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THE SENSE OF TOUCH

Physiology and Neural Correlates of Affective Touch and its Role in Subjective Wellbeing

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Abstract

The somatosensory system concerns the sense of touch. It is sectioned into various kinds of touch, such as the proprioceptive sense, providing information of sense of self and position of limbs, and the cutaneous sense, informing of the modalities of touching or being touched. The cutaneous sense is further divided into discriminative touch and affective touch. Discriminative touch is an exteroceptive sense of touch that responds to stimuli of pressure and vibration, and affective touch is an interoceptive sense of touch that corresponds to e.g. pleasant and painful stimuli, communicating information to the brain through A-delta and C-fibers. Recent studies investigates affective touch to have emotional affect on the subjective experience of touch, affecting subjective wellbeing. The aim of this thesis is to examine the sense of touch and its relevant neural correlates, focusing on affective touch and its role in subjective wellbeing and social relations. A presentation of physiological and neural aspects of touch will be held as well as a description of subjective wellbeing. The conclusion for this thesis is that affective touch appears to activate brain areas of orbitofrontal cortex, frontal polar cortice, prefrontal cortex and insula cortex, which are brain areas processing subjective wellbeing, e.g. evaluating positive and negative effect and processing emotional information and behavior. Examining correlations between affective touch and positive affect, negative affect, oxytocin release, social relations and affiliative behavior shows influence from affective touch on subjective wellbeing. A discussion of the current findings is provided, including directions for future research.

Keywords: Somatosensory system, affective touch, discriminative touch, C-tactile afferents, subjective wellbeing, positive affect, social relations

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Introduction

There are five different sensory systems within humans and other animals: audition, vision, smell, taste and touch (Field, 2001). The skin works as the sense organ for touch, and is the largest and oldest, because it is the first that is developed within the fetus. If not damaged, touch is the sense that normally remains intact the longest, in contrast to the other senses that might fade because of increasing age or other causes. However, the sense of touch has not been researched as much as the other senses, regardless of its great importance.

The sense of touch provides information of both the outside world and the position of oneself in it. Moreover, it helps to locate the stimulus on the surface of the skin (Niell, 1991; Serino & Haggard, 2010). Touch can also be used as a communication system, as it interacts with both the environment and between people, like a greeting form, encourage one another, share feelings and enhance motivation. Even the slightest touch of another person may evoke strong emotional physical and psychological responses in human bodies (Gallace & Spence, 2010).

The system that concerns the sensation of touch is called the Somatosensory system. There are different kinds of sensations of touch arising from physical attributes of surfaces, such as hardness, roughness, softness, and temperature. These factors, together with the velocity and force, added with top-down factors, such as previous experiences and expectations, as well as the identity of the touching person, makes up the interpretation and perception of the touch (Ellingsen et al., 2014).

Touch relies on different types of receptors within the skin. There are nociceptors that reacts to intense stimuli, thermoreceptors reacting to temperature, proprioceptors that informs of position and movement, mechanoreceptors that reacts to pressure, and various chemoreceptors which are involved in respiratory feedback. These receptors report the somatic information to neurons within the central nervous system (CNS) and further to the primary and secondary somatosensory system within the brain (Ackerley, Saar, McGlone & Wasling, 2014; Blatow, Nennig, Durst, Sartor & Stippich, 2007).

Touch can be divided into two categories; discriminative touch and affective touch (McGlone, Vallbo, Olausson, Löken, & Wessberg, 2007). Discriminative touch provides sensory information of objects being handled with, processed through mechanoreceptors in the skin. Affective touch provides and supports information about emotional, hormonal and behavioral responses of skin-to-skin contact with others. In hairy skin, such as on forearms, there are C-mechanoreceptive units called C-tactile afferents, that have a closer connection to the limbic system in the brain, which refers to emotions, memories and arousal, than to motor-and cognitive functions (Rolls et al., 2003). The C-tactile afferents are activated by slow, caresslike touch with the specific speed of 1-10cm/s, perceived as pleasurable. Pleasant touch like this is said to increase positive affect, subdue negative affect and perception of pain, and increase the release of oxytocin, a hormone studied to affect social bonding and trust. Affective touch, or emotional touch, therefore provides subjective hedonic experiences of the caress, such as stress relieving, soothing, calming and pleasurable (Pawling, Cannon, McGlone & Walker, 2017; Morrison, 2016; Koppel, Andersson, Morrison, Västfjäll & Tinghög, 2017).

When describing subjective wellbeing, many of the effects of affective touch are mentioned as factors for a good, full life. Hedonic wellbeing refers to the notion of that decreasing pain and increasing pleasure will lead to happiness. Hedonic view of wellbeing, together with eudaimonic view of wellbeing - which focuses on meaning and self-realization - represents the current research perspective of subjective wellbeing today (Ryan & Deci, 2001).

The aim of this essay is to examine the sense of touch and its relevant neural correlates, focusing in particular on affective touch and its role in subjective wellbeing and social relations. The definitions of different kinds of touch will be presented with relating physiological factors - such as types of receptors and responding axons - as well as evidence of their neural correlates will be discussed, with the main focus on affective touch and its involvement in subjective wellbeing and components of it.

Firstly, the somatosensory system will be defined, with its various types of touch and the physiology of it will be described, including skin stimulation, receptors and axons. Secondly, a review of the neural correlations in the brain when different touches are applied to the skin will be held, with a main focus on the cutaneous sense, specifically the affective touch. Thirdly, wellbeing will be defined and the role of affective touch in it. Fourthly, an examination of if affective touch affects social relations and related concepts of it. Lastly, a discussion of the content will be held, regarding further research proposals and why concerned information of the essay may be important.

Definition of Touch

It was Aristotle that classified the sense of touch to be one of the five main senses, together with taste, smell, hearing and vision, that helps to interpret and interact with the physical world (Abraira & Ginty, 2013) Later in 1842, Johannes Müller introduced sensory modalities, questioning the different characteristics and qualities of the nerves in the skin. It became clear that when questioning the sensory neurons of touch, a greater understanding of our perception and reactions to the physical world appears (Abraira & Ginty, 2013).

The somatosensory system is the system that is held responsible for the sense of touch, which senses the stimulus in the skin, transports the information by the skin receptors to the central nervous system (CNS) and then to the brain for further interpretation and response. The system is firstly divided into two categories: the proprioceptive sense of touch and the cutaneous sense of touch. The first mentioned is the sense that provides us information about the positioning of the body and limbs, and the forces of the muscles, telling information for controlling them and plan our movements so that it is executed in a easy manner (McGlone et al., 2007). The cutaneous sense in turn, informs perception of stimuli both inside and outside the body - interoceptive and exteroceptive. It subserve the main four different modalities of touch, temperature, pain and itch, as well as it tells information if one is being touched by someone else, being touched by yourself, or oneself is touching someone else (McGlone & Spence, 2010).

The exteroceptive type of the cutaneous sense is called discriminative touch, telling haptic information about handled objects from the outside world by perception of texture, slip, vibration and pressure, informing of localization and intensity of the stimulus (McGlone et al., 2007; Morrison, Löken, & Olausson, 2010).

The interoceptive type of the cutaneous sense is called affective touch, which informs of the internal perception of the body, its wellbeing and illbeing, and controls emotion by reading itching, temperature, pain and pleasant touch (McGlone & Reilly, 2010). Pleasant touch, usually responding to a skin-to-skin contact such as between parent and infants, are conducted in a gentle, slow, low-force manner that affects responses emotion, hormones and behaviour (Morrison et al., 2010).

