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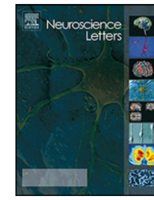

Does good + good = better? A pilot study on the effect of combining hedonically valenced smells and images

Sarah J. Banks*, Victoria Ng, Marilyn Jones-Gotman

Montreal Neurological Institute, 3801 University St, Montreal, QC H3A 2B4, Canada

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ABSTRACT

Responses to affective stimuli are usually studied in just one sensory system at a time. However, this is rarely the way they are experienced. We were interested in how combining affective stimuli of similar intensities across two sensory modalities (smell and vision) would affect both behavioral responses (ratings) and psychophysiological responses (skin conductance). We studied this using olfactory stimuli delivered birhinally while the subjects viewed affectively laden scenes on a computer screen. Bilateral skin conductance recordings were taken throughout. Subjects rated the pleasantness of the images that they were viewing. We found a particularly salient effect of unpleasant smells, which enhanced the pleasantness ratings of certain images and also the skin conductance responses to unpleasant images.

1. Introduction

Affective neuroscience studies usually focus on a single sensory modality. However, the world is multimodal, and our emotional selves react to an onslaught of different and often unconnected stimuli constantly bombarding the senses. How do these stimuli, with different affective properties, combine to spark a reaction in us? We attempt to answer that question by assessing behavioral and autonomic reactions to stimuli in two sensory modalities, visual and olfactory, presented individually and in combination.

Prior research into reactions to crossmodal affective stimuli has often focussed on food and whether stimuli are congruent (e.g., smell of an orange with image of an orange) or incongruent (e.g., smell of an orange with an image of fish). Pairing an odor with a congruent image facilitates the detection of that odor [8], and even pairing a congruent color or shape (e.g., a red patch with a strawberry odor) facilitates quick identification of that odor [6]. In addition to facilitation, this system is also vulnerable to trickery: modifying the green and yellow components of a lemon-flavored solution modified the sweetness rating [15]. Dying orange juice green led to it being misidentified as lime juice [3]. A delicate subject among wine connoisseurs, the coloring of white wine with red food coloring, has been shown to throw off even experts when asked to describe the taste of wine [13]. For a full review on the effect of color on food perception, see Spence et al. [18]. These studies focus on food and drink, but smell and vision combine to inform decision making on other topics too. For example, decisions about the pleasantness of a neutral stimulus (abstract pictures) are swayed by presentation of either pleasant or unpleasant sounds or smells (components of food, cosmetics or essential oils) [19].

Crossmodal paradigms have been used to probe social stimuli. Pause and colleagues were interested in the effect of body odors – sweat produced by anxiety or exercise – on judgments about neutral faces when primed with either happy or sad faces. Women specifically showed a reduction in the priming effect of happy faces when provided with the anxiety-produced sweat. The authors suggested that certain olfactory signals may exert a suppressing effect on responses to visual signals, presumably to increase survival chances [14]. In another study, Li et al. [10] presented odors immediately before asking subjects to rate likeability of faces with neutral expressions. They showed that only when smells were presented below consciously perceivable thresholds did they have an influence. A pleasant odor enhanced likeability whereas an unpleasant odor reduced it [10]. In a similar study, Dematte et al. [7] found that pleasant odors increased attractiveness ratings of male faces by women, and unpleasant odors decreased those ratings. This was true of body-relevant odors (body odor or cologne) and non-body-relevant odors (geranium or rubber) [7]. Outside of the chemical senses, Logeswaran and Bhattacharya [11] had their subjects listen to happy or sad music, and this affected how they judged the emotional expression of faces, especially when portraying a neutral emotion. Similarly, Baumgartner et al. [2] showed either sad or fearful images either alone or paired with emotion-inducing classical music. This not only affected the ratings of the image but also the brain activation patterns. Whereas pictures alone caused increased

* Corresponding author. Current address: Cleveland Clinic Lou Ruvo Center for Brain Health Las Vegas NV 89106, USA. Tel.: +1 702 783 7002; fax: +1 702 260 9797.
E-mail addresses: sarahjlbanks@hotmail.com (S.J. Banks), victoria.ng@mail.mcgill.ca (V. Ng), Marilyn.jonesgotman@mcgill.ca (M. Jones-Gotman).

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activation in more cortical regions labeled as "cognitive" by the authors, when paired with music there was additional enhanced activation in the subcortical "emotional" regions.

While the abovementioned studies all encompass judgments regarding approach or avoidance, others have looked directly at judgments of pleasantness with crossmodal pairings. Seo et al. [16] showed that introducing a pleasant or unpleasant sound prior to an odorant influenced the pleasantness rating of that odorant, the valence of the sound carrying over into the judgment of the smell. How olfactory–visual pairings in categories other than food or social stimuli combine to affect hedonic ratings is less well understood.

