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Sleep changes vary by odor perception in young adults

Namni Goel *, Raymund P. Lao

Department of Psychology, 207 High Street, Judd Hall, Wesleyan University, Middletown, CT 06459, USA

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Abstract

Peppermint, a stimulating odor, increases alertness while awake and therefore may inhibit sleep. This study examined peppermint's effects on polysomnographic (PSG) sleep, alertness, and mood when presented before bedtime. Twenty-one healthy sleepers (mean age ± S.D., 20.1 ± 2.0 years) completed three consecutive laboratory sessions (adaptation, control, and stimulus nights). Peppermint reduced fatigue and improved mood and was rated as more pleasant, intense, stimulating, and elating than water. These perceptual qualities associated with sleep measures: subjects rating peppermint as very intense had more total sleep than those rating it as moderately intense, and also showed more slow-wave sleep (SWS) in the peppermint than control session. Furthermore, subjects who found peppermint stimulating showed more NREM and less REM sleep while those rating it as sedating took longer to reach SWS. Peppermint did not affect PSG sleep, however, when these perceptual qualities were not considered. Peppermint also produced gender-differentiated responses: it increased NREM sleep in women, but not men, and alertness in men, but not women, compared with the control. Thus, psychological factors, including individual differences in odor perception play an important role in physiological sleep and self-rated mood and alertness changes.

Keywords: Perception; Peppermint; Aromatherapy; Intensity; Hedonics; Mood; Polysomnography; Sleepiness; Fatigue; Gender

1. Introduction

Aromatherapeutic essential oils produce physiological and psychological effects, including sleep and mood changes, though most data obtain from case reports and small studies (Buckle, 2001; Gyllenhaal et al., 2000; Price and Price, 1999; Tisserand, 1988). For example, exposure to various essential oils improved sleep—including decreased time awake, increased total sleep time and efficiency and reduced daytime sleepiness—in young, elderly, and demented subjects (Connell et al., 2001; Hardy, 1991; Henry et al., 1994; Hudson, 1996; Raudenbush et al., 2003; Sano et al., 1998; Svoboda et al., 2002; Wolfe and Herzberg, 1996). More recently, lavender, a sedating odor, increased deep or slow-wave PSG sleep in healthy young adults (Goel et al., 2005). Other than this experiment, however, the aforementioned studies were uncontrolled, with small sample sizes and subjective sleep evaluations. Therefore, further studies are necessary to determine whether other odors—including stimulating ones such as peppermint—produce different effects than sedating odors on objective sleep.

Peppermint is stimulating when presented during wakefulness: it decreases theta activity (Klemm et al., 1992), increases contingent negative variation amplitude (Torii et al., 1988), and reduces the pupillary unrest index, a physiological daytime sleepiness measure (Norrish and Dwyer, 2005). Similarly, peppermint exposure during sleep increases EEG speed and heart rate (Badia et al., 1990) and produces EEG and behavioral arousals during stage 1 sleep (Carskadon and Herz, 2004). Moreover, peppermint increases alertness and performance on various tasks (Barker et al., 2003; Raudenbush et al., 2001, 2002, 2004; Stampi et al., 1996; Sullivan et al., 1998; Warm et al., 1991), reduces self-rated fatigue and increases vigor (Raudenbush et al., 2002, 2004), and improves mood (Ilmberger et al., 2001; Klemm et al., 1992; Warm et al., 1991).

Peppermint also ranks highly on self-rated perceptual scales. Peppermint is rated as very pleasant (Klemm et al., 1992; Warm et al., 1991) and intense (Klemm et al., 1992) compared with other odors. Moreover, it is perceived as

* Corresponding author. Tel.: +1 860 685 2072; fax: +1 860 685 2761.
E-mail address: ngoel@wesleyan.edu (N. Goel).

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highly stimulating (Gould and Martin, 2001; Klemm et al., 1992; Warm et al., 1991). Finally, subjects rate peppermint as more pleasant, intense, and stimulating than water (Ilmberger et al., 2001). Such perceptual qualities relate to experimental measure variations. The sedating/stimulating quality of odors is associated with differential physiological changes (Badia et al., 1990; Bensafi et al., 2002a,b; Klemm et al., 1992; Lorig and Schwartz, 1988; Romine et al., 1999) as are odor hedonics (Bensafi et al., 2002a,b,c; Brauchli et al., 1995; Ehrlichman and Bastone, 1992; Henkin and Levy, 2001; Kline et al., 2000; Millot and Brand, 2001; Miltner et al., 1994) and intensity (Bensafi et al., 2002a; Carskadon and Herz, 2004; Wang et al., 2002). We assessed whether such perceptual measures associated with peppermint-induced sleep changes, a relationship thus far unexplored.