The information of touch starts at the skin. The touch stimulus activates the receptors in the skin, which depending on the kind of sensory axon, responds to these different types of touch mentioned. The sensory axons differ depending on their degree of myelination. Myelin is a fatty substance sheath that surrounds the nerve fibres. The less myelin there is the more sensitive the axon will be of nerve impulses. Myelin also determines the speed of nerve impulses, traveling from a nerve cell body to another. The different kinds of axons has different names, depending on size, speed and sensitivity caused by different degrees of myelination. The largest kind is called the A-alfa axons, which are common with the receptors in the proprioceptive sense system. Within the system of the cutaneous sense, however, there are types of axons called A-beta, A-delta and C-fibres (McGlone et al., 2007).

Discriminative touch typically uses A-beta axons to communicate information, activated from four low-threshold mechanoreceptors (LTMR). Two of them, Meissiner's corpuscles (light touch) and Pacinian corpuscles (pressure and vibration) are fast adaptive (FA) receptors, which means they get used to the stimulus fast and corresponds to temporal stimuli. Merkel's disks (pressure) and Ruffini endings (skin stretch and sustained pressure) are the other two LTMR with A-beta axons involved in discriminative touch, and they are slow adaptive (SA) which entails they corresponds to constant stimuli (McGlone & Reilly, 2010) .

Within the somatosensory system of affective touch, the lightest myelinated axons are used to transport information of the interoceptive sense, the A-delta axons and the c-fibre axons. The LTMR nociceptors (sharp pain) and thermoreceptors (temperature) of affective touch uses A-delta axons. Furthermore, the high-threshold mechanoreceptors (HTMR) nociceptors (second burning pain), itch receptors, warm and cool thermoreceptors, C-autonomic receptors as well as LTMR C-tactile (light and pleasant touch) communicates with C-fibre axons (McGlone & Reilly, 2010).

Physiological Aspects of Touch

The skin is a large, adjustable body sensory organ, that contains approximately five million hairs and two million sweat glands on an adult human (McGlone & Reilly, 2010). The first layer of the skin is called epidermis, where the start of the touch stimulus occurs. Viable epidermis is the second layer of the skin, followed by the third layer, dermis, and the fourth and last layer of the skin, called hypodermis (Jepps, Dancik, Anissimov & Roberts, 2013).(McGlone & Reilly, 2010, Gazzaniga, Ivry & Mangun, 2009). Within all of these layers of the skin are mechanoreceptors (transforms mechanical pressure and distortion to nerve impulses) and neurons, which transform the stimulus on the skin to nerve impulses that sets off to the brain. The basic construction of a neuron is a cell body, dendrites and an axon. The cell body contains a metabolic system which help preserve the neuron. The dendrites works as the neurons antennas for the ingoing information. The axon is like an arm from the cell body that sends out the information to the next neuron (Gazzaniga et al., 2009).

As mentioned, the axons sends out information in different speed depending on their myelination. The more myelin surrounds the axon, the faster the speed signal is. Along the myelinated axons there are gaps of the myelin. These gaps are called nodes of Ranvier and when the signal jumps between these nodes, the signal arrives to the adjacent neuron's dendrites faster, further to the neuron after that, travelling like this all the way to the brain. This is why unmyelinated axons transmits the signals slower, since having no myelin entails having no nodes of Ranvier (McGlone & Reilly, 2010).

The sensory axons are classified depending on their size and myelination. The A-alfa axon, being the largest and fastest, includes proprioceptive neurons like the receptors of muscle stretch. The second largest and fastest type of axons are the A-beta axons involves the discriminative touch receptors earlier mentioned, Meissner's corpuscles, Merkel's disks, Ruffini endings and Pacinian corpuscles, and are low threshold mechanoreceptors (LTMR). Thirdly, the A-delta fibers are coupled with nociceptors and cool receptors which responds to pain and temperature. The fourth type is the unmyelinated C-fibre axons, which also includes nociceptors, warm and cool receptors, and, most importantly for the theme of this thesis, C-tactile afferent (CT) receptors, which responds to emotional touch (or pleasant touch) (McGlone & Reilly).

The four different types of A-beta LTMR: Merkel's disks, Meissner's corpuscles, Pacinian corpuscles and Ruffini endings, are the ones that are integrated with discriminative touch (McGlone et al., 2007). These receptors are organized by their different functions. Meissner's and Pacinian corpuscles responds to mechanical and temporary stimuli on the skin and handles fast movements, meaning they are fast-adaptive (FA). On the other hand, Merkel's disks and Ruffini endings are receptors that keep reacting during a constant stimuli, meaning they are slow-adaptive (SA). Furthermore, the A-beta LTMRs can be organized by the area of skin which the receptors are sensitive to: their receptive fields (RF), which has to to with which anatomical area the receptors are located within the skin. Merkel's disks and Meissner's corpuscles that lies between the dermal/epidermal boundary have small RFs, however Ruffini endings and Pacinian corpuscles have larger RFs because they both lie deeper within the dermis.

Moreover, many of the myelinated afferents gives faster impulses the faster a stimuli changes and are very sensitive. This means they conduct fast and responds to rapid moving stimuli (Vallbo, Olausson, & Wessberg, 1999). Also, the force and the properties of the stimulus decides the response of the myelinated afferents as well as the size of their RFs which gets larger the harder the force is. This means that the complexity, size and shape of myelinated afferents, and c-fibre afferents, diversify depending on what kind of stimuli it is (Wessberg et al., 2003).

Zotterman (1939) did an experiment on cats, where light and gentle touch were conducted repeatedly with short intervals on the cats, comparing the signals when the cat was picked on by a needle. This was the first study that showed that there is difference between touch signals and pressure signals and the difference between A-fibre axons and C-afferents: myelinated and unmyelinated and the results of that.

Later on, Nordin (1990) found low threshold C mechanoreceptors within humans, more specifically in the forehead. This made Nordin think that the forehead was the only place humans inhabit them, however later research has identified them in human hairy skin, like the forearm, face and legs. Because the C-afferents were found to respond to light stroking of the skin, they were then classified as tactile mechanoreceptors (Wessberg et al., 2003; Vallbo et al., 1999; Olausson et al., 2002; Edin, 2001).

Todays research shows that C-tactile afferents, however not myelinated afferents, reacts to pleasant tactile stimuli, like for example soft brush stroking, and makes up a peripheral pathway for affective pleasant touch that gives signals of affiliative social body contact (Löken, Wessberg, McGlone & Olausson, 2009).

Neurological Aspects of Touch

This section will focus on the neural aspects of touch, starting with a brief description of the somatosensory system pathways as well as the proprioceptive sense, followed by the main attention of the cutaneous sense.

