Aalto University
School of Science

Touch in human communication

Advanced Course on Human Brain Functioning
20.04.2016

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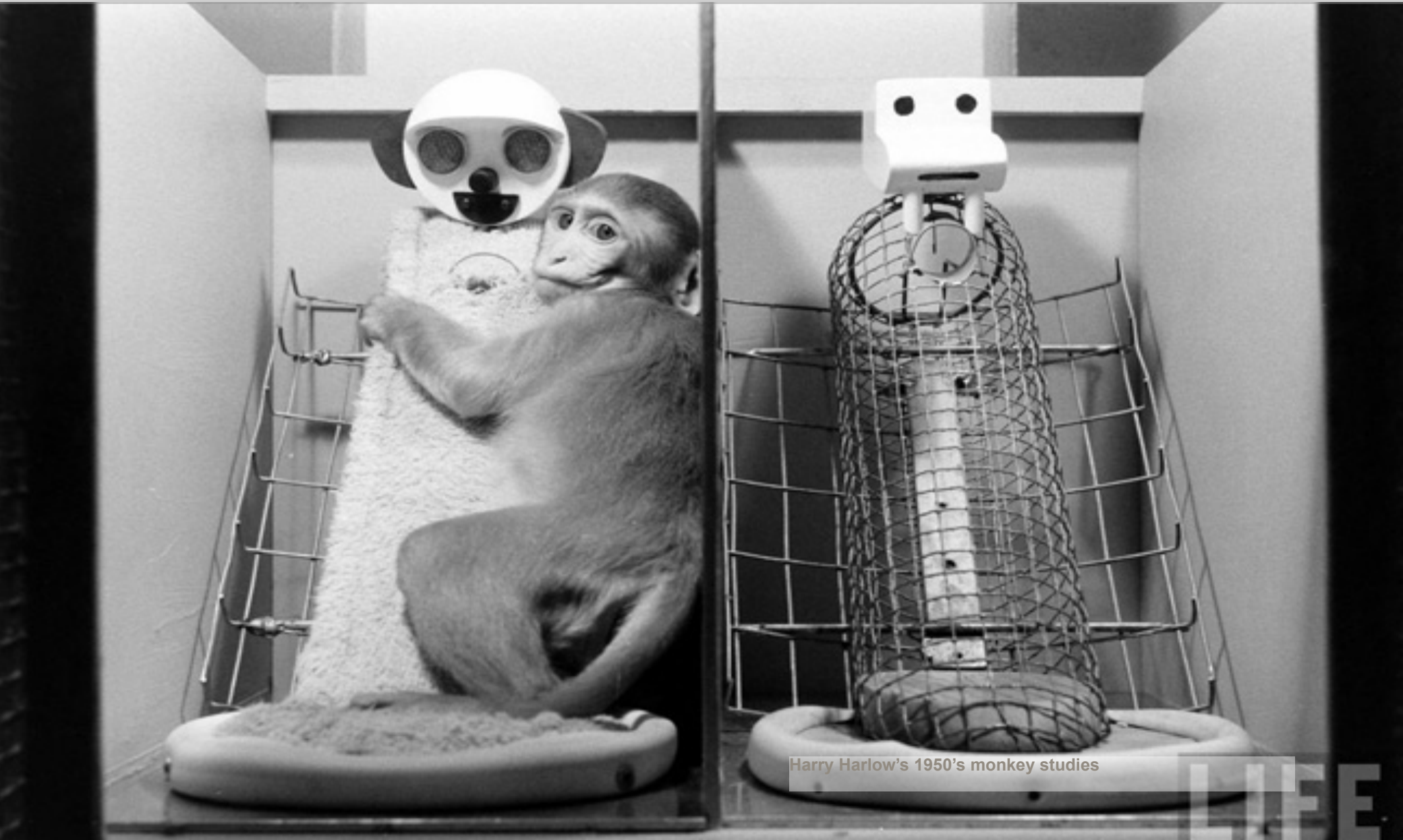
Agenda

- Motivation
- Grooming
- Behavioral studies
- Tactile perception
- Neurochemistry of social touch
- Recent studies
- (Disorders)

Why is touch important?



Why is touch important?

Grooming

Time spent on social grooming differs greatly among species

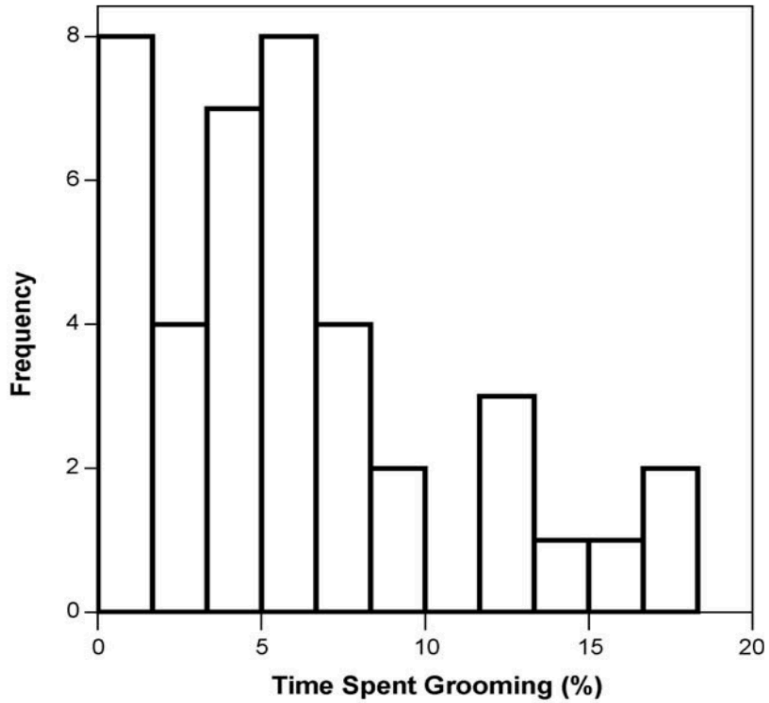


Fig. 1. Frequency distribution of the percentage of total daytime devoted to social grooming by Old World primates. Data are species averages (individual groups may devote more time to grooming) and the *y*-axis indexes the number of species with a particular mean grooming time. Data source: Lehmann et al. (2007).

Dunbar, R. I. (2010). The social role of touch in humans and primates: behavioural function and neurobiological mechanisms. Neuroscience & Biobehavioral Reviews, 34(2), 260-268.

Time spent on social grooming does not correlate with skin surface area

- Time spent on allo-grooming (grooming others) is not proportional to animal skin area
- Time spent on allo-grooming far exceeds time spent on self-grooming in most primates
- Evolutionary view suggests that spending up to 20% of time on an activity means that the activity is somehow beneficial

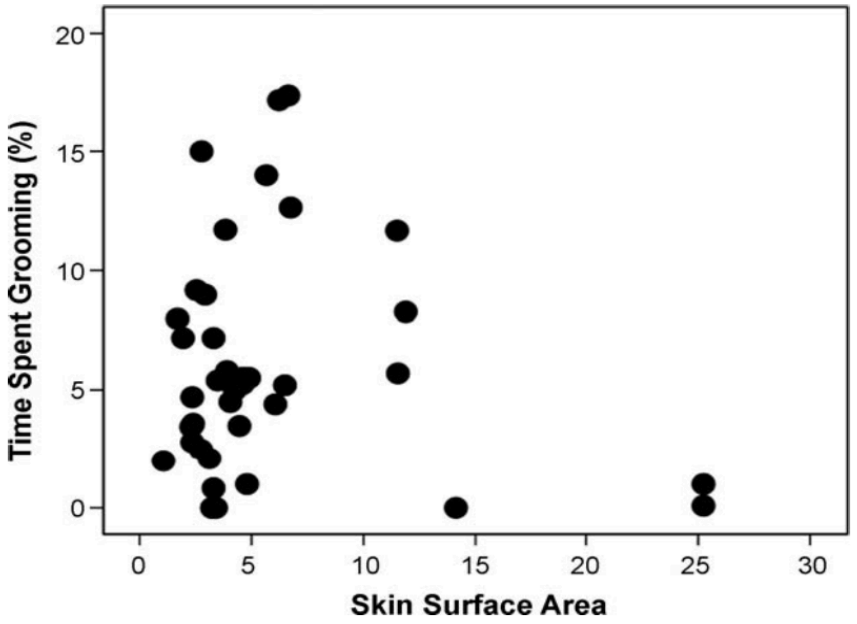


Fig. 2. Distribution of the percentage of daytime devoted to social grooming by individual species of Old World primates (prosimians, monkeys and apes) as a function of skin surface area (indexed as body mass raised to the 0.67 power). Source: data from Lehmann et al. (2007).

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Time spent on social grooming correlates with group size

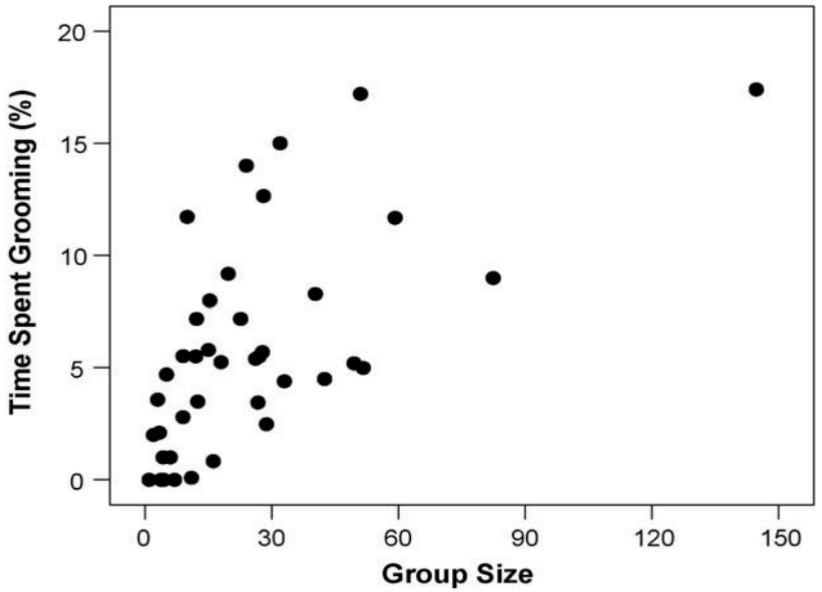
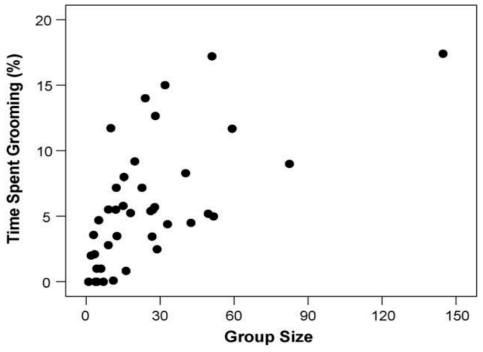


Fig. 4. Mean percentage of available daytime spent in social grooming plotted against mean social group size for individual species of Old World primates (prosimians, monkeys and apes). Source: data from Lehmann et al. (2007).

