Central modulation of affective touch, pain, and emotion in humans

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ABSTRACT

Hedonic feelings – pleasure and displeasure – strongly motivate human behavior. When well-functioning, hedonic feelings guide adaptive decision-making that promotes survival and well-being. Specialized afferent systems transmit information about the environment that gives rise to somatic pleasure or pain. However, these feelings are also influenced by expectations, learning, and information from other sensory modalities. This thesis investigates how hedonic somatic sensations are shaped by expectations and socially relevant information from other senses in healthy humans. Moreover, we assess the neurobiological systems involved in modulation of hedonic feelings. For instance, we examine the role of the neuropeptide oxytocin in the interplay between visual information of facial emotional expressions and gentle inter-personal touch, which characterizes a range of social encounters.

To navigate in the social world, humans combine available sensory information, such as facial emotional expressions and gentle affective touch. The neuropeptide oxytocin plays an important role in social bond formation, and is thought to be central in affective touch signaling. Using intranasal oxytocin and a crossover design, we assessed the role of this neuropeptide in the interaction between socially relevant tactile and visual information (Paper I). After intranasal oxytocin treatment, gentle inter-personal touch sharpened social impressions of concomitantly presented facial expressions, making smiling faces appear more friendly and attractive, but frowning faces less friendly and attractive. Correspondingly, gentle human touch was rated as most pleasant when paired with a smiling face, but least pleasant when combined with a frowning face. We found no evidence that oxytocin modulated touch perception. Further, we investigated oxytocin effects on sensitivity to others' explicit and implicit (hidden) emotional expressions (Paper II). We found that oxytocin intensified evaluations of explicitly and implicitly expressed emotions, in both angry and happy faces. This was underpinned by oxytocin-induced increase in stimulus-related pupil dilation, which we interpret as an indication of increased attention to these socially relevant stimuli.

The malleability of hedonic feelings is illustrated by placebo effects, whereby the meaning of a medical treatment can provide significant symptom improvement, even when the treatment itself does not contain any ingredients that affect symptomatology. We compared the brain processing involved in placebo improvement of positive (pleasant touch) and negative (pain) hedonic feelings, using functional magnetic resonance imaging (Paper III). Placebo-induced increase in touch pleasantness (hyperhedonia) was underpinned by increased sensory processing, while decrease in pain (analgesia) was underpinned by suppression of sensory processing. Moreover, both placebo hyperhedonia and analgesia were associated with activation of similar circuitry implicated in emotion and valuation. The close correspondence of placebo hyperhedonia and analgesia might reflect an underlying shared mechanism. Recent theorizing suggests that placebo effects may build on a generalized mechanism of reward prediction. In Paper IV, we investigated whether expectation of either hyperhedonia or analgesia alone, would be enough to improve both positive and negative hedonic feelings. Participants were divided into two groups. One viewed a video documentary designed to induce expectation of hyperhedonia only, whereas the other group was led to expect analgesia after a (placebo) treatment. Both groups showed robust placebo hyperhedonia and analgesia, and the magnitudes of these effects were comparable across groups.

The work in this thesis sheds light on how expectations and available cross-sensory information shape hedonic somatic feelings, and how this impacts on social evaluation of others. These findings may contribute to the understanding of how expectations, motivations, and the quality of the patient-clinician encounter impact on hedonic sensations and, in turn, treatment outcome.

Keywords: Hedonic, touch, pleasure, pain, placebo effect, emotional expressions, oxytocin, fMRI, psychophysics, pupillometry

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This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. **Ellingsen DM**, Wessberg J, Chelnokova O, Olausson H, Laeng B, Leknes S. In touch with your emotions: Oxytocin and touch change social impressions while others' facial expressions can alter touch.
Psychoneuroendocrinology 2014; 39: 11-20.

II. Leknes S, Wessberg J, **Ellingsen DM**, Chelnokova O, Olausson H, Laeng B. Oxytocin enhances pupil dilation and sensitivity to 'hidden' emotional expressions.
Social Cognitive and Affective Neuroscience 2013; 8, 741-749.

III. **Ellingsen DM**, Wessberg J, Eikemo M, Liljencrantz J, Endestad T, Olausson H, Leknes S. Placebo improves pleasure and pain through opposite modulation of sensory processing.
Proceedings of the National Academy of Sciences of the United States of America 2013; 110: 17993-17998.

IV. **Ellingsen DM**, Leknes S, Triscoli C, Olausson H, Wessberg J. Expectation of either analgesia or hyperhedonia leads to both.
Manuscript.

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