Gender differences in olfaction also have been investigated, whereby women show superior abilities (see reviews, Brand and Millot, 2001; Velle, 1987). In addition, many odors produce gender-differentiated physiological responses, often with greater responses in women (Becker et al., 1993; Evans et al., 1995; Henkin and Levy, 2001; Levy et al., 1999; Yousem et al., 1999). Moreover, we found that lavender produced gender-differentiated changes in specific sleep measures, with opposite effects in women and men (Goel et al., 2005).

This study examined peppermint oil's effects on PSG sleep in healthy young men and women. We hypothesized that peppermint, a stimulating odor, would disrupt sleep and produce gender-differentiated effects, with larger changes in women. We also predicted that peppermint's perceptual or psychological qualities (assessed by pleasantness, intensity, depressing/elating, and sedating/stimulating ratings) would relate to physiological sleep changes. Finally, peppermint was predicted to reduce sleepiness and fatigue and increase vigor.

2. Methods

2.1. Subjects

Twenty-one subjects, 11 women and 10 men, ages 18–26 years (overall mean age ± S.D., 20.1 ± 2.0 years; men: 20.4 ± 2.3 years; women: 19.9 ± 1.8 years) participated in the study. All subjects were in good physical and psychological health, were healthy sleepers, and were not using central nervous system medications. Subjects with extreme morningness or eveningness, assessed by the Morningness–Eveningness Questionnaire (Horne and Östberg, 1976), or with a history of respiratory disease such as chronic asthma or sinus problems were excluded during the initial interview. To test olfactory function, subjects were exposed to several odors and water and asked whether they could detect each. Those with detection difficulties were excluded. This supra-threshold detection approach insured that each subject had a similar minimal level of olfactory functioning and avoided possible expectancy or suggestion effects which may emerge with sub-threshold concentrations (Campenni et al., 2004; Torii et al., 1988).

Smokers, subjects scoring ≥10 on the Beck Depression Inventory (Beck et al., 1961) and women on oral contraceptives or with irregular menstrual cycles also were excluded. A nearly equal number of women were in the luteal ($n = 5$) or follicular ($n = 6$) menstrual cycle phases. For one week before study entry, subjects maintained a habitual bedtime of 24:00 h and wake-up time of 08:00 h, verified by sleep logs and daily call-ins at bedtime and upon awakening to an answering machine with time stamp. Wesleyan University's Institutional Review Board approved the study and all procedures conformed to the Declaration of Helsinki. Subjects received monetary compensation for participation and signed informed consent before study entry.

2.2. Polysomnographic (PSG) recordings

Central and occipital electroencephalographic (EEG), electrooculographic (EOG), and submental electromyographic (EMG) measures were recorded from 24:00 h (lights off) to 08:00 h (lights on). During the adaptation night, subjects were screened for sleep pathologies, including apneas, oxygen desaturation, and periodic limb movements by monitoring respiratory effort, nasal airflow, arterial oxygen saturation level, bilateral anterior tibialis EMG, and heart rate (EKG). Sleep records were visually scored in 30-s epochs according to Rechtschaffen and Kales' (1968) standard scoring criteria by two trained scorers blind to the experimental conditions. Inter-rater reliability for the two scorers was 93.5%.

2.3. Subjective sleepiness and mood questionnaires

The Stanford Sleepiness Scale (SSS; Hoddes et al., 1973) quantifies the progressive, subjective stages of the sleep-alertness continuum, with a scale from 1 to 7 (1, feeling active, vital, alert, or wide awake; 7, sleep onset soon; lost struggle to remain awake), and has been tested with repeated acute sampling periods (e.g., 15 min).

The Profile of Mood States Questionnaire (POMS; McNair et al., 1992), a 65-item self-report scale, assesses transient affective states in response to various stimuli including olfactory cues (Bensafi et al., 2002c; Goel et al., 2005; Jacob and McClintock, 2000; Jacob et al., 2001; Schiffman et al., 1995). The POMS has been validated in repeated measures designs (see Schiffman et al., 1995) and sleep studies (Dollins et al., 1994; Goel et al., 2005; Jockovich et al., 2000). Moreover, it has been tested with repeated acute sampling periods (e.g., 3 min; McNair et al., 1992). Each item is rated on a scale from 0 to 4 (0, not at all; 4, extremely), on one of six factors: depression–dejection (Depression), tension–anxiety (Tension), anger–hostility