- Time spent grooming correlates with group size
- Grooming partnerships tend to be stable and long-lasting
- Grooming partnerships form alliances
  - predict aid of another female animal in time of attack
  - more dominant animals less likely to attack
- Non-primate taxa do not have similar non-reproductive relationships

Dunbar, R. I. (2010). The social role of touch in humans and primates: behavioural function and neurobiological mechanisms. Neuroscience & Biobehavioral Reviews, 34(2), 260-268.

Group size correlates with both time spent on allo-grooming and neocortex ratio



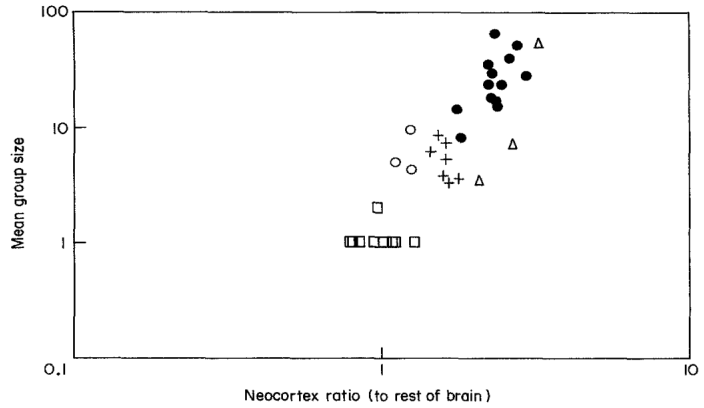


Figure 1. Mean group size for individual genera plotted against neocortex ratio (relative to rest of brain; i.e., total brain volume less neocortex). (●) Polygamous anthropoids; (+) monogamous anthropoids; (○) diurnal prosimians; (□) nocturnal prosimians; (△) hominoids. Source: Table 1.

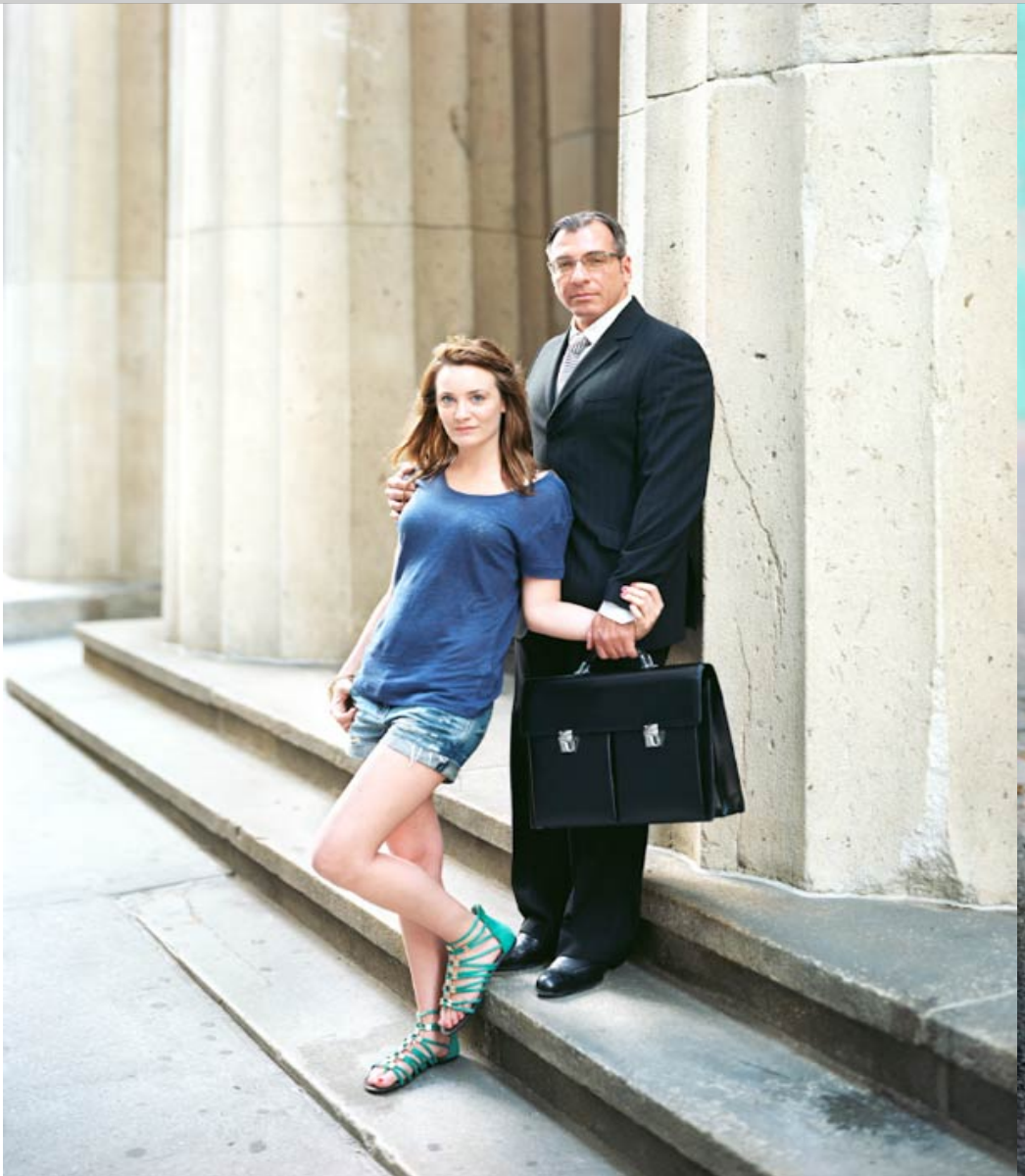
- Complex social dynamics (grooming relationships, non-reproductive pairbonds) require mental processing
- Non-human primates establish and maintain social relationships via grooming
- Fun fact: based on neocortex ratio, humans estimated to have group size of ~150 (Dunbar's number)

Bottom figure: Dunbar, R. I. (1992). Neocortex size as a constraint on group size in primates. Journal of Human Evolution, 22(6), 469-493. Chicago

Humans using social touch

Who are these people to one another?
Take a moment and discuss with a friend or think about this by yourself

Who are these people to one another?
Take a moment and discuss with a friend or think about this by yourself



Images by Richald Renaldi
from the Touching Strangers series
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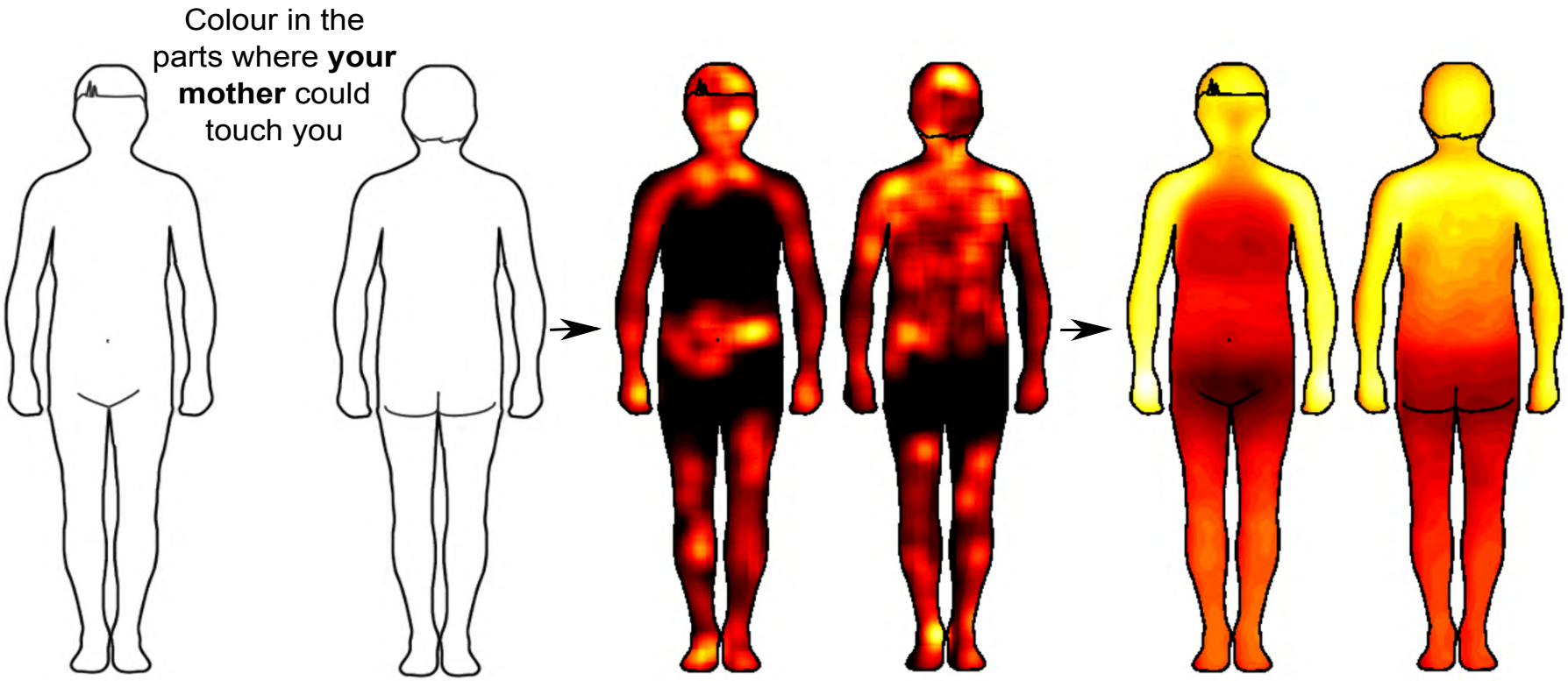
Touch allowances in different social network members