Neural Pathways of the Somatosensory System

The primary somatosensory system and the secondary somatosensory system (the S1 and S2) are the main cortical regions that are responsible for perceiving touch (Blatow et al., 2007). S1 is found in the postcentral gyrus that is within the parietal lobe, which holds responsible for the body representation, called the somatotopic organization map. The stimulus of touch travels from the skin by primary afferents to the thalamic nuclei and further on to S1, contralateral side of stimulus. Furthermore, S2 is found in the region of the parietal operculum, and has also a somatotopic organization map, although somewhat more diffuse and complicated than the S1's, and S2's input of stimuli are mostly from both sides of the body. (Blatow et al., 2007). The somatotopic organization map can also be called the somatosensory homunculus, meaning 'the little man' (Pinel, 2009). It is a kind of body representation build upon how different body parts are sensitive to stimuli. The more sensitivity, the larger the representation. Furthermore, it is in the posterior parietal cortex and association cortex the outgoing information from both S1 and S2 arrives for further interpretation. When locating and recognizing objects through touch, just as other sensory systems, the somatosensory system has a 'where' and a 'what' neurological pathway. The 'where' pathway tells where around you objects are located, and goes from S1 to the posterior parietal lobe. The 'what' pathway, on the other hand, identifies objects and goes from S1 to S2, where form and texture is processed (Reed, Klatzky, & Halgren, 2005; De Santis, Spierer, Clarke, & Murray, 2007).

Proprioceptive Sense

The sense that informs us about the positions of our limbs and planning and executing our movements, as well as effort and balance, with or without sight, is called the proprioceptive sense (Proske & Gandevia, 2012). This means that if someone closes their eyes, they know where their limbs are and also relating to each other, even though they can not see. However, the proprioceptive sense and the visual sense does work together, more specifically when reaching and moving towards an object (Proske & Gandevia, 2012). The neurological pathway of the proprioceptive sense goes from the area in question signaling the limb position, through spinal cord, medulla, cerebellum and then to the S1 (Stillman, 2002). If it were to be a movement signal, it would transport to the primary motor cortex, and then further to the S1. From there on, the feedback information would be sent to the limb that were moved, possibly for it to move itself.

Cutaneous Sense

As noted earlier, the cutaneous sense, divided into discriminative and affective touch, tells information from active, passive and intraactive touch. Therefore this section will clarify the distinction between and the role of these elements.

As it comes to the perception of touch experience, Bolonowski, Verillo and McGlone (2004) differentiate between the feeling of touching others (or objects) and the feeling of being touched by others (or objects) one one's body parts. In short, there is a difference in the cutaneous sense of touching and being touched, and is represented in different brain areas. Moreover, touching oneself is also a type of touch distinguished from others. Active touch is the touch when touching others or objects, as one is trying to form an impression of the object or person by touching. Contrarily, passive touch is when one is being touch by someone or something that gives an subjective sensation internally. Lastly, intraactive touch is the type of touch that is when touching oneself. Yang, Wu and He (2011) did a study on active and passive touch, using presentation system of automated tactile stimuli and controlling subjects of the experiment's finger movement path and deciding where the stimuli would be. The brain activation was measured throughout the subjects doing different active and passive touch tasks. The results from the passive touch movement with the tactile stimuli system showed activation in left primary motor cortex, left premotor cortex, left supplementary motor cortex, left side of S1 and S2, and in the right cerebellum. The active touch movement activated almost the same areas of the brain, with a slight more activation within the right cerebellum and the primary motor cortex, however there was not a significant difference. Another study by Zaman, Moody, McGlone and Roberts (2001) measuring brain activation by letting 10 subjects to do 6 different stroking tasks. The results of the study showed that the prefrontal cortex (that is associated with planning complex cognitive behaviour, decision making, personality expressions, adjusting social behaviour etc.) only showed activation during subjects interacting with someone else, and not while touching oneself.

Discriminative Touch

As earlier mentioned, discriminative touch gives information of the spatial and temporal localisation of the stimuli on the surface of the body (McGlone & Reilly, 2010). As for example, the feeling of an insect crawling on the foot or the temperature of a breeze on the arm. Discriminative touch is vital for interpreting non-verbal communication, like a handshake or pat on the back. Also, discriminative touch tells of the intensities of a stimuli, like how warm and hard a handshake is and perception of pressure, texture, vibration and slip (McGlone et a., 2007). Being active, passive and intra-active, discriminative touch is thereby measured in the primary motor cortex, premotor cortex, supplementary motor cortex, S1, S2 and in the cerebellum.

An example of the importance of discriminative touch and also the plasticity of the brain is braille reading. Braille is a substitutional tactile letter form instead of the visual form for the blind, consisting of a series of raised dots which is read by the fingers (Sadato, 2005). It involves translating the tactile information into patterns of meaning of lexical and semantic properties. It is argued that several studies suggests that blind subjects have advanced tactile acuity and therefore advocate cross-modal plasticity within blind subjects brain, involving their visual cortex in tactile processing as well as the somatosensory system.

Affective Touch

As earlier stated, affective touch tells information about skin-to skin social contact and mechanical slow moving, low force stimuli. This creates responses of hormones, behaviour and emotion (McGlone et al., 2007). It precepts temperature, pain, itchiness and pleasant touch (McGlone & Reilly, 2010).

When studying touch a common problem is that it is hard to tell which axons in question are stimulated by which stimulus. Therefore has different kinds of stimuli of painful (noxious), neutral and pleasant stimuli been tested to see which brain areas responds to which stimuluses. In a NIRS (near-infrared spectroscopy) study by Kida and Shinohara (2013) the neural activation was examined when stroking the forearms hairy skin and in contrast to stroking the glabrous skin on hands. 31 subjects were exposed to three different types of materials to cause different types of touch. The first touch was interpreted as neutral touch, which were a piece of wood that was stroked over the skin. Second, a stick of wood wrapped with cotton and velvet was interpreted as pleasant touch. Thirdly, rated as noxious touch, a pointed stylus stroked over the skin. The sense of pleasantness was rated on a VAS (visual analogical scale). From the results of the NIRS scanner, the orbitofrontal cortex (OFC) showed activation, which later has been coupled with reward processing. It also showed activity within the frontal-polar cortice, which is part of the preforontal cortex, that has been argued to be involved in evaluating and monitoring the tactile induced plesantness, social behaviour and also the reasoning of psychological attributes of people without impact of self or others. However, the NIRS scanner did not show any significant difference between neutral touch (wood) and pleasant touch (velvet). It was shown that the frontal-polar cortice and the OFC are engaged in the pleasantness caused by gentle touch.

Affective touch has been shown to provide to the perception of body ownership, implicating also the psychological self (Crucianelli, Metcalf, Fotopoulou & Jenkinson, 2013). Subjects with Anorexia Nervosa (NA), a disorder usually involving fear of gaining weight, restricted eating and distortion of the body image, has been shown to have an impairment in the CT based affective touch system, which could explain their reduced perception of pleasantness of social interactions and distorted body representation (Crucianelli et al., 2016).

Pain

Pain can be divided into internal and external pain. Internal pain is the perception of pain from within the body and the internal bodily organs. External pain, however, which will be the reference in this essay, is pain as touch, meaning external stimulation on the body surface.

Cutaneous pain is what arises from the surface of the skin and the tissue that serves pain - the nociceptors. The nociceptors answers to A-delta fibers and C-fibers (Jarvis, 2008). The A-delta fibers pain information comes from the brain and gives a sharp and short pain within a specific location. This is called the first pain. The pain information from C-fibers to the brain tells a more aching and diffuse pain, that can still linger on after the stimulus is gone. This is called the second pain (Brannon & Feist, 2010).

The sensation of pain has two sensory pathways. The first path goes from the skins receptors and travels to the spinal cord. That is were an action response is sent out, for example, a reflex. The second sensory path goes further through the spinal cord, through the dorsal horn, continuing to the thalamus in the brain, where pain is perceived (Taylor, 2012). The information of pain is then sent further in the cerebral cortex, where it is identified as pain and where it is coming from and can then send impulses to diminish the pain through the periductal gray in the midbrain which sends the information back to the dorsal horn.

