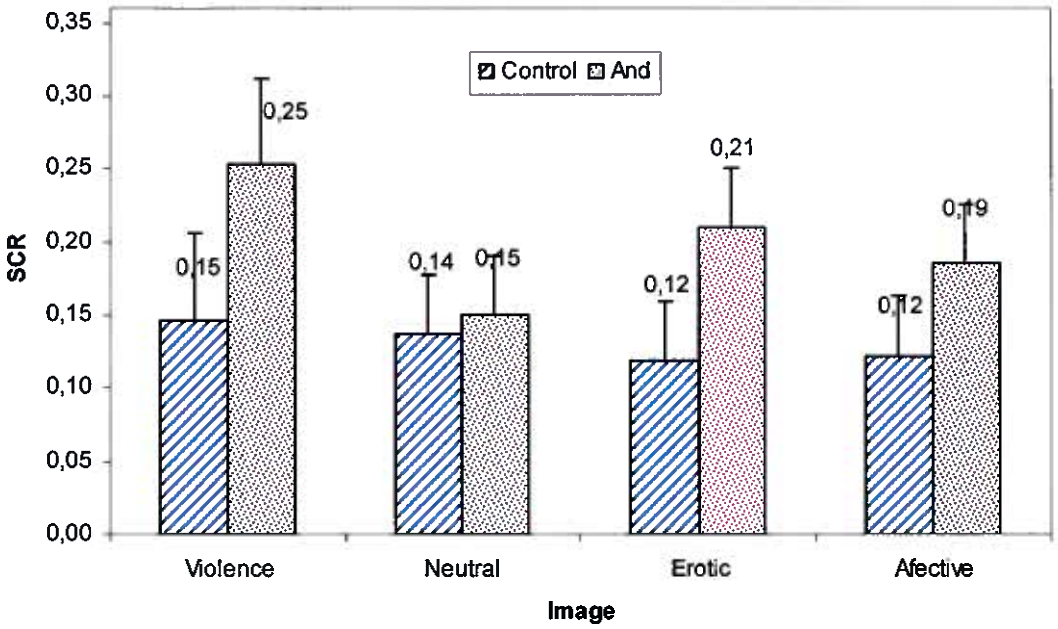
	Women			Men		
Components	**1**	**2**	**3**	**1**	**2**	**3**
Syncronization	**0.63**	-0.02	0.16	0.08	**0.49**	0.49
Hairflip	**0.62**	-0.11	0.02	0.01	-0.12	**0.56**
Automanipulations	**0.59**	0.48	-0.34	0.29	0.12	**0.38**
Primping	**0.54**	0.17	0.03	**0.58**	0.41	0.21
Space maximization	**0.42**	-0.11	0.28	0.33	-0.28	**0.33**
Eye contact	-0.04	**0.62**	0.41	**-0.71**	0.34	0.11
Lean	0.02	**0.58**	-0.06	-0.06	**0.68**	0.14
Aid solicitation	-0.16	**-0.54**	0.01	-0.02	0.05	**-0.37**
Objectcaress	-0.13	**0.51**	-0.16	**0.48**	-0.13	0.11
Illustrator	-0.13	**0.39**	-0.3	**-0.44**	0.30	0.24
Brushing	0.03	**0.34**	0.19	-0.16	0.16	**0.62**
Open body	0.01	-0.02	**0.7**	**-0.57**	-0.04	-0.03
Look up	0.5	0.01	**-0.57**	-0.19	**0.48**	-0.18
Head akimb	0.11	0.14	**0.56**	0.00	**-0.31**	0.04
Coysmile	-0.14	0.12	**-0.36**	**0.55**	0.37	-0.43