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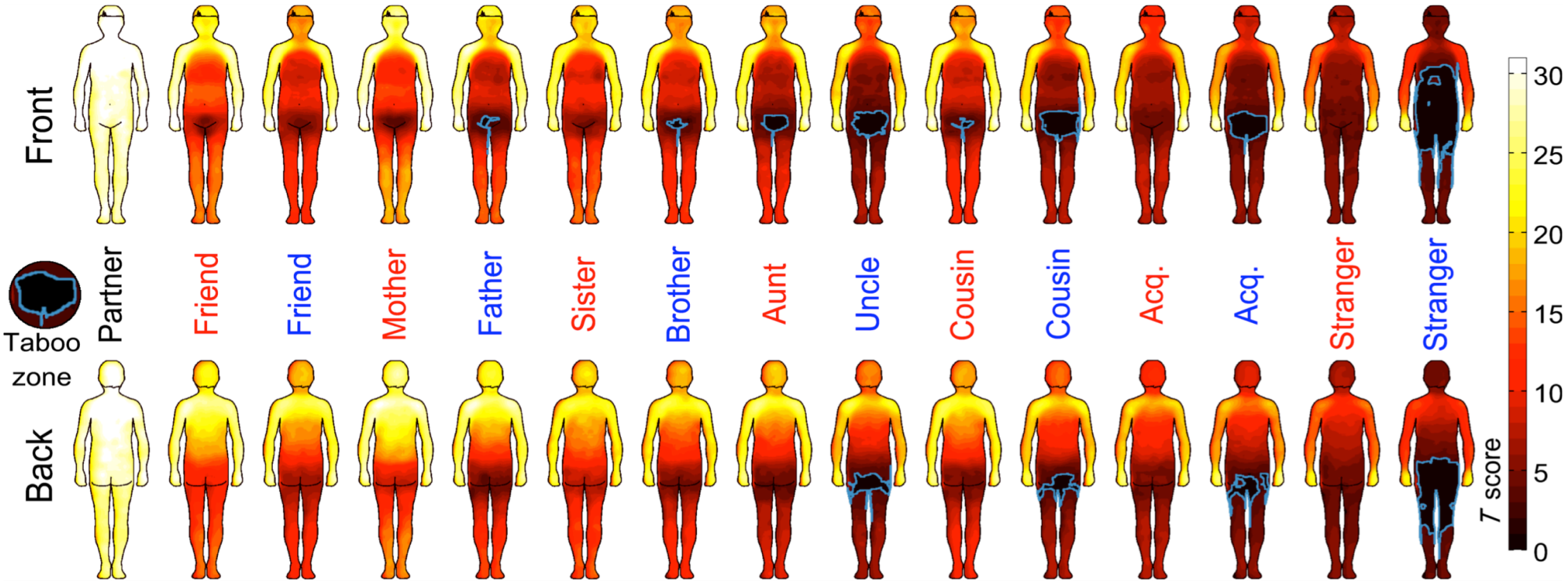
Suvilehto, J. T., Glerean, E., Dunbar, R. I., Hari, R., & Nummenmaa, L. (2015). Topography of social touching depends on emotional bonds between humans. Proceedings of the National Academy of Sciences, 201519231.

Touch allowances in different social network members



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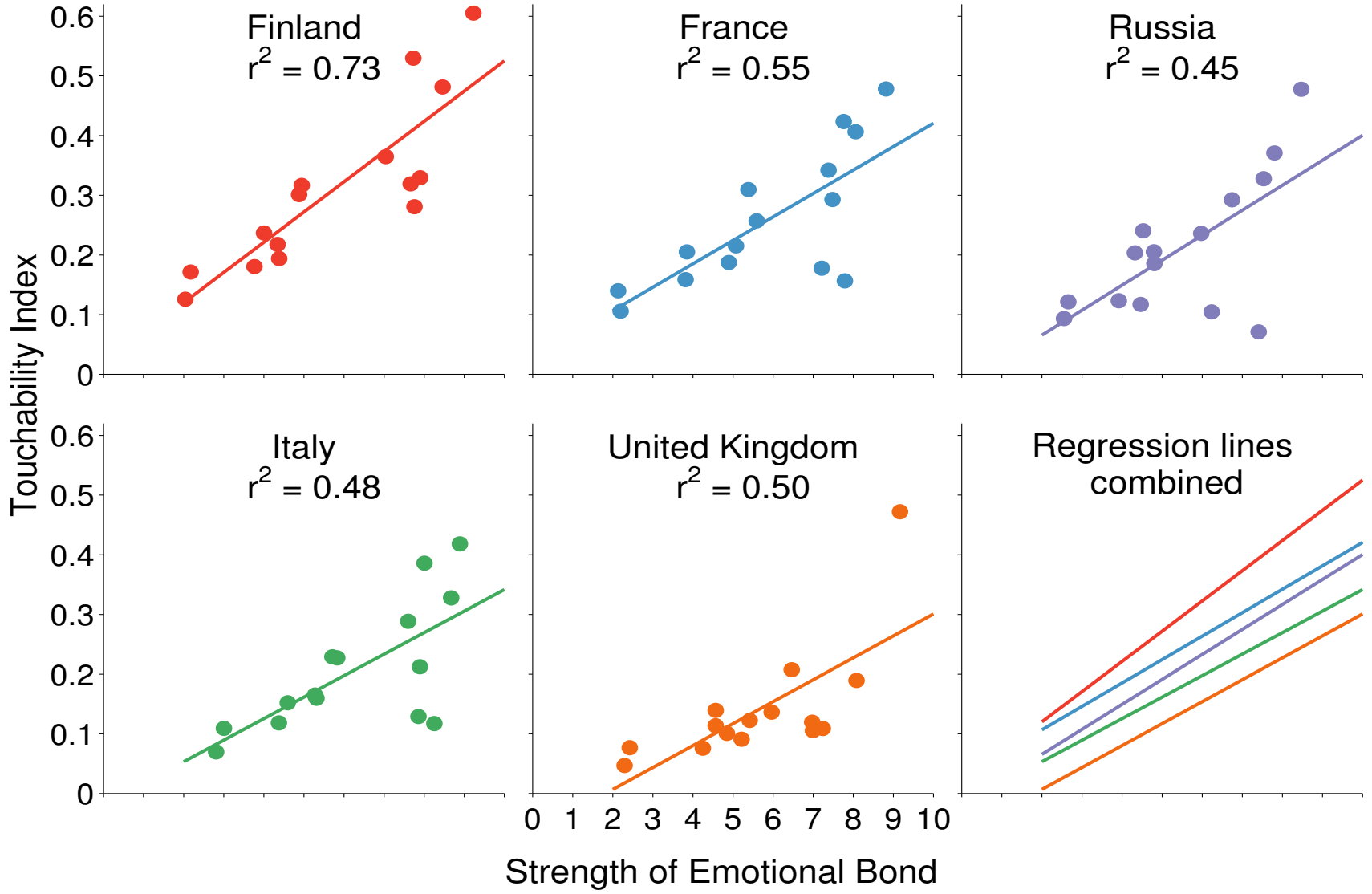