Negative emotions have been found to affect the perception of pain to be felt stronger. Pain can also be influenced by factors like genetics and gender (Apkarian, Bushnell, Treede, & Zubieta, 2005). Therefore, everyone experiences pain somewhat differently. Furthermore, studies have shown that emotional pain activates the same areas of the brain as physical pain does. Eisenberger (2015) explains that emerging evidence show that social pain (which are the painful feelings that are caused from loss, social rejection or exclusion) activates the same neural regions that also process the physical pain, which highlights a possibility of physical-social pain overlap. Danziger and Willer (2005) examined a patient with congenital insensitivity to pain, which is a kind of pain disorder that impaired his sensory component of pain but not the affective part of pain. The patient reported that after his younger sibling passed away he experienced pain for the first time. This comes to show that social pain is still able to be felt as long as the affective components of pain are still intact even though the sensory still is not.

Wellbeing and Affective Touch

The following section will mainly focus on psychological wellbeing and how much affective touch plays a part in it. An investigation of what defines psychological wellbeing will be held, preceding with examining the relations between affective touch and oxytocin, anti-stress, reduced feelings of social exclusion, romantic relations and mother-infant connections.

Definition of Wellbeing

The philosophical and psychological investigation of what is happiness and wellbeing originates in Greece, India and China nearly 2500 years ago with Aristotle, Socrates, Buddha and Confucius (Desan et al., 2016). There are many similarities between the modern science of wellbeing and the insights of these philosophers.

When defining what wellbeing is, there are essentially two approaches - the hedonic and the eudaimonic approaches.

Hedonic wellbeing, or subjective wellbeing, is about seeking physical pleasure as well as the cognitive-emotional pleasure and comfort. It defines wellbeing as continuously comparing pleasure versus pain, in the sense of viewing wellbeing as subjective happiness by including all judgement concerning the good as well as the bad elements of life (Ryan & Deci, 2001). Diener (1999) defined subjective wellbeing as life satisfaction, positive affect and negative affect as the primary components of happiness, that can be empirically measured.

The Eudaimonic approach to wellbeing, however, stems from a different perspective. Aristotle discard the idea of wellbeing as hedonic, perceiving it to be vulgar, as if humans were following their desires as slaves. Instead he posited that true happiness can be found when expressing virtue, meaning to do what is worth doing (Ryan & Deci, 2001). Today, eudaimonic wellbeing refers to a pursuing of development of the best in oneself and trying to live accordingly to one's virtues or the true self. It is to be fully engaged in activities that stems with deeply held values.

The pioneer researcher Seligman (2002) presented a theoretical model of happiness, combining the virtue ethics of Aristotle, Mencius and Confucius with modern psychological motivation theories, called PERMA. It stands for pleasure, engagement, relations, meaning and accomplishment, which are presented to be the vital elements to experience a full life. To conclude, combining the different views of hedonic and eudaimonic wellbeing, subjective wellbeing relies on how we feel, what we think and what we do.

The neuroscience of wellbeing is quite complex. Studies has shown that the structures usually working together that are activated during processing of emotional information and behaviour is the insular cortex (body representation and subjective emotional experience), the anterior cingulate cortex (attention and reward anticipation), hippocampus (memory), amygdala (autonomic responses and sexdrive) and the prefrontal cortex. The prefrontal cortex has specifically been the research focus on the count of that it shows an asymmetric activation when processing positive and negative emotions (Huppert, 2009). People that have a positive emotional style are showing at rest higher levels of left prefrontal activation than the right when using EEG of fMRI. Individuals with a negative emotional style have a tendency to show higher levels of activation in the right prefrontal cortex at rest (Davidson, 1992; Tomarken, Davidson, Wheeler, & Doss, 1992; Urry et al., 2004). What has also been reported by Davidson and colleagues is that induced negative mood, independently of emotional style, increases relative activation on the right side. Furthermore, when inducing positive mood, the left side activation increases (Davidson, 2005; Davidson, Chapman, Chapman, & Henriques, 1990). Moreover, neurobiological evidence has shown that left and right frontal lobes function differently when processing information. Left prefrontal cortex controls the spontaneous strategy production and the right prefrontal cortex is accountable for error detection (Shallice, 2004, 2006).

Furthermore, research has shown that when exposed to stress, the hypothalamic-pituitary-adrenal (HPA) axis is activated and the stress hormone cortisol is increased in secretion, more than the healthy level pattern. However, this can in turn be modulated by individual differences in psychological wellbeing, e.g. emotional style or self-esteem (Jacobs et al., 2007; Polk, Skoner, Kirschbaum, Cohen, & Doyle, 2005; Pruessner, Hellhammer, & Kirschbaum, 1999; Smyth et al., 1998). High scores on measures of wellbeing such as positive affect and optimism is associated with healthy patterns of cortisol secretion, which refers to a post-awakening peak and later in the day a 20-fold decrease (Clow, 2004), although not on measures of illbeing such as negative affect, pessimism, fear and anxiety (Lai et al., 2005; Ryff et al., 2006; Steptoe, Gibson, Hamer, & Wardle, 2007; Steptoe & Wardle, 2005). Therefore, both positive and negative states associates with cortisol response, although independently of one another.

Serotonin is another neurochemical that associates with mental states. It is reduced in depression, which in turn anti-depressant drugs increases to make available to the brain cells, called serotonin reuptake inhibitors (SSRIs) (Huppert, 2009). Flory, Manuck, Matthews, and Muldoon (2004) studied if there were any relationship between serotonin and mental states. An experiment was carried out, investigating 254 healthy adults that had to do daily ratings of their mood. It was found that serotonin levels had relations with positive moods on average for 7 days, but no relations to negative mood. However serotonin had relations to a measure of neuroticism. The conclusion from this of the authors was drawn that deficiencies in serotonergic function can be reflected in the relative absence of positive mood.

Moreover, the mammalian hormone oxytocin has been studied to see if it increases in states of positive wellbeing. A further clarification of oxytocin will be held in later sections, however it has been shown to have a role in childbirth, lactation and effects mother-infant bonding (Kendrick, 2004). Oxytocin is, in humans, also released during orgasm (Huppert, 2009). A study by Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr (2005) showed that nasally administered oxytocin can lead to a higher degree of trust when it comes to a risky investment game. Therefore, some limited evidence show that oxytocin can play a part in social bonding, which is an important element of overall wellbeing.

Affective Touch and Positive Affect

As mentioned in the recent section, positive affect is an important element on what subjective wellbeing entails. Positive affect (PA) kan be described as the feelings of pleasure of engagement and environment, such as enthusiasm, joy, excitement, contentment and happiness (Pressman & Cohen, 2005). It can be brief, longer lasting or of a more stable nature, such as traitlike feelings. As interests of positive psychology and the benefits of PA has increased, it can now be empirically measured by tests such as e.g. the positive affect and negative affect schedule (PANAS), which is a self-questionnaire with two 10 item mood scales that measures positive and negative affect (Watson, Clark & Tellegen, 1988).