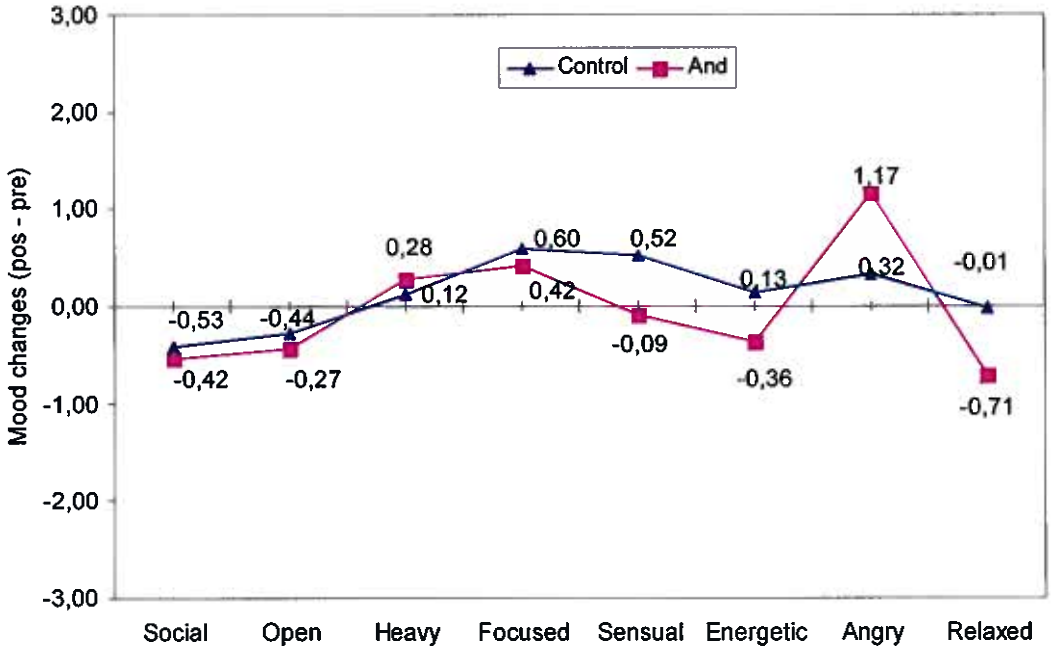

Control And
Valence (unpleasant-pleasant: 1-9)
9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
1,93
2,53
4,88
4,91
6,78
6,69
7,03
7,14
Violence
Neutral
Erotic
Afective
Image

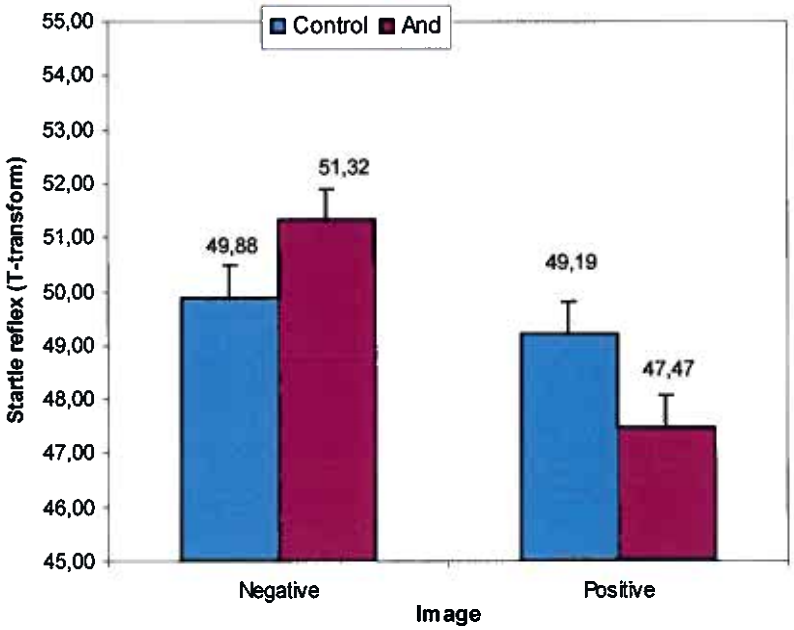

9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
Perceived Arousal (1-9)
Control
And
5,78
5,56
2,34
2,17
5,69
5,09
4,62
4,18
Violence
Neutral
Erotic
Afective
Image


9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
Dominance (1-9)
Control And
3,33
3,78
5,19
5,88
5,96
6,10
5,95
5,98
Violence
Neutral
Erotic
Afective
Image


9000,00
8000,00
7000,00
6000,00
5000,00
4000,00
3000,00
2000,00
1000,00
0,00
Viewing Time (ms)
Control
And
5034,25
4098,19
4279,03
3555,15
6238,54
5255,71
4559,27
3928,24
Violence
Neutral
Erotic
Afective
Image


0,35
0,30
0,25
0,20
0,15
0,10
0,05
0,00
SCR
Control
And
0,25
0,15
0,14
0,15
0,21
0,12
0,19
0,12
Violence
Neutral
Erotic
Afective
Image


3,00
2,00
1,00
0,00
-1,00
-2,00
-3,00
Mood changes (pos - pre)
Control
And
-0,53
-0,44
0,28
0,12
0,60
0,42
0,52
-0,09
0,13
-0,36
1,17
0,32
-0,01
-0,71
-0,42
-0,27
Social
Open
Heavy
Focused
Sensual
Energetic
Angry
Relaxed


Control
And
55,00
54,00
53,00
52,00
51,00
50,00
49,00
48,00
47,00
46,00
45,00
Startle reflex (T-transform)
49,88
51,32
49,19
47,47
Negative
Positive
Image