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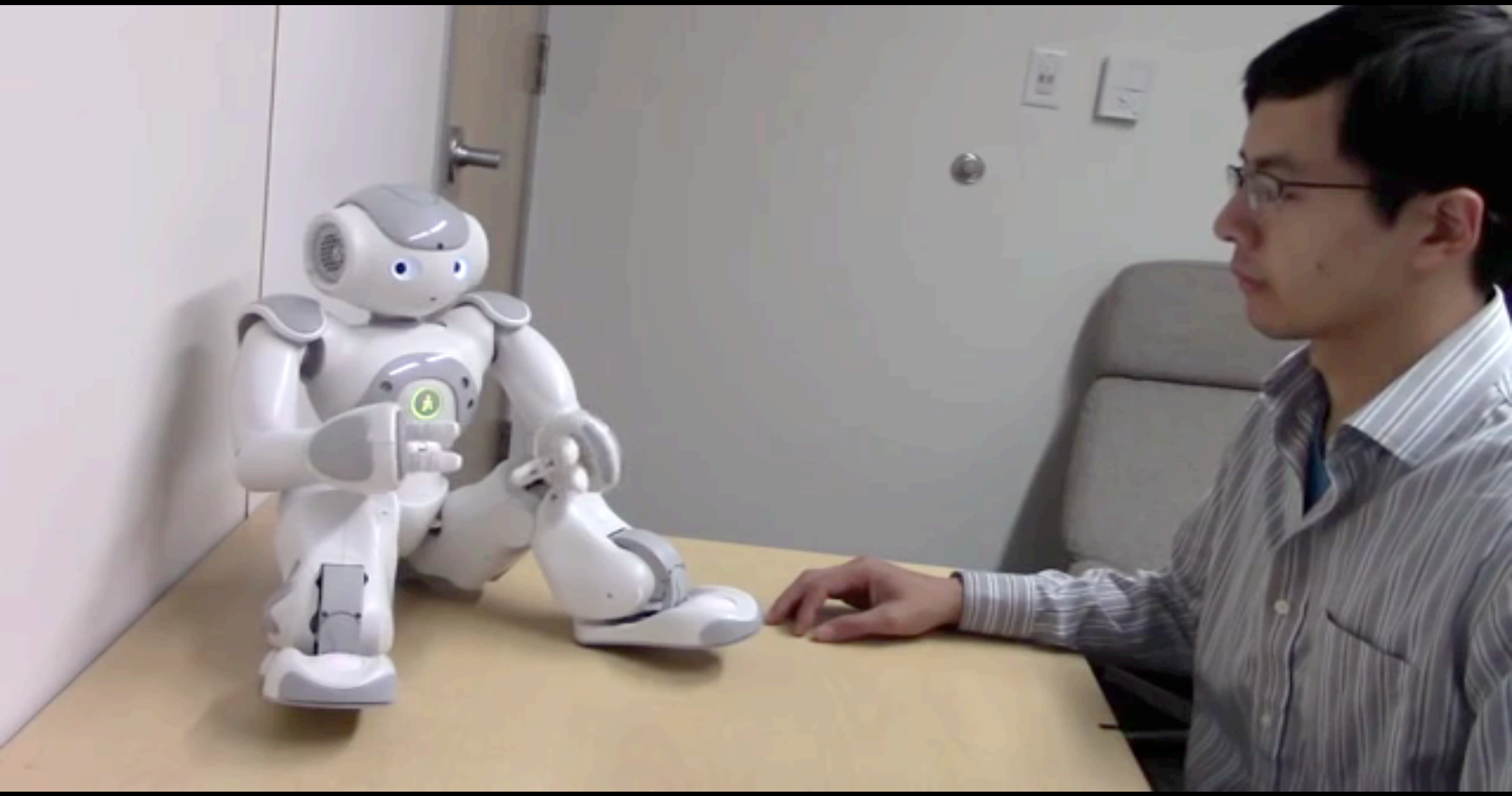
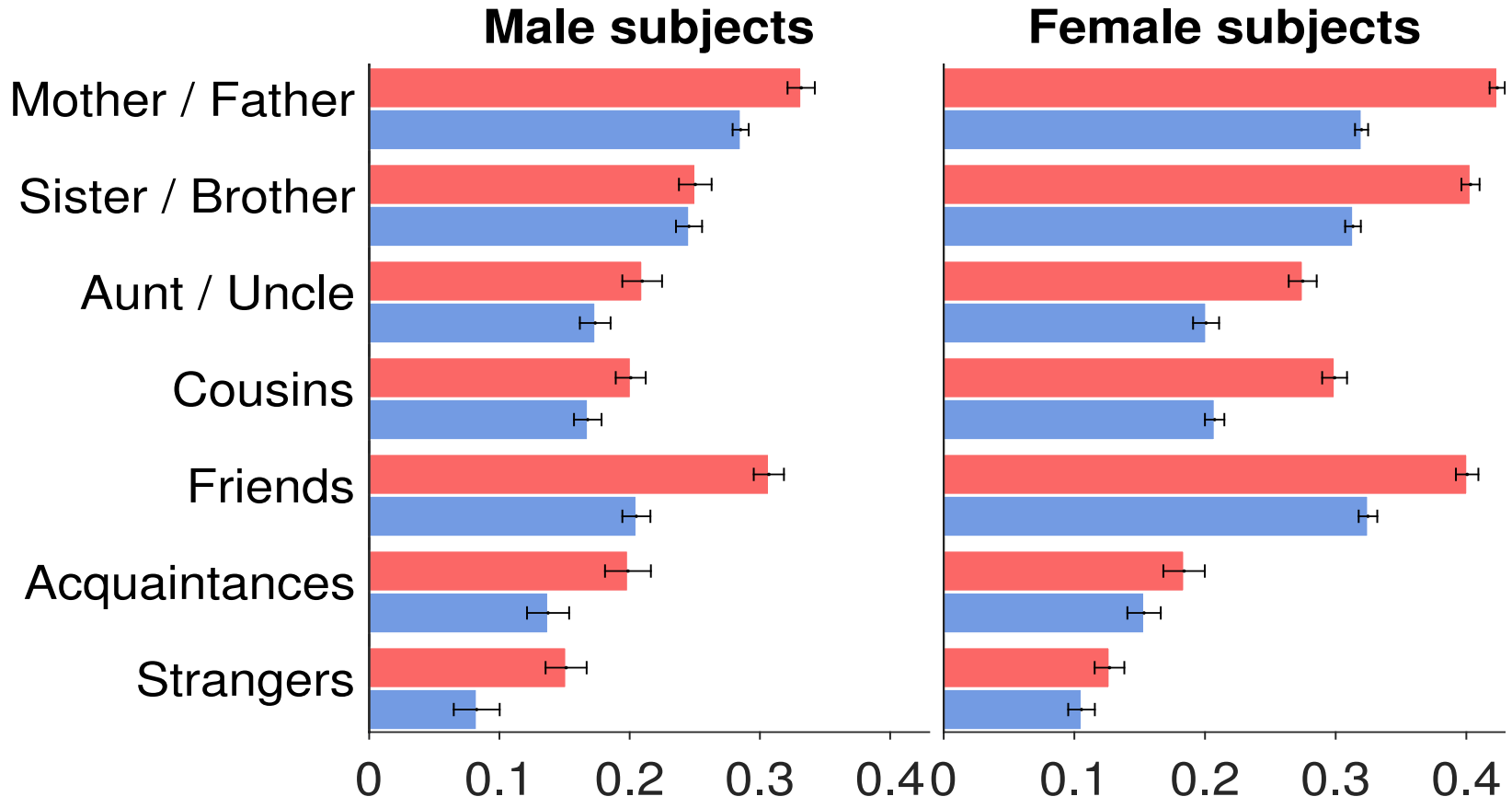


watch video and read about the study at http://spectrum.ieee.org/automaton/robotics/humanoids/stanford-touching-nao-robot

Sex of toucher and person being touched both impact touch allowances



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The Communication of Emotion via Touch

Table 1
Percentage of Decoding Accuracy for All Emotions

Emotion	Encoder–decoder group				Average
	Male–male	Male–female	Female–female	Female–male	
Well-studied emotions					
Anger	80**	77**	75**	83**	78**
Fear	60**	58**	48**	67**	56**
Happiness	44*	61**	59**	75**	60**
Sadness	44*	52**	57**	42*	50**
Disgust	48**	48**	43**	67**	50**
Prosocial emotions					
Love	64**	71**	61**	79**	68**
Gratitude	76**	77**	70**	75**	74**
Sympathy	64**	65**	70**	67**	67**

* $p < .05$. ** $p < .01$.

Hertenstein et al. 2009
Emotion

Tactile sensations and interpersonal judgments

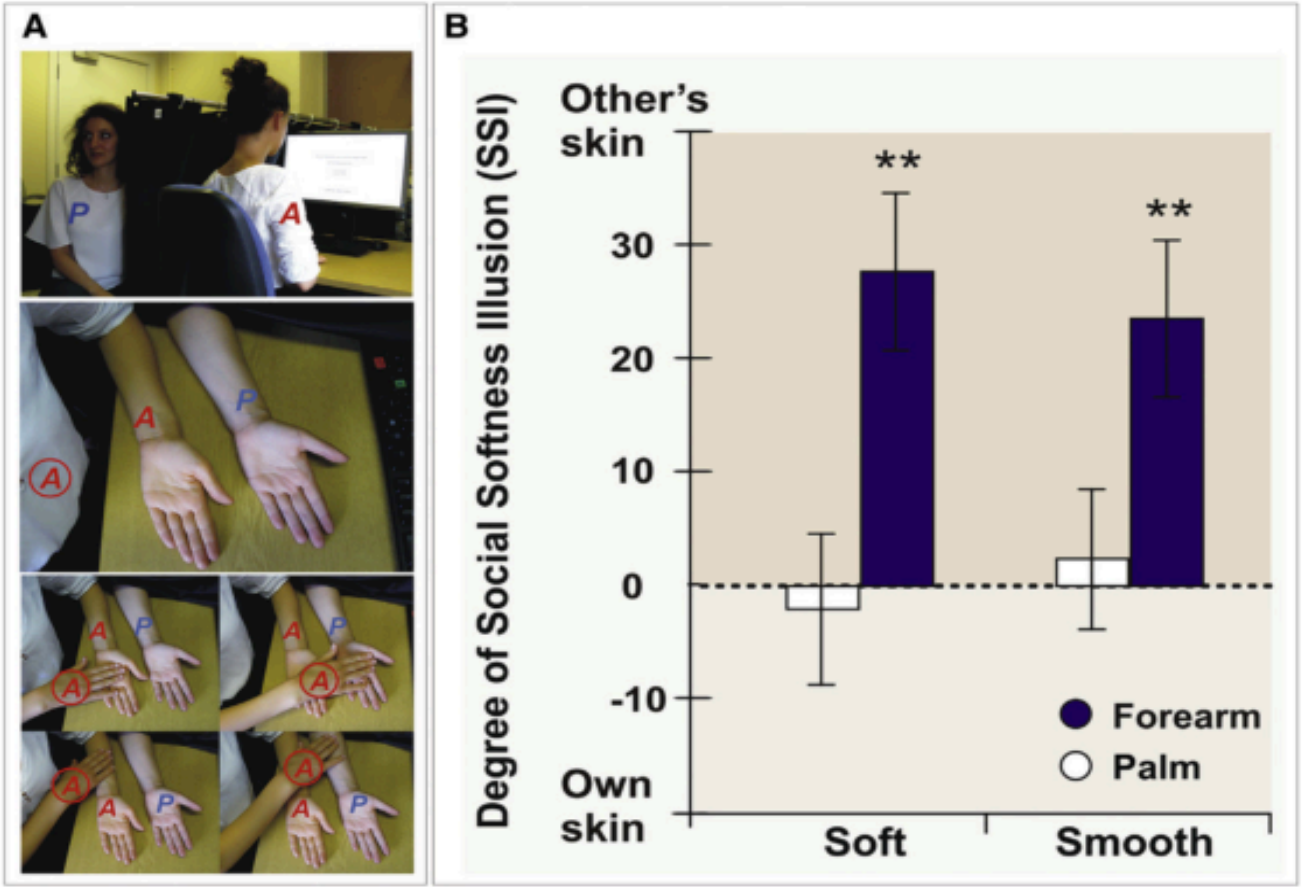
- Subjects judged description of person as significantly more “warm” after having briefly held hot (vs iced) coffee
  Williams & Bargh (2008). Experiencing physical warmth promotes interpersonal warmth. Science
- Properties of handled object (e.g. heaviness of clipboard) influenced unrelated social judgments (e.g. job candidate suitability)
  Ackerman et al. (2010) Incidental Haptic Sensations Influence Social Judgments and Decisions. Science