Previous data of that C-tactile afferents interprets socially relevant, rewarding tactile information within humans has been somewhat empirically limited. Pawling et al., (2017) were the first through their study to provide empirical evidence of that tactile stimulation in humans which ideally activates C-tactile afferents carries a positive affect valence, which can be measured implicitly. The study was of 29 subjects combined subjective ratings of pleasantness of touch while implicitly measuring affective state (facial electromyography) as well as the autonomic arousal (heart rate) of the subjects. This was done to resolve if C-tactile afferents activation gives a positive affect value. Using facial electromyography (EMG) two facial muscles sites where measured that is of importance for emotion - the zygomaticus major, which is the smile muscle associated with pleasant stimuli and PA, and the corrugator supercilii, being the frown muscle associated with unpleasant stimuli and negative affect (NA). The reasoning for using EMG is that it can measure the affective response relatively independent of autonomic arousal. It can also differentiate affective responses to perceptually akin sensory stimuli, unlike subjective ratings of pleasantness. Measuring the facial muscles, the participants estimated the pleasantness of the experimenter's administered stroking touch of a soft brush, following a LCD display and earpiece. The stroking were at two different velocities, one optimal for C-tactile afferents at 3 cm/sec and one non-optimal for C-tactile afferents at 30cm/sec. The stroking also occurred on two skin sites - the forearm, innervated with C-tactile afferents, and the palm, not innervated with C-tactile afferents. On both sites the stroking touch of 3 cm/sec was rated to be more pleasant and similarly the heart rate were greater than the stroking of 30 cm/sec stimulation. Nevertheless, neither the self-report rating or the heart rate responses discriminated the stimulation on the forearm stroking from the palm stroking. In contrast, there were significantly more activation of the smiling muscle, the zygomaticus major, specifically seen to the stroking of C-tactile optimal 3 cm/sec on the forearm compared to all other stimuli. Given that activation of the zygomaticus major muscle site has previously been connected with positive affective reactions in former studies, the findings of this study demonstrate the C-tactile afferents having a role in giving information of the reward-value of the social tactile interactions, resulting in an implicit emotional response (Pawling et al., 2017).

Oxytocin and Affective Touch

As mentioned earlier, oxytocin (OT) is known for its physiological functions within labor and lactation, although also in social bonding, which is an important element in wellbeing. According to Ross and Young (2009), OT is a neurohypophyseal peptide, produced within the hypothalamus and becomes released within the neurohypophyseal system, peripherally released during nursing and centrally released on the onset of behavior of maternal nurturing. Moreover, OT has also been found, in both sexes, a more general role in modulating affiliative behaviour. It has been shown that OT receptors are distributed in different areas of the brain (Landgraf and Neumann, 2004) that are connected with social behavior, like affiliation and attachment, social memory and social stress reactivity in nonhuman mammals (Carter, 1998; Fergueson et al., 2000; Young and Wang, 2004). Studies of OT has shown that it reduces response to social stress and that it increases trust when socially interacting (Heinrichs et al., 2003; Kosfeld et al., 2005).

In a study by Ellingsen et al. (2014) OT was investigated to have affect on touch experience and the social impression of others. The study was a placebo-controlled crossover, using intranasal OT, with 40 healthy subjects. Pupil diameter was monitored while gentle human touch - affective touch - or control machine touch was performed in a C-tactile afferents optimal pace, approximately 5cm/s, simultaneously showing faces with different facial expressions. After each pair of stimulus, the subjects rated the perceptions of the faces and the pleasantness and/or intensity of the touch. After being treated by intranasal OT, affective touch sharpened the effect on social evaluation in comparison to machine touch. Moreover, smiling faces increased the pleasantness of affective touch, however OT itself did not alter the pleasantness of the touch.

Nevertheless, other studies have shown that affective touch is connected to peripheral OT release. For instance, when nonhuman primates interact in social grooming behavior, OT plays a key role (Pedersen et al., 1988; Francis et al., 2000). Elevated OT plasma levels can be predicted with a high frequency of physical contact in human studies was shown by Light et al., (2005). In another study Morhenn et al., (2008), it was shown that people that are being given massage comes to be more trusting in social interacting trust game later on. This affect covaries with the levels of plasma OT. Interestingly, it was shown that the subjects’ levels of plasma OT increased only when the subject had received a massage and then participated in the social interaction, but not after receiving massage or participating in the social interaction alone. Moreover, peripheral levels of OT has a positive association with parental touch of infants. Specifically, with the affectionate touch of mothers associates with high plasma OT levels, as to stimulatory touch in fathers (Feldman, 2012). This will be further explored in a later section.

Affective Touch as Anti-Stress Implement

When discussing stress in this context of this article it is referred to the chronic stress exposure for a longer period of time, and its destructive outcome. However, stress in itself is not necessarily a harmful concept. Stress response refers to activation of systems in the body specific for fast reaction to prompt, sometimes life threatening, events. The body shifts to 'fight or flight' mode, which releases hormones and chemicals in the body, such as cortisol, norepinephrine (stress hormone and neurotransmitter) and adrenaline. This causes different kinds of reactions in the body, such as blood diverted to muscles and unnecessary (for the time being) bodily functions shuts down (Morrison, 2016). These stress responses show that the body's efficient and effective use of energy economy and adaptive modulation of behaviour is crucial. Such stress responses, under typical circumstances, are adaptive. However, they can have a dangerous flipside (Valentino & Van Bockstaele, 2015). Some stress responses can occur at the expense of vital immune inflammatory processes. Being exposed to stress during a longer period of time can impair growth and healing and level out the stress responses. It has even been shown to shrink hippocampal neurons that are involved in learning (Miller et al. 1994, Sapolsky 1994; Herman & Cullinan 1997; Sapolsky 2005). In short, stress is a physical response vital for survival, however being exposed of stress for a longer period of time can be destructive and dangerous.

The subjective feeling of stress is without a doubt classified as negative affect. As earlier stated, having a prominent subjective wellbeing concerns, among other aspects, reducing negative affect, leaving room for enhancement of increasing positive affect. Morrison (2016) examined if social affective touch plays a part in the physiological regulation when the body responses to acute stressors. After reviewing different studies of this field evidence was found that touch can 'buffer' unfavorable physiological effects of potentially maladaptive or inefficient responses. A stress buffer, in the sense of being a process or mechanism that softens, attenuate, diminishes or prevents energy efficiency to be lost among the regulatory systems, while still being adequately responsive to external challenges. It was found that affective touch works strongest as a physiological regulator for systems that control the maintenance of physical closeness to conspecifics during different circumstances. For instance, social physical contact in mammals has been shown to involve social thermoregulatory processes, such as snuggling and huddling, which as well relies on somatosensory and tactile thermosensory pathways. Moreover, the researcher indicates that when consoling someone else with prosocial touch, the stress level can be decreased. For instance, holding someone's hand in anticipation of pain can reduce anxiety (Coan et al., 2013). Not only for the one that is anticipating the pain but also for the one that is observing someone else with anxiety. Mere observation of stress in others elevates stress responses in us, therefore consoling others does not only relieve other's from stress, but can also be a way for physiological regulation of stress of our own (Morrison, 2016).

Lastly, evidence have been showed that supports touch contributing to prevent social separation and to control the reinstatement of contact followed by social separation. Panksepp et al., (1978a, b) suggested a theory called Brain Opioid Theory of Social Attachment (BOTSA), which entails that affiliative, social behaviors are driven by the same basic system as perception and alleviation of pain. According to this model, social separation entails a pain like neurochemistry which can be blocked as neurohormones (beta-endorphins) connects to MOR receptors (opioids for pain management) in the brain when social contact occurs. Evidence suggest that this may relieve the subjective aversive effects if isolation (Panksepp et al., 1997; Nelson & Panksepp, 1998).