Autonomic nervous system reactions, such as skin conductance, are often used to measure affective responding at a more primitive level than ratings or judgments. Unilateral recordings are usually used (e.g., [1]), which may conceal lateralization effects such as right hemisphere dominance in reaction to odors [20] and frequently found right hemisphere dominance in emotional reactivity [4]. Brand et al. [5] used bilateral recording in their study of response to one pleasant and one unpleasant odorant. They found stronger response from the left hand compared with the right, and greater SCR for an unpleasant odorant [5]. Another group found stronger responses with the right hand and no valence effect on SCR [12]. Using unilateral recordings from the nondominant hand, Soussignan et al. [17] found healthy subjects to have stronger responses to unpleasant than pleasant or neutral olfactory stimuli and similarly stronger responses for unpleasant than pleasant visual stimuli (International Affective Picture System (IAPS) images), although with the images the difference between neutral and unpleasant was not significant. However, in their study subjects rated unpleasant stimuli as more intense than pleasant stimuli. To our knowledge, no research has yet explored the effect on SCR of combining semantically unrelated, non-food visual and olfactory cues.

We investigated how hedonically valenced stimuli in the olfactory and visual modalities interact to produce behavioral and autonomic reactions. Does the presence of a valenced-odor influence the perceived pleasantness of an image and the magnitude of the skin conductance response?

2. Methods

2.1. Participants

Sixteen healthy right-handed women (median age: 20 years; range: 19–33 years) were recruited from the McGill University Psychology Participant Pool. All reported normal ability to smell. All women refrained from eating and drinking in the 2 h prior to participation. Technical problems prevented SCR recording from eight participants; we used their behavioral data, but not their physiological data.

2.2. Stimuli

Unpleasant odorants were isobutyric acid (IBA; 50%) and pyridine (PYR; 2.5%). Pleasant odorants were bergamot (BER; 100%) and muguet (MUE; 90%). Solutions were diluted using propylene glycol. Based on earlier pilot studies, these odorants differed in valence but not in intensity.

We selected two sets of 18 IAPS [9] images. Each set contained: three unpleasant images, three neutral images and three pleasant images, based on the published IAPS ratings. One set, for example, contained the following: an assault, a muddy foot, a scared child (unpleasant); graffiti, a motorcycle, a city crowd (neutral); a scenic mountain, seagulls and kittens (pleasant). The sets were matched for content and excluded images that could be directly associated with a specific odor or any that contained discernible human faces. They were matched on arousal ratings and valence ratings. We also included four non-affective control images; a rectangle oriented into four positions.

Each participant was exposed to only one of the image sets, but to all odorants. We combined the visual and olfactory stimuli in a counterbalanced manner to create two unique sets.

2.3. Equipment

EPrime was used to present visual cues and control olfactometer valves. We used an eight-channel olfactometer (Dancer Design; Oxford); seven glass flasks contained odorant solutions and one flask contained water. The eight output tubes of the olfactometer connected to a Teflon dual-port demand valve unit, attached to latex-free nasal cannulae feeding into each nostril.

A scuba tank delivered air, which was regulated at .75 bar (11 psi) by a 2-stage pressure regulator. When a channel's valve was opened, air traveled through that channel's tubing into its associated flask. The air bubbled through the stimulus solution, forcing odorant molecules out of the flask and into an output channel, odorizing the air (the flask containing only water delivered odorless air). The air stream traveled into a Teflon filter and into the nasal cannulae.

2.3.1. EDA recording

Skin conductance data sampled at 100 Hz were recorded for each hand with a PowerLab 4 SP System. Two SCR amplifiers provided 75 Hz of constant voltage (ADInstruments, Milford, MA). Dry, bright-plated bipolar electrodes, registering 0.4 Ohms each, were attached by Velcro straps to the medial phalanges of the index and ring fingers of both hands. Signals were transduced and extracted using LabChart (ADInstruments).

2.4. Procedure

The full procedure comprised a breathing practice, a detection task, the cross-modal experiment (separated into two sections) and an odor rating task. Behavioral data were collected on the detection, cross-modal and rating tasks; SCR data only for the cross-modal task. Participants wore a headset to prevent auditory contamination.

2.4.1. Breathing practice

Participants were first trained to inhale gently in response to a series of timed cues.

2.4.2. Forced-choice detection task

Four cycles of two trials: on each trial, participants answered either "yes" or no" to the question, "Did you smell something?" They also answered either "very sure" or "not very sure" to the question, "How confident were you?" The first trial of each cycle administered an odorant for 2 s, followed by the two questions and 1 s of air. The second trial of each cycle administered odorless air for 2 s, followed by the two questions and 13 s of additional air.

2.5. Cross-modal task

We adapted the Self-Assessment Manikin (SAM) scales [9] by adding continuous and numerical components. We modified the original SAM instructions only for experimental context, and participants were clearly instructed on the visual and numerical anchors. Since participants reported their ratings orally (due to bimanual recording), the scale provided 17 increments along a continuous red line. Five SAM pleasantness figures were placed above the line at designated marks (1,3,5,7 and 9). Participants understood that