By Damianosullivan CC-BY-SA via Wikimedia Commons

Interpersonal touch and social judgments

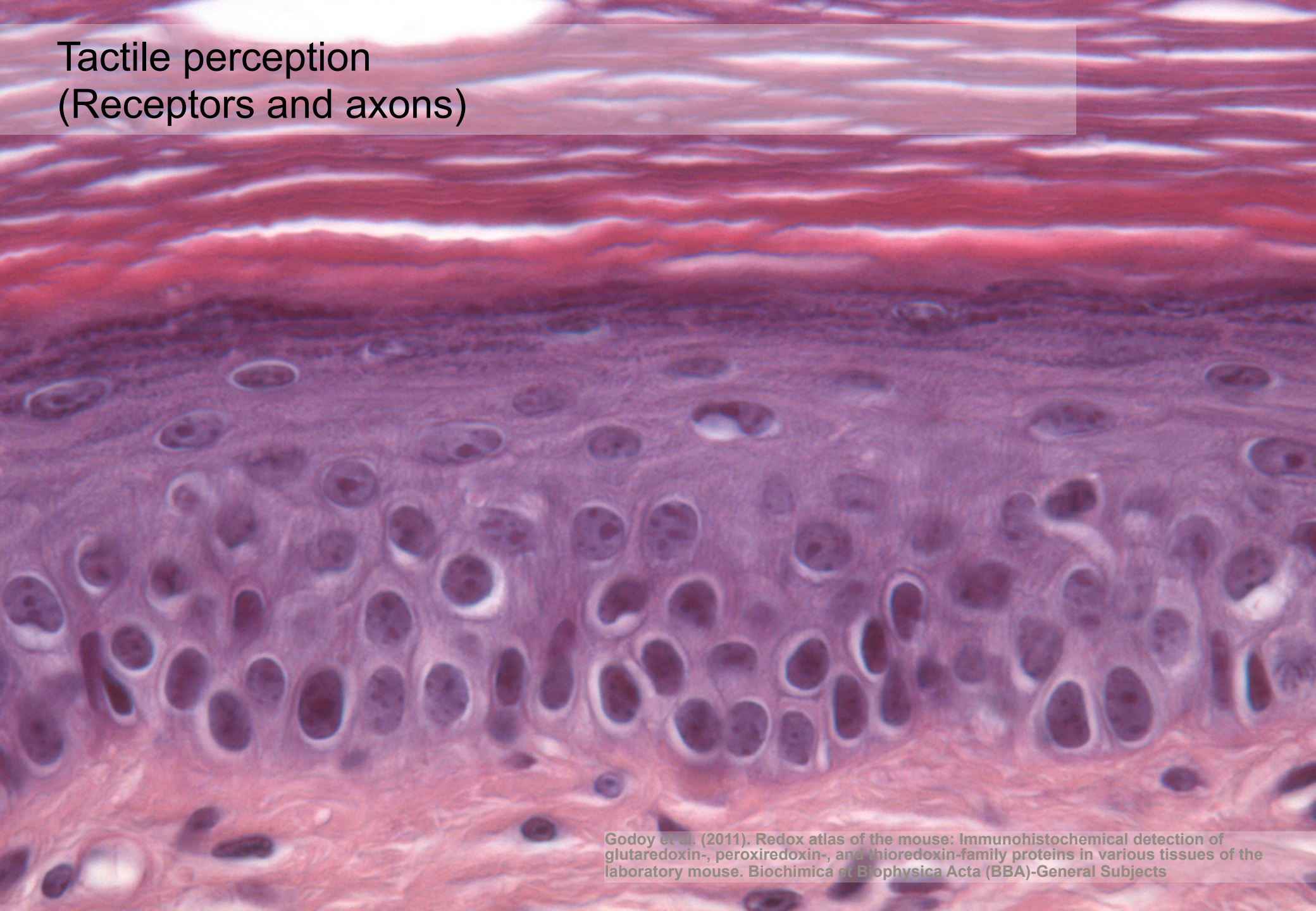
- Social touch, even if not consciously perceived, can impact judgment (so called Midas effect)
  - Higher tips for waitresses who touched patrons when handing back change
    Crusco & Wetzel (1984). The midas touch the effects of interpersonal touch on restaurant tipping. Personality and Social Psychology Bulletin
  - Higher evaluations of library environment and librarian when touched when handing back library card
    Fisher, et al.(1976) "Hands touching hands: Affective and evaluative effects of an interpersonal touch." Sociometry
- Social softness illusion

Social Softness Illusion



Gentsch et al. (2015). Active Interpersonal Touch Gives Rise to the Social Softness Illusion. Current Biology

Tactile perception
(Receptors and axons)



Godoy et al. (2011). Redox atlas of the mouse: Immunohistochemical detection of glutaredoxin-, peroxiredoxin-, and thioredoxin-family proteins in various tissues of the laboratory mouse. Biochimica et Biophysica Acta (BBA)-General Subjects

Sensory receptors

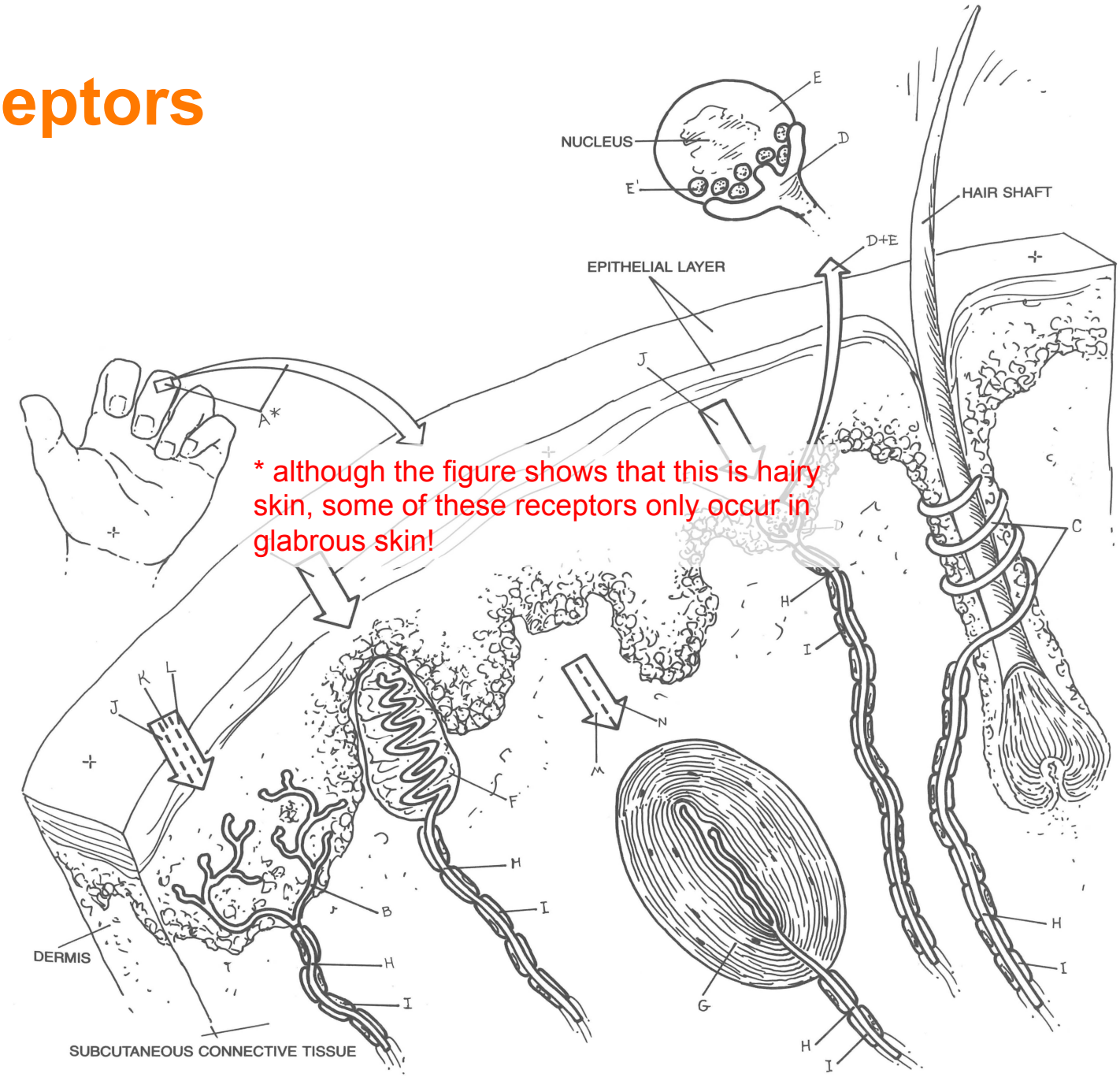
terminology

afferent
= ascending, brings sensory information to the brain

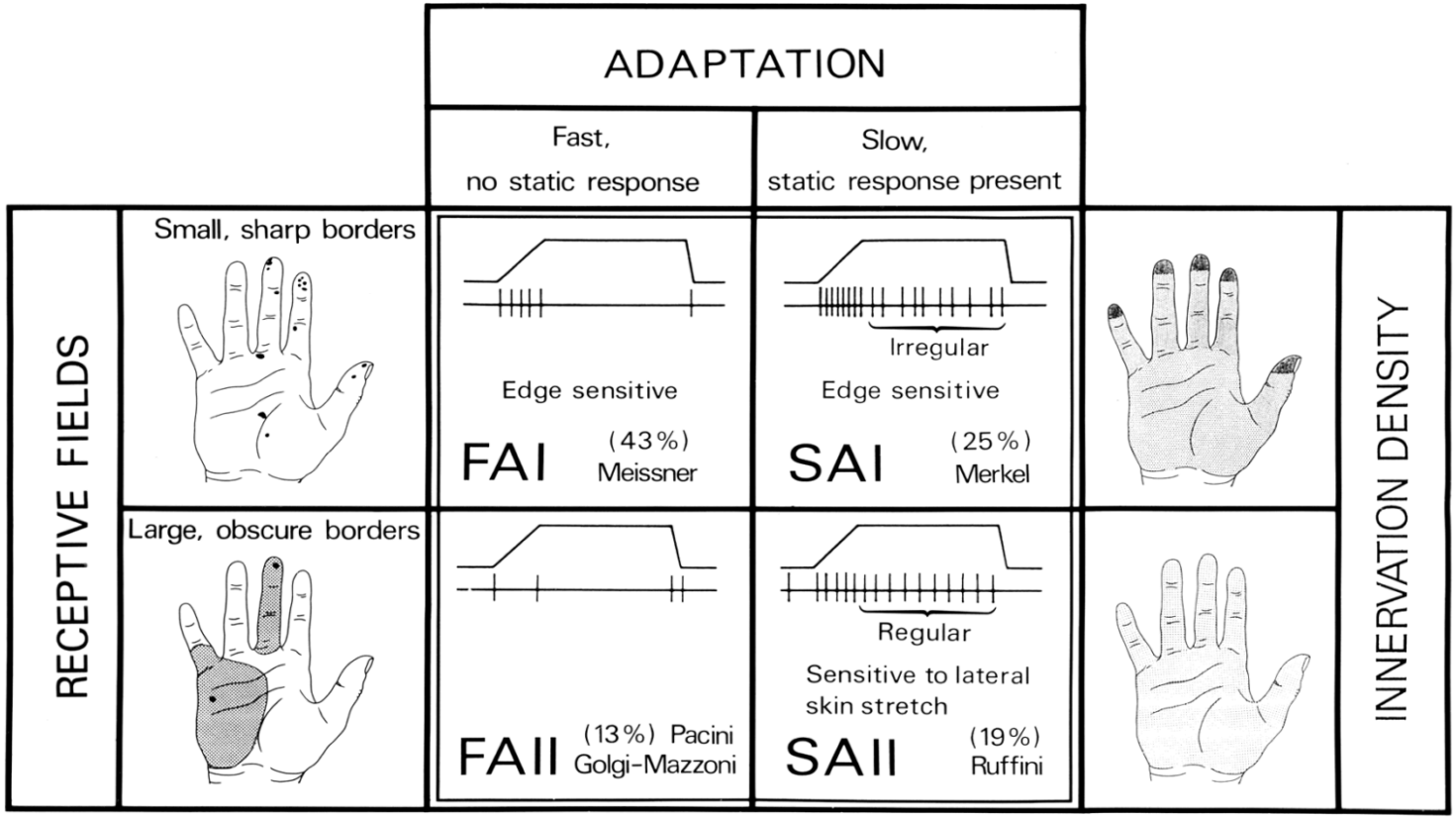
efferent
= descending, brings motor information to the periphery