Affective Touch and Social Relations

Seligman (2002) explains in the PERMA model that relationships and social connections is to be one of the most vital aspects of a full life. As humans we are social animals that flourish on love, intimacy, connection and strong physical and emotional interaction with other humans. Therefore, building positive relationships are important since isolation, in an evolutionary perspective, is the worst that can happen for survival.

Affective touch has come to show a number of different outcomes on perception of social coherence and relationships. This section will examine touch's ability to comprehend social information, the reduced feelings of social exclusion with affective touch and its role in romantic, and mother-infant relationships.

The Skin as a social organ

As already explain, cutaneous touch provides information about location of stimulation on the skin surface. It also explores objects haptically and identifies and manipulate them.

Moreover it contributes to the perception of the sense of oneself's body (Serino & Haggard, 2010). Morrison, Löken and Olausson (2010) continues with describing affective touch, or pleasant touch, as at the heart of the social domain, as it allows positive hedonic experience varying from a reassuring pat on the back to the thrill of a sensual caress.

Nonsexual, positive hedonic form of social touch can be divided into three different categories, depending on its tentativeness (Morrison, Löken, & Olausson, 2010). Firstly, the 'simple touch' imply a brief, intentional contact on a quite restricted location on the surface of the body of the receiver at a social interaction. For example, a soft pat on a hand or a gentle touch on an elbow for a request. Second, a 'protracted' touch, which entails a longer and usually mutual skin-to-skin contact amidst individuals, often with a component of pressure, like holding hands, embracing and cuddling. Finally, a 'dynamic' touch involves a continuous move over the skin from point A to point B, often repetitive like in stroking, caressing or rubbing.

The role of pleasantness in these different categories of social touch amongst humans is that it plays as a foundation for affiliative behaviour. Secondly, it provides as a mechanism for formation of social bonds and the maintenance of them. Furthermore, pleasantness communicates emotions on a nonverbal level. However, varieties of social touch is interpreted differently depending on culture, context and gender and may not always be pleasant or welcome (Dibiase & Gunnoe, 2004). However, what is affiliative behavior? Morrison, Löken and Olausson (2010) continues that it is what increases or reflects the situation of one or more members when an interaction is sought for close contact with another. This is assumed to be followed by feelings of positive affect and alleviates stress and anxiety.

The effects of touch during social interactions have been found in studies to increase fondness of a place or person, as well as facilitating a trust or compliance, usually demonstrated in increased prosocial behavior. For instance, a study show that when touched by a salesperson, the evaluation of the store increased positively (Hornik, 1992). Another study showed that recipients of 'simple' touches are more likely to be more unselfish and compliant like giving more tips in a restaurant (Crusco & Wetzel, 1984) or giving back money that was left in a public phone (Kleinke, 1977). Resources in these studies with a great degree of generosity and compliance indicates that such fundamental social touches can possibly provide a platform for cooperation and trust in future exchange (Morrison, Löken, & Olausson, 2010).

Lastly, touch can serve as a communicative tool. It can be used to express feelings and thoughts, and to regulate them in others (Hertenstein, Verkamp, Kerestes, & Holmes, 2006a). Tactile communication does not need to always involve mutual touching because the touch of the giver can affect the participants' emotions and signals without answering touches. In a study by Hertenstein et al., (2006b) individuals from US and Spain had to evaluate different categories of emotion based on how they were touched. Both positive and negative categories of emotions were accurately decoded. The negative emotions that were successfully recognized were the pancultural negative emotions when expressed in the face: disgust, fear and anger. The positive emotions that were successfully decoded were the ones that can be implied in relationships: sympathy, gratitude and love. Interestingly, the 'sadness'-stroking was perceived as love or sympathy, which suggests that interpreting ambiguous interpersonal touch stimuli may show a positive emotion bias.

Affective Touch and Reduced Feelings of Social Exclusion

Psychology and neuroscience has over the past 15 years investigating the relations with social isolation (typically operationalized as having less than monthly form of communication with friends and family, being single and/or not participating in clubs, organizations or religious groups) and negative health outcomes (Cacioppo, Capitanio, & Cacioppo, 2014). A hypothesis called the social control hypothesis supports this as suggests that interactions with family, friends and congregations inclines better health behaviour and decreases risk for mortality and morbidity. The investigators of this area typically measures the person's perception to be socially isolated. For example, the same relationship can be perceived both protective and caring or threatening and callous (Cacioppo et al., 2000). Moreover, frequency and numbers of social contacts is not as vital as the actual quality of the social relationship, in terms of feeling isolated (Hawkley et al., 2008; Wheeler, Reis, & Nezlek, 1983). One can feel isolated or lonely of physical/objective social isolation, though one can feel just as lonely in a marriage, family, friendship or congregation. Furthermore, the perception of isolation can differ on the cause of personality traits variations, such as introversion and extroversion (Cacioppo et al., 2006).

Loneliness is the perception that the social relationships are inadequate in relations to the preference of social involvement (Weiss, 1973). Perceived isolation (i.e., loneliness) is suggested to be strongly associated with the most toxic physical and mental health outcomes (Cacioppo et al., 2006; Holwerda et al., 2012; Wilson et al., 2007). Social exclusion on a small-scale, like ostracism, has been found to induce various strong negative reactions, affecting physiology, cognition and affect (Williams, Cheung, & Choi, 2000). Even more, the physical pain system, namely the anterior insula and the dorsal anterior cingulate cortex, has been proposed to be signaled when social relationships are threatened (Eisenberger, 2014; Eisenberger, Lieberman, & Williams, 2003).

In a study by von Mohr, Kirsch and Fotopoulou (2017), the relations between affective touch and social exclusion was explored. They suggested that because recent studies has shown that affective touch regulates the perception of physical pain, these would be a possibility that affective touch is also able to reduce the feelings of social exclusion as it is a form of social pain. The authors employed a social exclusion paradigm called the ‘Cyberball task’, which entails a computerized ball-tossing game where a group of three people tosses a ball between them back and forth. Without the participant knowing, two members of the group that are tossing are employed by the experimenters and are following a pre-arranged script. Typically in this experiment, half of the participating subjects are excluded from the task after a few tosses and does not get the ball again. There were 84 female participants in this 2x2 mixed design study where half (N42) was assigned affective social support of slow touch after exclusion. The experiment supported the authors hypothesis, that the provision of affective touch, compared to fast-neutral touch, led to feelings of social exclusion being decreased, beyond general mood effects. These findings show that affective touch has a soothing function, especially in a context of rejection or social separation, which suggests that there is a relation between social bonding and affective touch.

Earlier research has shown that physical pain can be modulated when followed by affective touch (Krahé et al., 2016). In an experiment exposing subjects to heat pain, followed by C-tactile afferents optimal touch of slow brushing, compared to fast brushing or vibration, resulted in that slow brushing (affective touch) was effective in reducing pain, whereas fast brushing or vibration was not (Liljencrantz et al., 2017). The study by Mohr, Kirsch and

Fotopoulou (2017) also show that optimal C-tactile afferents, affective touch has an affect on ‘social pain’, such as ostracism, at least for a short time. Thereby, these findings supports elements that affects physical pain may also influence social pain, which is consistent with the hypothesis of physical-social pain overlap.

