Chapter 17
Evaluating the Psychobiologic Effects of Fragrances through Salivary Biomarkers

Masaki Yamaguchi
Iwate University, Japan

Vivek Shetty
UCLA, USA

ABSTRACT
Olfactory stimulation by odorant molecules produces neurobiologic responses that manifest in the salivary proteome. This chapter highlights recent progress in the use of salivary biomarkers to augment conventional psychological assessments of the effects of fragrances and odors. New, low-cost, portable salivary biosensors enable point-of-use measurements of physiological effects of fragrances in naturalistic settings. The ability to operationalize measurement of the sedative state induced by a fragrance will clarify the mechanistic underpinnings of olfactory stimulation and facilitate investigations of structure-odor relationships that are necessary for the synthesis of new odorant molecules.

INTRODUCTION
Considerable evidence links our sense of smell with the triggering of a range of psychological and physiological responses. As evident by the widespread use of fragrances to enhance an individual’s sense of emotional well-being, the intake of aroma molecules can act on the brain to enhance mood and create relaxing states. The reflectorial effect theory (Hirsch, 2001) suggests that odors perceived as positive may induce positive moods, and these mood changes may enhance both physical and psychological well-being. The capacity to engage olfaction in creating positive emotional...
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states has led to the application of fragrances and essential oils in the treatment of depression, anxiety, dementia, insomnia, and stress-induced ailments (Buchbauer & Jirovetz, 1994; Ballard, et al., 2002). Given olfaction’s role in the triggering of emotional responses, there is growing interest in exploring the linkages between smell and its biobehavioral outputs so that our sense of smell can be used to expand our sensory repertoire.

As Jellinek (1997) notes, the effects of fragrances on behavior and physiological response systems occur through two principal mechanisms: (a) pharmacological where there is a direct interaction between odor molecules and olfactory receptors or nerve endings, and (b) psychological which involves the subjective experience of odor and involves memories and emotions. Correspondingly, efforts to assess the effects of olfactory stimulation on an activating-sedating (relaxing) dimension have involved subjective evaluations such as the use of questionnaires or self-reports (Lundström, et al., 2003) or the use of more objective physiological parameters including blood pressure (Haze, et al., 2002), heart rate (Romine, et al., 1999), and brain wave patterns (Diego, et al., 1998; Grosser, et al., 2000). However, most of these measurement approaches require laboratory-based investigations, involve the application of awkward recording device, and are burdensome to the subjects. Minimizing measurement reactivity and advancing the assessment of the psychological effect of fragrances under naturalistic conditions necessitates the development of alternative approaches to conventional assessment practices. Beyond clarifying the mechanistic underpinnings of olfactory stimulation, unobtrusive, objective, field-practical measurement techniques that produce unique “fingerprints” of the body’s response to various fragrances and odors would be very useful in a variety of applications in medical, dental, food, pharmaceutical industries and environmental control fields.

SALIVARY MANIFESTATIONS OF OLFACTORY EFFECTS

Olfactory stimulation by fragrances or odors may be viewed as a stressor that produces either a state of eustress (good stress) or distress (bad stress). The neurobiologic responses to both types of stress responses manifest along common autonomic, endocrine, and immune pathways. Because the central changes in the brain are difficult to monitor, researchers have commonly utilized peripherally accessible biofluids, such as blood and urine, as a source for identifying accompanying neuroendocrine perturbations. However, the intrusive nature of biofluid collection (e.g. blood) alters the plasma profile of related biomarkers and raises concerns about the confounding impact of measurement reactivity. An attractive alternative is human saliva, which largely contains the range of proteins, hormones, antibodies, and other analytes normally measured in blood tests (Yan, et al., 2009). Sampling saliva has multiple advantages in that it is non-invasive, readily accepted by the subject, easily stored and transported and stable for longer periods.

Salivary indices of the individual stress response have included various components of the human salivary proteome including cortisol, dehydroepiandrosterone-sulphate (DHEA-S), testosterone, catecholamines, α-amylase, chromogranin A, and secretory immunoglobulin A (SIgA). Each of these putative stress biomarkers is considered reflective of the Sympathetic Nervous System (SNS), Hypothalamic-Pituitary-Adrenal axis (HPA) or the immune response system. Much of the attention has focused on salivary cortisol as an expression of HPA axis activation (Yehuda, 2005, 2006; Breslau, 2006). Cortisol is thought to enter saliva by passive diffusion and correlates closely with the free physiologically active serum cortisol fraction (Kirschbaum & Hellhammer, 1994). Unlike cortisol, conjugated
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