glabrous skin
= non-hairy (palms, soles of feet, lips, parts of genitalia)

non-glabrous (hairy) skin
= all the rest



The four types of low-threshold mechanoreceptors in human glabrous skin

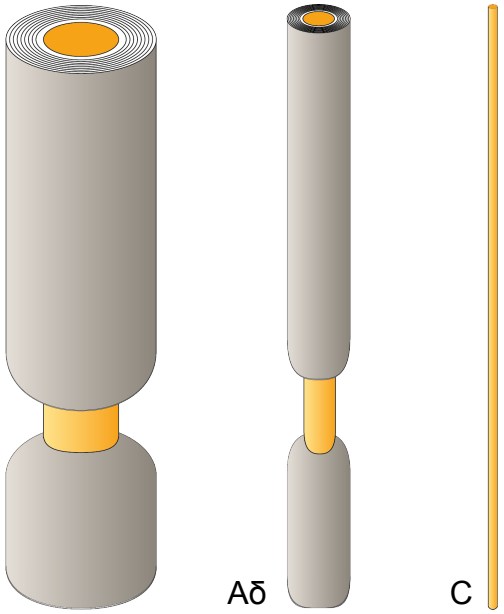


The four types of low-threshold mechanoreceptors in human glabrous skin are depicted. The four panels in the centre show the nerve-firing responses to a ramp and hold indentation and in % the frequency of occurrence and putative morphological correlate.

McGlone, F., Vallbo, A. B., Olausson, H., Loken, L., & Wessberg, J. (2007). Discriminative touch and emotional touch. Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale, 61(3), 173.

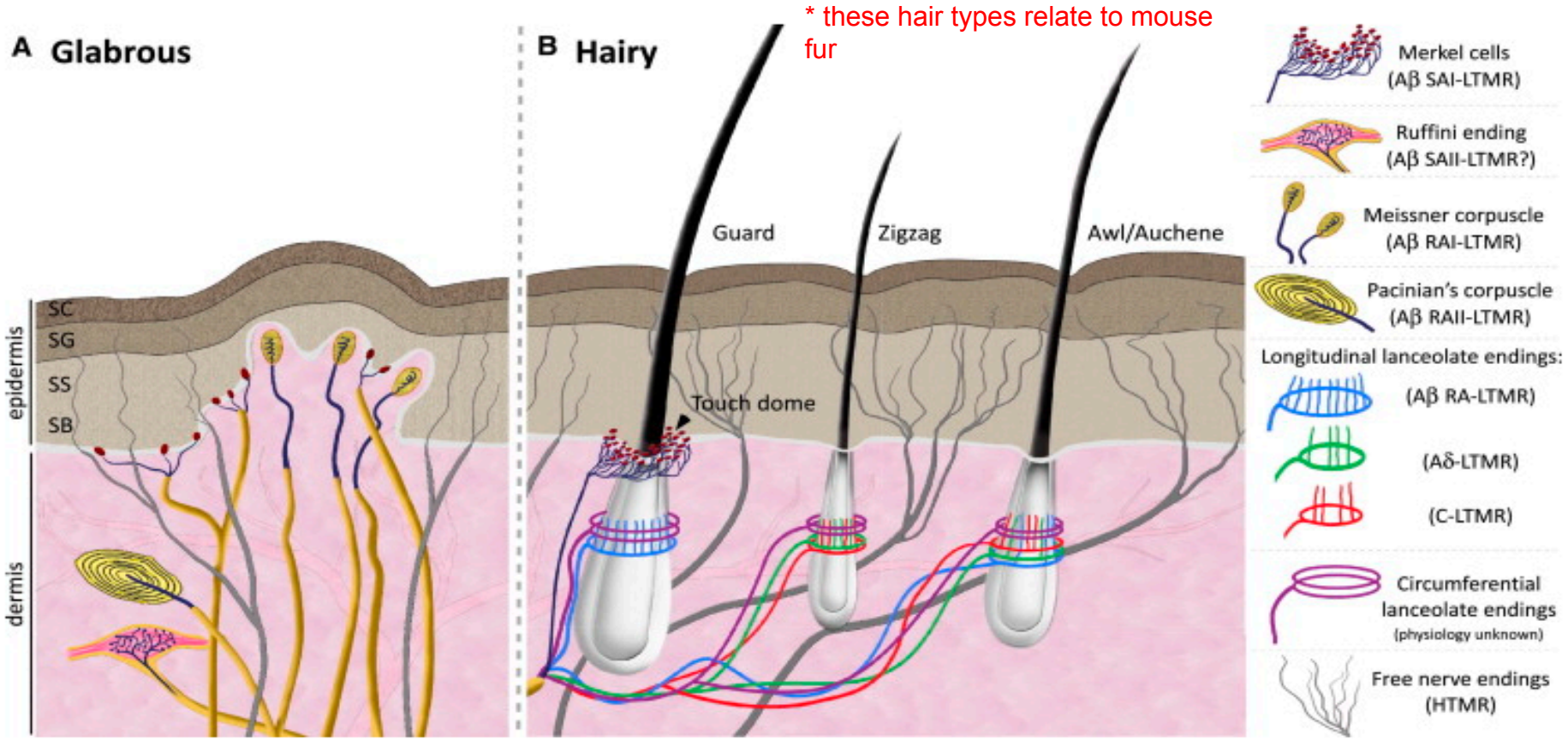
Recap discriminative touch

- Discriminative touch helps us handle objects
- Low Threshold Mechanoreceptors (LTMR) divided into slowly adapting (SA) and rapidly adapting (RA)
  - SA and RA LTMR further divided by receptive field (RF) into type I (small RF) and type II (large RF)
- Signals transmitted through myelinated, large-diameter Aβ afferents



	Aβ	Aδ	C
Diameter (μm)	6-12	1-5	0.2-1.5
Speed (m/s)	35-100	5-30	0.5-2
	mechano-receptors	pain, temperature	temperature, pain, itch, emotional touch

One more look at receptors in skin



Abraira, V., & Ginty, D. (2013). The sensory neurons of touch. Neuron, 79(4), 618–639.

C fibers

- There are 3-4 times as many C fibers as A-fibers
- Unmyelinated -> very slow
- Traditionally considered to contribute to detection of temperature (warmth), itch, and nociception (pain)
- A subclass, called C-tactile afferents (CT afferents), discovered only recently
  - Particularly responsive to slow stroking touch
  - Project to insular cortex, tightly linked to limbic system

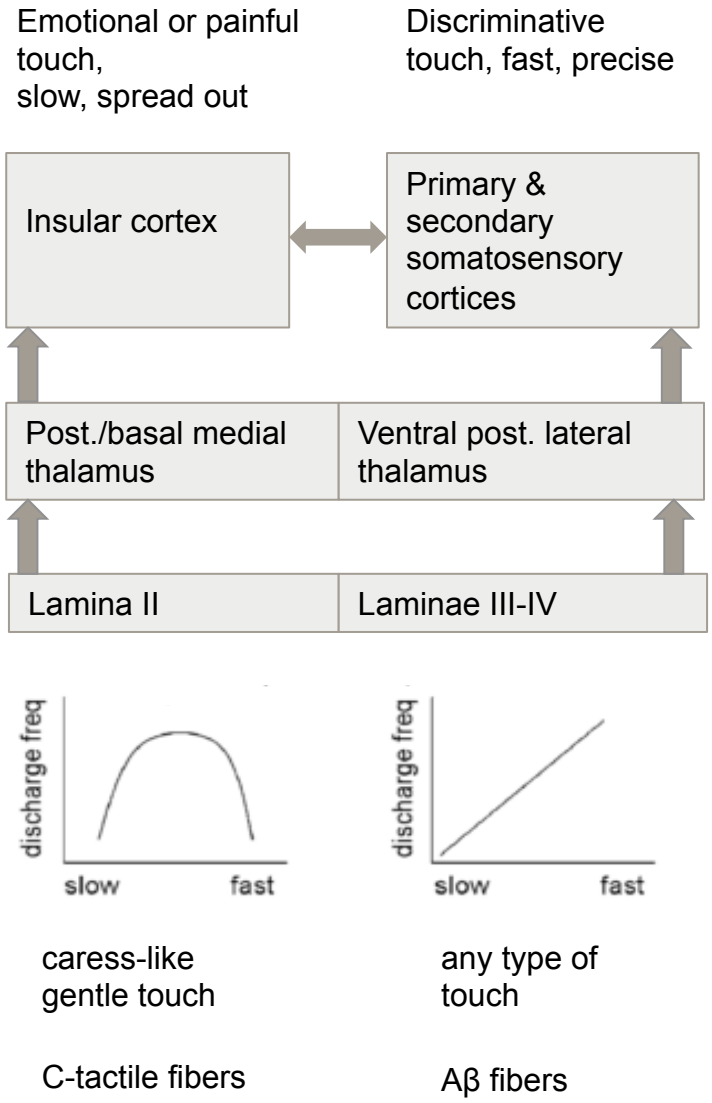
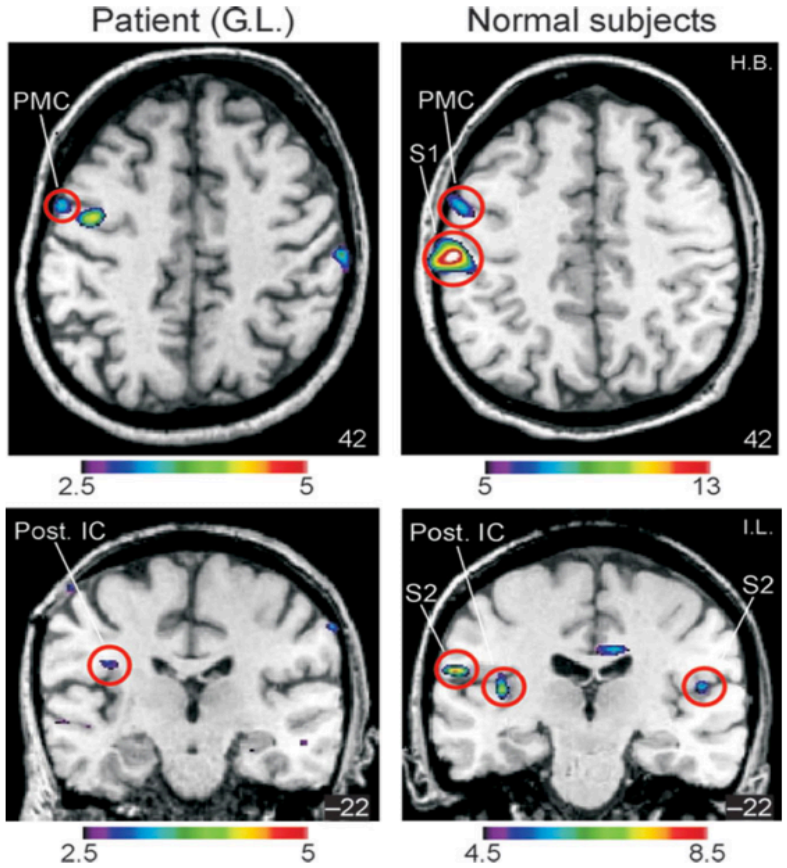