Affective Touch and Romantic Relationships

As already stated, touch plays an important role as it comes to social bonding and close relationships. It has also been found that affective touch has a fundamental part of the means of interpersonal communications within romantic relationships (Gallace & Spence, 2010). The field of social neuroscience has increased its interest of interpersonal touch, communication of affect and health as we are in an age of exacerbate virtual communication, facing a shortage of tactile stimulation, referred to ‘the touch hunger’ (Morrison et al., 2010; Field, 2001).

Earlier research on affective touch has mostly been focused on an individual level. Chatel-Goldman, Congedo, Jutten and Schwartz (2014), however, composed a study that investigated if affective touch increases autonomic coupling amongst romantic partners, aiming to extend the field of affective touch from isolated individuals to properly interacting dyads. The design was an ecological paradigm where fourteen romantic-sex couples, that had been together at least six months by the time of the scanning, interacted exclusively by touch while their empathic states were manipulated. Simultaneously, their autonomic activity of pulse, skin conductance and respiration were collected. The participants were instructed to think of four personal life events that had preferably been experienced together with the partner, that were a great emotional experience. Two of these life events had to be associated with negative emotion and two had to be associated with positive emotion. After the private decision making amongst the couples, they were installed inside the experimental room with all the various electrophysical measurement devices. During the experiment the couples were not allowed any eye contact and screens and input devices were set up to give unique instructions to the subjects and collect subjective feedbacks during the experiment. The empathy level were evaluated through an empathy test of each subject and the role of ‘the Empathizer’ (E) of the couple were given to the one subject with the highest score, and the one with the lowest score of the couple were given the role of ‘the Transmitter’ (T). The experiment consisted of ten runs of information exchange, with five of them being in no touching condition and the other five of touching of hands and forearms. The subjects were given instructions on their own personal screen. Participant (T) was instructed to recall one of the four events, positive or negative, and participant (E) was informed of the chosen event and was asked to be as empathic as possible, without focusing on the event itself, but to try to share the partner's emotional state. Half of the runs, the instructions given to the Transmitter were revealed to the Empathizer, meaning (T) remembered event X and (E) was informed about it. In the other half of the runs, the Empathizer was provided incongruent priming, meaning (T) was instructed to remember event X, and (E) was informed that (T) was asked to remember event Y. Two neutral runs were also introduced as a control for the arousal of emotion of the participants. At the end of each run the subjects reported subjective feedbacks.

The results of this experiment showed that interpersonal touch raised coupling of electrodermal activity amongst the interacting partners, in no matter of the valence or intensity of the emotions that were felt. Moreover, physical touch caused strong and reliable changes within the physiological states of the individuals. These results supported the notion of interpersonal touch having an instrumental role for affective supports in intimate relationships. Furthermore, the results are concluded that touch in itself allows the development somatovisceral response between interacting individuals, which is likely to form the conditions for empathy and emotional contagion (Chatel-Goldman et al., 2014).

In addition, Triscoli, Croy, Olausson and Sailer (2017) executed a study to examine affective touch within partners, if stroking is pleasurable for the person performing it, and if it has the same effect as being stroked on wellbeing and autonomic nervous function. The experimenters also compared hedonic and autonomic nervous outcomes of stroking oneself and stroking a partner. 40 subjects were stroked on the forearm of their romantic partner, followed by both the Receiver and the Stroker rated the pleasantness, as heart rate was monitored and stroking velocity was tracked during the session. Neither in this experiment were the participants able to see each other. In experiment two, the same design of experiment was replicated with 20 subjects, where conditions of self-stroking and rest were added. Both self-stroking and stroking the partner were performed in an optimal C-tactile afferents activating velocity. Stroking the partner, being stroked and self-stroking were all experienced as pleasant. Nonetheless, being stroked had the significantly highest ratings of pleasantness, which was also the only condition that decreased significantly in heart rate. Couples in satisfying relationships felt more pleasure to be touched by their partner. They also showed a greater heart rate decline when they were being touched. The researchers advocated that the result showed that affective touch has a role in regulating heart rate when being stroked and that the absence of autonomic effects when performing the stroking could be the cause of no visual feedback from the stroked person. The researchers continue that the high pleasure of giving and receiving touch could support affective tactile interactions between romantic partners and therefore reinforce the relationship (Triscoli et al., 2017).

Affective Touch and Mother-infant Relationships

The mother-infant bond has been proven to be of a substantial role of our evolutionary-based biology. Moreover it is a principal component of the cultural heritage of the human as images of maternal-infant closeness over human history and across different cultural communities are deeply established in our unconsciousness and serve as the fundamental symbol of human capacity of loving. The maternal affection's behavioral building blocks, such as touch and affect, serve as the primary channels for expressing love that derive any form of human affection (Feldman, 2011). The most elementary mammalian maternal behavior is touch, as when an infant is born the first a mammalian mother does is to engage in typical species repertoire of maternal behavior that consists fundamentally of close physical proximity and providing maternal touch. This contributes to the development and growth of the young as importance for their adaptation and survival (Feldman, 2011).

As mentioned, levels of OT has been associated with affective touch of a parent to an infant, especially of mothers (Feldman, 2012). Research suggests that increased OT levels during pregnancy promotes postnatal maternal behaviour and aids to form an emotional bond between mothers and their infants in humans by reducing anxiety and improve responses to external stresses. This will help mothers to focus on the infant care, adjust their mood and be able to respond more effectively to nonverbal cues of the infant in a context of a reward system and social learning (Galbally, Lewis, IJzendoorn, & Permezel, 2011; Uvnas-Moberg, Widstrom, Nissen & Bjorvell, 1990; Chiodera et al., 1991; Light et al., 2000; Mezzacappa & Katkin, 2002;

Domes, Heinrichs, Michel, Berger, & Herpertz, 2007).

A recent study investigated youth OT response of affective touch between mothers and youth with anxiety disorders. The results were that affective touch - together with maternal intrusiveness, maternal sensitivity, youth initiative and engagement - all contributed to youth OT response and there were a positive association between OT response and presence of separation anxiety disorder (SAD) and with children ratings of anxiety of separation. The conclusions drawn from this study was that the findings emphasize the importance of the dyadic and maternal behavior patterns to OT responses in youth with clinical anxiety, and highlights the association between SAD and OT (Lebowitz et al., 2017).

Discussion

The aim of this thesis has been to examine the sense of touch and its relevant neural correlates, focusing in particular on affective touch and its role in subjective wellbeing and social relations. The focal points have been to present different kinds of touch and the physical and neural factors of them, with a special interest of affective touch. Furthermore, the role of affective touch in subjective wellbeing have been examined, by first defining what wellbeing is, following an exploration of affective touch's possible influence on factors of it, such as positive affect, negative affect and social relations.

Firstly, it was found within the physiological view, that the A-delta axons within affective touch corresponds to LTMR nociceptors (first sharp pain) and the thermoreceptors (temperature). The C-fibre axons corresponds to HTMR nociceptors (second burning pain), itch receptors, thermoreceptors and LTMR C-tactile afferents (light and pleasant touch) (McGlone & Reilly, 2010).

The results of the studies of Yang, Wu and He (2011) and Zaman et al., (2001), implicating C-tactile afferents-evoking stroking, implied that brain areas such as orbitofrontal cortex, frontal polar cortice, prefrontal cortex and insula cortex (which is part of the limbic system) are activated in active and passive affective touch, which are brain areas that are also activated in processing subjective wellbeing, such as reward processing, social behavior planning, evaluating positive and negative affect and emotion, etc. This suggest a neurological connection between affective touch and subjective wellbeing.

