Physiology & Behavior 123 (2014) 127–135

Contents lists available at ScienceDirect

Physiology & Behavior

journal homepage: www.elsevier.com/locate/phb

Effect of hydration on the tactile and thermal sensitivity of the lip

Steve Guest [a,*], Greg K. Essick [a], Anahit Mehrabyan [b], Jean-Marc Dessirier [c], Francis McGlone [d]

[a] Regional Center for Neurosensory Disorders, School of Dentistry, University of North Carolina, Chapel Hill, NC, USA
[b] Department of Neurology, University of North Carolina, Chapel Hill, NC, USA
[c] Unilever R&D, Trumbull, CT, USA
[d] School of Natural Sciences and Psychology, Liverpool John Moores University, Liverpool, UK

HIGHLIGHTS

- Hydration of the lip increases its sensitivity to light touch.
- Hydration of the lip does not alter its sensitivity to spatial stimuli.
- Changes in lip mechanics are proposed to underlie any hydration-related changes in lip sensitivity.

ARTICLE INFO

Article history:
Received 26 March 2013
Received in revised form 4 October 2013
Accepted 18 October 2013

Keywords:
Lip
Tactile sensitivity
Thermal sensitivity
Sensation
Lip hydration

ABSTRACT

The vermilion lip is a body site particularly susceptible to water loss. Therefore, the role of hydration in tactile perception at the lip was investigated. A series of measures of tactile performance and response were obtained from 22 female subjects, namely: (1) the subjective assessment of lip feel, (2) tactile sensitivity, (3) spatial acuity, (4) thermal sensitivity, and (5) the subjective assessment of thermal stimulation. These measures were obtained from lips in their natural (untreated) state, and lips that had been treated using a hydrating preparation. The preparation altered the subjective feel of the lips consistent with the treatment increasing lip hydration and compliance. Hydrated lips showed greater sensitivity to light touch, and there was a trend toward the lip's thermal sensitivity being altered consistent with the lip treatment having a physical cooling effect. Spatial acuity was unaltered by the state of lip hydration. The sensitivity changes on hydration were proposed to have mechanical basis.

1. Introduction

Of the many aspects of skin mechanics, one that is commonly altered in daily life is the state of hydration of the stratum corneum [1,2], which is thought to affect both thermal [3] and tactile sensations. Green has suggested that the oral tissues are more thermally sensitive, in part, due to their special state of hydration, conferring greater thermal conductivity than that observed on less well hydrated tissues. In contrast, other investigators have suggested that increasing hydration may decrease thermal sensitivity by increasing a property referred to as 'thermal inertia' [4].

Similar to thermal sensitivity, the existing literature does not provide a clear account as to whether hydration increases or decreases tactile sensitivity. In the earliest literature, Grossman [5] reported, based on his extensive experience studying orofacial tissues, that normally hydrated oral muscosa seemed to be more sensitive to touch than dried mucosa. However, experimental evidence suggested the opposite was true of extrafacial skin sites [6]. For example, Weinstein showed that a petrolatum barrier, presumably hydrating the skin, decreased sensitivity to light touch on the volar forearm.

More recent research has failed to resolve the uncertain effect of hydration on tactile sensitivity: Lévêque et al. [7] showed that hydrating dry cheek and forearm skin in aged individuals increased spatial acuity at those sites, a finding which the authors explained on the basis of mechanical differences in well-hydrated versus relatively dehydrated skin. In particular, well-hydrated skin was suggested to have increased compliance and to conform better to the test stimulus surfaces when pressed into the skin. The work of Lévêque et al. seems consistent with other research that has shown spatial acuity to be strongly correlated with skin compliance [8]. However, Vega-Bermudez and Johnson found that the loss in spatial acuity with aging was not related to the loss in skin compliance [also see Ref. 9].

Other investigators have found that hydration has a variable effect on tactile sensory function. For example, Verrillo et al. [10] found that with increasing hydration vibrotactile sensitivity at the thenar eminence was unaltered, but the perceived roughness of fine sandpapers at the fingerpad decreased. It is known that well hydrated skin has a higher friction coefficient than drier skin [11] and thus may slide less freely over touched stimulus surfaces. Therefore, Verrillo et al.'s (1998)

* Corresponding author. Tel.: +1 919 537 3619; fax: +1 919 966 5339.
E-mail address: steve_guest@dentistry.unc.edu (S. Guest).

0031-9384/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.physbeh.2013.10.013

finding of decreased perceived roughness could not be explained simply by a change in friction. All considered, it is likely that hydration has the effect of increasing sensitivity to some types of tactile stimulation, while decreasing sensitivity to others; and that the effects vary further with the site tested due to differences in the physical properties of the skin or its innervation.

Here, we report a study that sought to investigate the effect of lip hydration on tactile and thermal sensitivity on the vermilion. Hydration is an issue of particular importance for the lip because this body site is very susceptible to evaporative water loss through the skin [12]. If the lip's sensitivity is altered by variations in its state of hydration, the changing sensitivity may be of import in everyday behaviors that involve the lips. Normal lip hydration is necessary to maintain a healthy lip feel, and could be required for the maintenance of the lips' tactile-discriminative functions.

2. Methods

2.1. Subjects

Twenty-two female subjects (mean age 23 years, range 19–41 years) were recruited by advertisement in a local newspaper to participate in a study of lip sensation. Subjects agreed to refrain from using any cosmetic product or therapeutic treatment on the lips for 2 days prior to every scheduled testing session. The study was approved on ethical and safety grounds by the Biomedical Institutional Review Board (IRB) at the University of North Carolina at Chapel Hill.