Figure adapted from Morrison et al. (2010). The skin as a social organ. Experimental Brain Research

Cortical projections of C afferents can be studied with patients who lack A-afferents

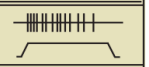
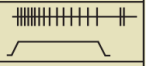
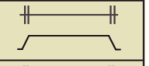
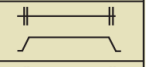
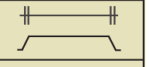


Cortical activations evoked by brush stroking on the right forearm of the patient G.L. and two normal subjects. The right side of the images corresponds to the right side of the participant, and red circles indicate regions of interest. Color bars show t-values. Note that color coding differs between images

Olausson et al. (2002). Unmyelinated tactile afferents signal touch and project to insular cortex. Nature Neuroscience

Recap receptors and afferents

Table 1. A Comparison of Cutaneous Mechanoreceptor Subtypes

Physiological subtype	Associated fiber (conduction velocity[1])	Skin type	End organ/ending type	Location	Optimal Stimulus[4]	Response properties
SAI-LTMR	Aβ (16-96m/s)	Glabrous	Merkel cell	Basal Layer of epidermis	Indentation	
		Hairy	Merkel cell (touch dome)	Around Guard hair follicles		
SAII-LTMR	Aβ (20-100m/s)	Glabrous	Ruffini[2]	Dermis[3]	Stretch	
		Hairy	unclear	unclear		
RAI-LTMR	Aβ (26-91m/s)	Glabrous	Meissner corpuscle	Dermal papillae	Skin movement Hair follicle deflection	
		Hairy	Longitudinal lanceolate ending	Guard/Awl-Auchene hair follicles		
RAII-LTMR	Aβ (30-90m/s)	Glabrous	Pacinian corpuscle	Deep dermis	Vibration	
Aδ-LTMR	Aδ (5-30m/s)	Hairy	Longitudinal lanceolate ending	Awl-Auchene/ Zigzag hair follicles	Hair follicle deflection	
C-LTMR	C (0.2-2m/s)	Hairy	Longitudinal lanceolate ending	Awl-Auchene/ Zigzag hair follicles	Hair follicle deflection	
HTMR	Aβ/Aδ/C (0.5-100m/s)	Glabrous Hairy	Free nerve ending	Epidermis/Dermis	Noxious mechanical	

Skin is innervated by complex combinations of low- and high-threshold mechanoreceptors, each with unique physiological profiles and response properties elicited by distinct tactile stimuli.

[1]Conduction velocities can vary across species; please see the following references for more detailed interspecies comparisons: Leem et al. (1993) (rat); Brown and Iggo (1967) and Burgess et al. (1968) (cat and rabbit); Perl (1968) (monkey); and Knibestol (1973) (human).

[2]Though SAII-LTMR responses have been observed in both glabrous skin of humans and hairy skin of mice, they have only been postulated to arise from Ruffini endings, though direct evidence to support this idea is lacking (Chambers et al., 1972).

[3]Although SAII-like responses are present in the mouse, Ruffini endings or Ruffini-like structures have not been identified in rodents.

[4]The stimulus described is the optimal stimulus known to elicit the response properties depicted in the last column of this table. However, it is probable, and often times documented, that multiple physiological subtypes can be recruited with any one particular tactile stimulus. For example, indentation of hair skin is likely to activate not only SAI-LTMRs associated with guard hairs but also longitudinal lanceolate endings of the Aβ-, Aδ-, and C-LTMR type (see Figure 2).

Discriminative touch

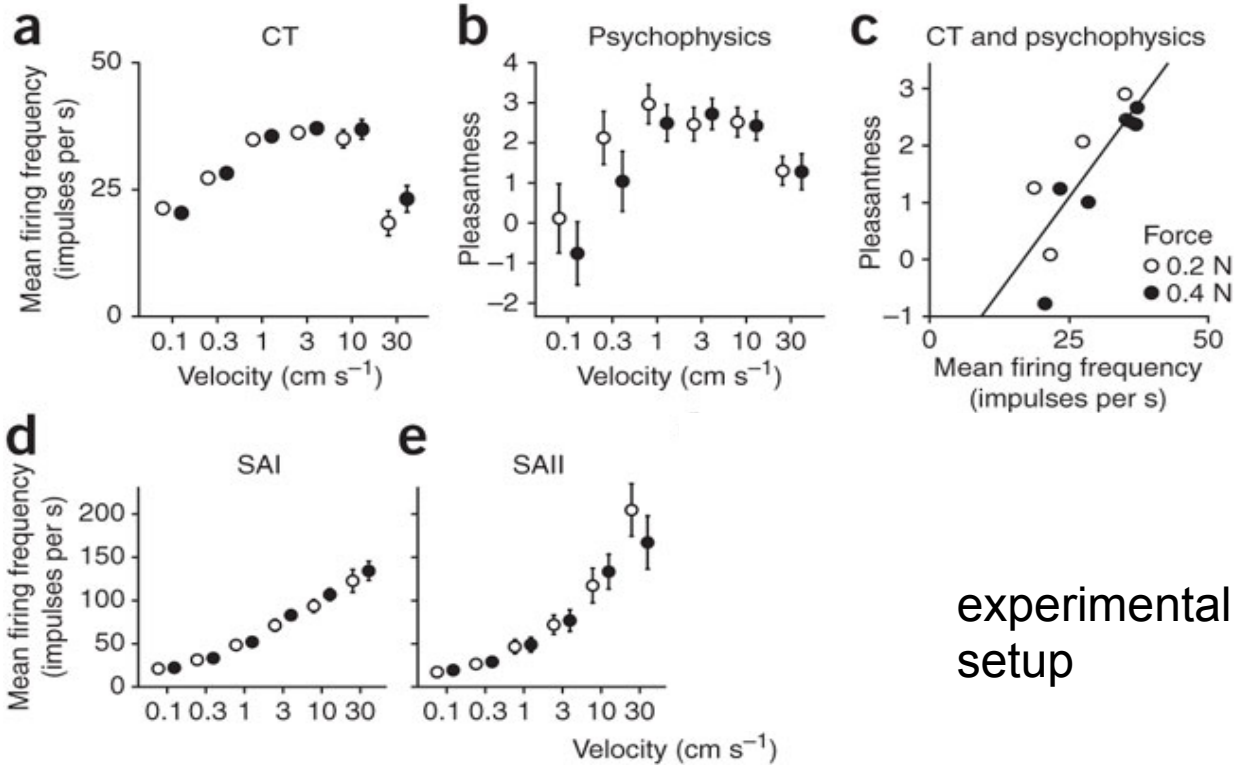
Cool

Emotional touch

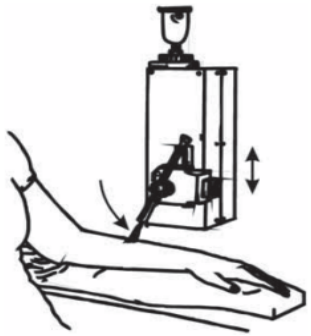
Temperature, pain, mechanical stimuli

Abraira, V., & Ginty, D. (2013). The sensory neurons of touch. Neuron, 79(4), 618–639.

How would you explain this figure to your friend who has not been to this lecture? Pair and share



experimental setup →



Modified from Löken et al. (2009). Coding of pleasant touch by unmyelinated afferents in humans. Nature Neuroscience

Neurochemistry of Social Touch

Image by Richald Renaldi
from the Touching Strangers series
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Oxytocin

- OXT linked to mothering behaviors in mammals (including humans)
- In both animals and humans, reduces the physiological and behavioral indices of stress
- Effectiveness of OXT reduces after first contact
- Only reliable sampling method from cerebrospinal fluid (painful!)
  - sampling from blood possible, but blood OXT levels not necessarily correlated with CNS OXT levels

Opioids

- Endogenous opioids mediate reward for social behavior
  - social play, allogrooming, maternal behavior, infant attachment
- Opiate agonist/antagonist influence affiliative behavior in monkeys