The study of Pawling et al., (2017) showed that affective touch provides positive affect valence, showing activation in facial muscles connected to positive affect reactions. As increasing positive affect is said to be a vital part of subjective wellbeing, this evidently suggests affective touch to play a part in wellbeing.

The hormone oxytocin as well, shown to play a part in social bonding and trust (Pedersen et al., 1988; Francis et al., 2000; Light et al., 2005; Morhenn et al., 2008; Feldman, 2012), was shown to be of a higher level in association of pleasant affective touch, which also supports the notion of affective touch to affect subjective wellbeing, as social bonding plays an important part of it. However, the research of oxytocin's influence of higher level social cognitive behaviours has only been of recent focus, and should in itself be studied more.

Furthermore, Morrison (2016) uplifted relevant data showing that affective touch can be used as stress reducing or softening physiological regulator systems coupled with stress response, such as holding someone's hand in anticipation of pain reduces anxiety, and snuggling and huddling affecting social thermoregulatory processes. Moreover, affective touch was found to reduce stress of social separation (Panksepp et al., 1978a, b) which is another aspect of showing affective touch enrollment in subjective wellbeing as it reduces negative affect, more specifically, negative stress.

Affective pleasant touch showed in the study of Morrison, Löken & Olausson (2010) to play as a foundation for affiliative behavior, followed by feelings of positive affect and alleviated stress and anxiety. Again, these findings reconnected with factors of a prominent subjective wellbeing. Therefore, it came as no surprise when studies of perceived social exclusion and loneliness showed variations of negative effects, such as toxic physical and mental health outcomes (Cacioppo et al., 2006; Holwerda et al., 2012; Wilson et al., 2007). Neural pain systems, such as anterior insula and dorsal anterior cingulate cortex, has been proposed to be signaled when social relationships are threatened (Eisenberger, 2014; Eisenberger, Lieberman, & Williams, 2003) and the study by Mohr, Kirsch and Fotopoulou (2017) showed that social pain, just like physical pain, could be soothed by pleasant affective touch, especially in a context of rejection or social separation. Arguably, these findings shows that affective touch is an important tool in terms of comforting and consoling, which are important elements in social bonding and showing support for another.

Also, affective touch was demonstrated in the study Chatel-Goldman et al., (2014) to increase in autonomic coupling and empathy and emotional contagion amongst romantic partners. As romantic relationships are arguably one of many important relationships to an individual's wellbeing, some might even claim it to be the most important Therefore, it would be interesting to further research these interactions, as for now, studies of couples and affective touch has still only recently been explored and there is a lot to be explored more thorough.

When researching for this thesis, it has been inevitably to notice that there is still a lot to be investigated as it comes to affective touch. Most studies of affective touch that have been done so far has focused on the physiological aspects, such as on the CT afferents and on what they specifically react to and how, such as speed and force. Many of the studies examining the CT afferents have been done on animals and only recent studies has examined them on humans and in these cases, mostly on individual levels. Although this is vital information for the understanding of affective touch, it would be interesting to examine this research area further.

As a suggestion, a step further in this direction would be to examine what exactly it is that determines the subjective experience of affective touch. What is it that determines if a touch is pleasant, soothing, loving, intrusive, etc. As the study of Dibiase & Gunnoe (2004) mentioned, social touch can be interpreted differently depending on culture, gender and context, although why this is, and how, is not further explained. Further research of the subjectiveness of touch would very likely lead to more understanding of affective touch and its affect on wellbeing and relations. If we can understand the subjective experience of touch and what determines it, perhaps an understanding of how to alter it would grow as well. Knowing how to alter the subjective experience of touch might help erase cultural boundaries amongst the human population and fewer misconceptions would appear when using touch as a communicative tool and would bring everyone closer.

Furthermore, as mentioned by Morrison, Löken and Olausson (2010), pleasant touch is the heart of the social domain and the skin can be used as a social organ. There is a somewhat general knowledge of the importance of physical contact, however the information conveyed in this thesis of affective touch should preferably be expanded to the layman, as it shows important elements to this day in age. In our society today we are being exploited to many stressfactors, such as bad work and/or home environments, social media and unachievable goalsettings, which is leading to more and more leave of illness from work on the cause of physical or mental collapse caused by overwork or stress. At the same time, as mentioned in the thesis, we are living in a time right now of “touch hunger”, meaning we are having less and less physical contact with each other. A time, when we actually need it the most. Therefore, this knowledge of touch’s affect on stress reduction and social bonding is important to pass on to the public for the sake of its general psychological health.

One can speculate, judging from the findings from this thesis, that a person deprived of human touch from an early age would feel very socially excluded and lonely, perhaps leading to depression and/or anxiety. Also, since touch is involved in comprehending and executing social interaction, it is likely that this person would have trouble with this and have trouble understanding the affiliative behaviour. Their empathy might not be properly evolved and they would have a misstrusting nature over them, which perhaps would evolve into an aggressive behaviour as a coping mechanism.

As a further research proposal, after examining the subjective experience of affective touch and what determines it, it would be of interest to implement the knowledge into applied psychology. If affective touch can be used as a stress buffer, perhaps it can be used to treat general anxiety or other mental disorders, as they can be caused by stress or traumas. Also, it would be of interest to combine the research of affective touch with research of autism spectrum disorder (ASD), known for being a neurobehavioral condition with impairment of social interaction. Perhaps studying how affective touch is perceived with ASD patients might contribute to a broader understanding of both affective touch and ASD.

Moreover, as already mentioned, studies of romantic, or other, relationships as most studies so far have been on an individual level. One can speculate, as affective touch has shown to soothe the pain in social separation (Mohr, Kirsch and Fotopoulou, 2017) that perhaps it works on a preventive level, and could be used to increase trust and sustainability in the relationships. Also, more crosscultural-and-gender studies should be held, investigating affective touch and couples from different cultures or same-sex marriages could be of interest, as well as comparing divorced and not divorced longterm couples and their habits of affective touch.

Conclusion

The aim of this thesis was to examine the sense of touch and its relevant neural correlates, focusing in particular on affective touch and its role in subjective wellbeing and social relations. The sense of touch seems to have a complex system with its different receptors and axons in the skin, sending information of a stimulus through the CNS further to the posterior lateral and medial thalamic nuclei and further to the cortical regions primary somatosensory system, and the secondary somatosensory system. The affective touch, which responds to painful and pleasant touch, appears to activate the brain areas of orbitofrontal cortex, frontal polar cortice, prefrontal cortex and insula cortex, which are also areas that are activated when processing subjective wellbeing, such as processing emotional information and behavior, and evaluating positive and negative affect. Therefore, affective touch seems to have an important influence on subjective wellbeing, which studies have shown when examining correlations between affective touch and positive affect, negative affect, oxytocin, social relationships and affiliative behavior.

In order to understand the somatosensory system, especially affective touch and its role in subjective wellbeing and social relations, further research is needed. Notably, because the scientific interest of this area is still new as most of the research is quite recent. Suggestively, investigating oxytocin in humans more, applying affective touch as treating anxiety disorders, and affect of affective touch on trust and sustainability of relationships.

Finally, sense of touch is important for further research, because it plays a vital role for humans to interact with the outside world. Further understanding of affective touch and its effects can be applied as alleviating physical and mental subjective wellbeing, something that is an ongoing interest in this “touch hungry” world.

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