2.2. Design

Each testing session consisted of two consecutive, identical series of sensory tests. Each series was conducted with the lip vermilion in an untreated (U) state or after the lip had been treated (T) with an agent known to moisturize the skin. Data were collected from 20 of the 22 subjects during three testing sessions defined as follows: No treatment prior to the first series, no treatment prior to the second series (UU); no treatment prior to the first series, treatment prior to the second series (UT); and treatment prior to the first series, treatment prior to the second series (TT). The other two subjects each participated in only one testing session. For the 20 subjects, the sessions were conducted on different days with the constraint that at least 2 days separated a UT or TT session and a UU session. Given this exception, the order in which subjects participated in UU, UT, and TT sessions was pseudo-randomized so that each type of session would be conducted about a third of the time on each of days 1, 2 and 3 of testing. Each session required 2 h to complete both series of sensory tests. All subject recruitment and testing were undertaken by one experimenter (A.M.).

2.3. Lip moisturization

Prior to the T series of sensory tests, the lower lip vermilion was treated with a lip moisturizing product known to have a rapid onset of action and duration of action exceeding that of the testing session, as measured using instrumental means [e.g., corneometry and allied techniques, 13,14]. To determine the amount of agent to be used on the lower vermilion, the total area of the red lips was grossly estimated using the formula $a = \pi \frac{hw}{4}$, where a is the area in cm^2; h is the height of the lips in cm, measured between upper to lower vermilion borders along the midline; and w is the width of the lips in cm, measured between left and right commissures. For areas of <7.4 cm^2, 0.01 ml of the agent was dispensed from a 1 ml syringe onto the experimenter's index fingerpad, covered with a latex finger cot. A larger volume of 0.02 ml was used for lip areas of >7.4 cm^2. Using three circular sweeps, the experimenter applied the agent to both the lower and upper vermilion. The subject was instructed to keep the lips together and to speak only when necessary during the subsequent series of sensory tests.

2.4. Sensory tests

During each series, the tests were administered in following order: Subjective assessment of lip feel; touch detection sensitivity; spatial acuity; thermal perception sensitivity; subjective assessment of suprathreshold thermal stimulation; subjective assessment of a textured surface. With the exception of the first, all tests evaluated sensation on the lower vermilion. Medio-laterally, the site for stimulus application was located half-way between the midline and the commissure of the lips on the subject's dominant side. Anteroposterially, it was located half-way between the vermilion border with the facial skin and muco-cutaneous junction with the labial mucosa.

2.4.1. Subjective assessment of how the lips feel

The subject was instructed to purse the lips a few times and rate the feel of the lips using a previously developed touch perception task [TPT, 15]. The TPT consists of a list of 40 adjectives, subdivided into 26 that describe sensory-related attributes (e.g., dry) and 14 that describe emotion-related attributes (e.g., exciting). The degree to which each attribute described the tactile experience was obtained from the subject using a five-point category scale. The categories were; 'none' (not descriptive), 'slightly descriptive', 'moderately descriptive', 'highly descriptive' and 'very highly descriptive'.

2.4.2. Touch detection sensitivity

The touch detection threshold was measured using nylon monofilaments that vary in the force applied to the skin. In preliminary testing, it was discovered that the instruments commercially available (viz., Touch Test Sensory Evaluators; Stoelting, 620 Wheat Lane, Wooddale, IL 60191) were not useful on the lower vermilion: The force delivered by the finest filament (ca 5 mg-wt.; filament marked '1.65') was often detected, and the force of the second finest filament (ca 23 mg-wt.; filament marked '2.36') was always detected. Given the need for greater resolution, sets of nine filament stimuli graded in force to blanket the range 3 to 32 mg-wt. were custom made. Specifically, lengths of monofilament line (RIO Powerflex; RIO Products, 5050S. Yellowstone Hwy., Idaho Falls, ID 83402; (208) 524-7760) were cut, one end of each was grasped by a small (14 cm long) straight mosquito hemostatic forcep, and the force in gm-wt. delivered by the opposite, free end of the filament was measured using a Ohaus Explorer Balance (Model E0RV70; P.O. Box 2033, Pine Brook, NJ 07058; (973) 377-9000). The free ends were re-cut and re-measured until the set of nine filaments was obtained. Using RIO Powerflex 0.7 kg/0.076 mm-diam-line, calibrated forces of 3, 4, 8, 12, 16, and 20 mg-wt. were achieved with filament lengths approximating 6, 5.6, 4.8, 4, 3.6 and 3.3 cm, respectively. Using RIO Powerflex 1.1 kg/0.102 mm-diam-line, calibrated forces of 24, 28 and 32 mg-wt. were achieved with filament lengths approximating 4.5, 4.3, and 4 cm. A total of 124 sets were made so that a new set of calibrated filaments could be used during each series of tests for each session for each subject. A few sets were recalibrated after use to confirm that the forces applied by the filaments had not changed.

Testing consisted of 40 trials. During each trial, a filament was applied to the skin during one time interval and no stimulus was applied during a second time interval. To the extent possible, the filaments were pressed into the skin creating a single buckle similar to that observed during the stimulus calibration procedure. Subjects identified the interval (first or second) during which the filament was delivered. Feedback as to correctness of response was given. The force delivered during the first trial was always 24 mg-wt. A computerized threshold-tracking program specified the random sequence of the interval for stimulus application, the monofilament to be used for each trial, and predicted the threshold force that would be detected in the correct interval on 75% of the trials (Harvey, 1986). The inverse of the threshold force provided a relative measure of the lip's touch detection sensitivity.