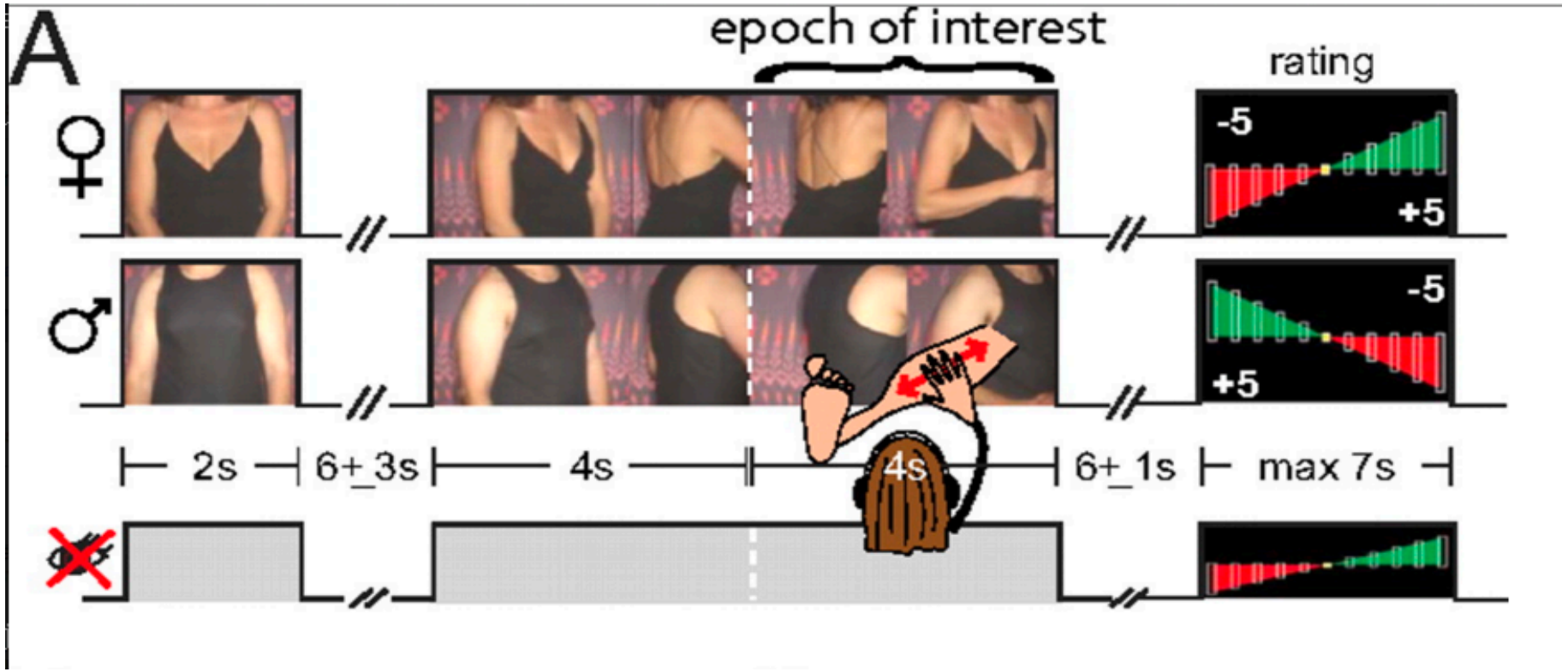
  Fabre-Nys, C., Meller, R. E., & Keverne, E. B. (1982). Opiate antagonists stimulate affiliative behaviour in monkeys. Pharmacology Biochemistry and Behavior
  - opiate antagonist (naltrexone) increased grooming solicitations
  - opiate agonist (morphine) decreased grooming behavior
- Opioids alleviate pain and distress

Opioids vs OXT

- Both hard to reliably sample in humans
- Both related to stress (relief)
- Both relate to social behavior in humans
- Both have also other functions
- Exact role of each in human bonding behavior unclear
  - Most likely both play some kind of role, exact role of either not known
  - One theory: oxytocin enables getting interested in the other (which is enough for most species), whereas opioids help sustain longer term relationships in primates (Dunbar 2010)
  - Another theory: main bonding neuropeptide changes from OXT to opioids when going from basal mammals to primates

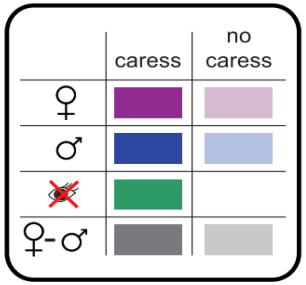

Recent Imaging Studies on Social Touch
By Daniel Schwen CC-BY-SA via Wikimedia Commons

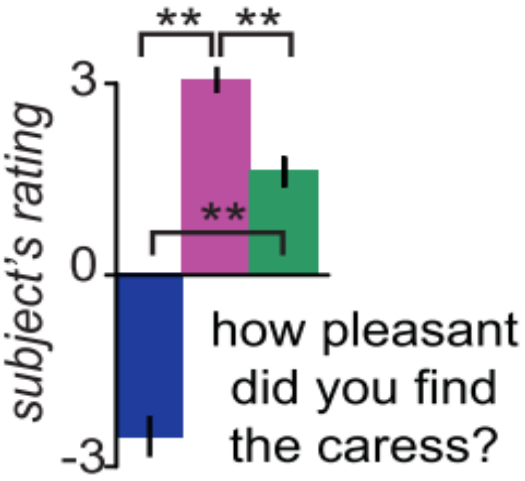
Toucher sex impacts perceived touch pleasantness and SI activation

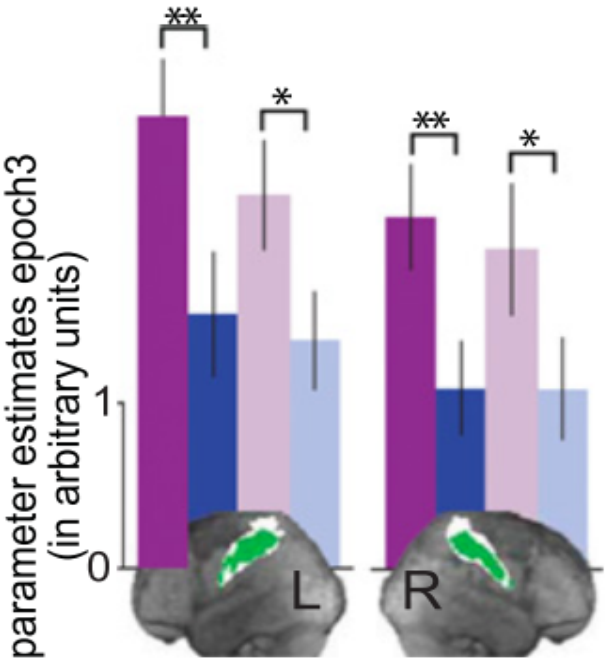


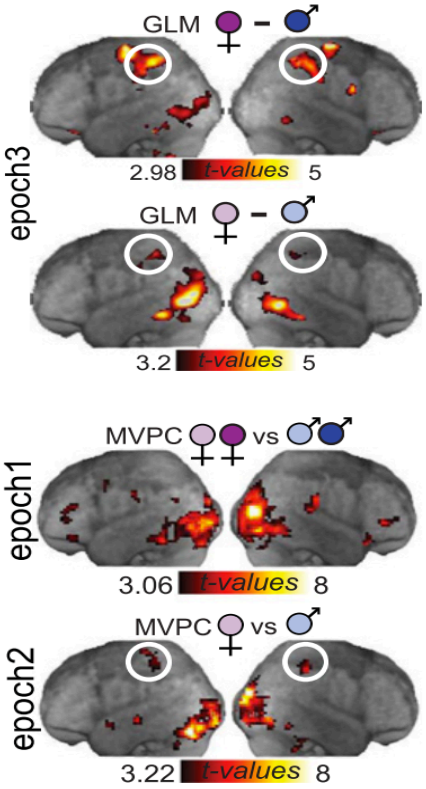
Gazzola et al. (2012). Primary somatosensory cortex discriminates affective significance in social touch. Proceedings of the National Academy of Sciences

Toucher sex impacts perceived touch pleasantness and SI activation









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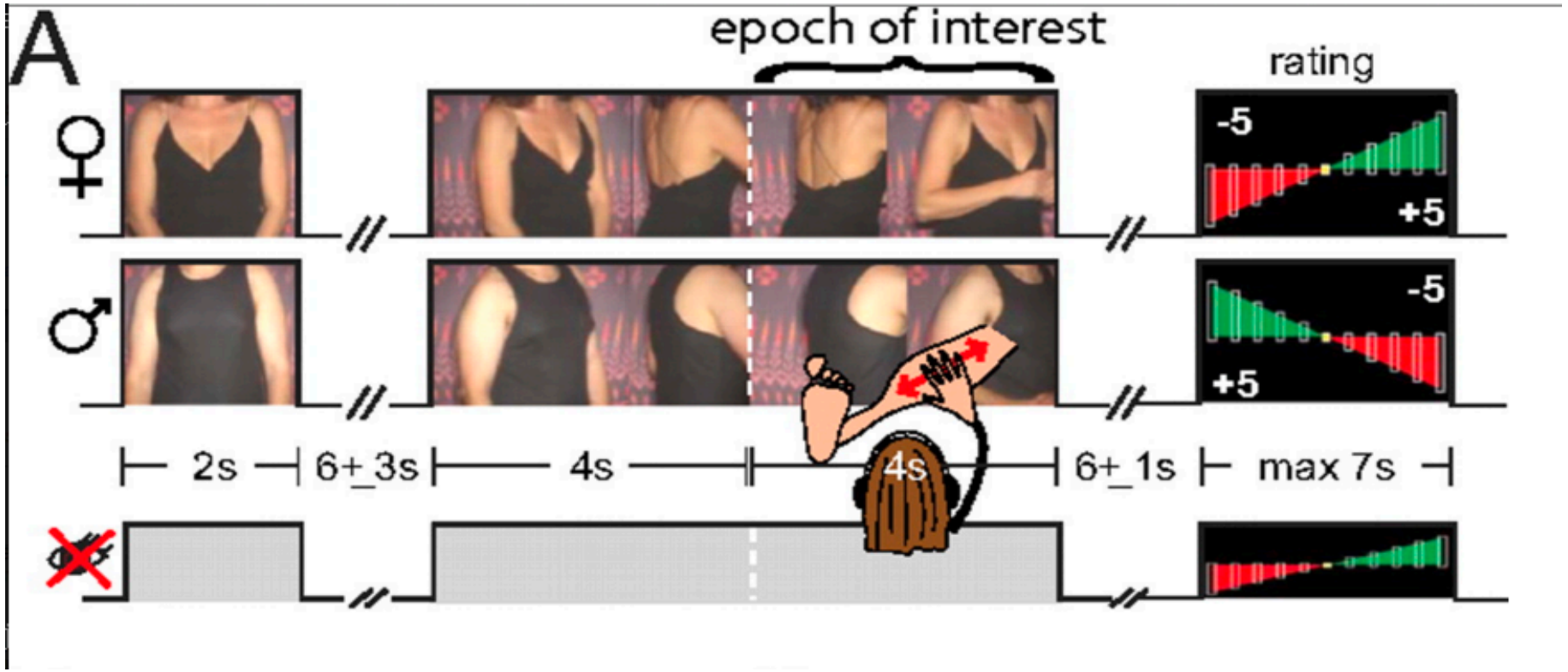
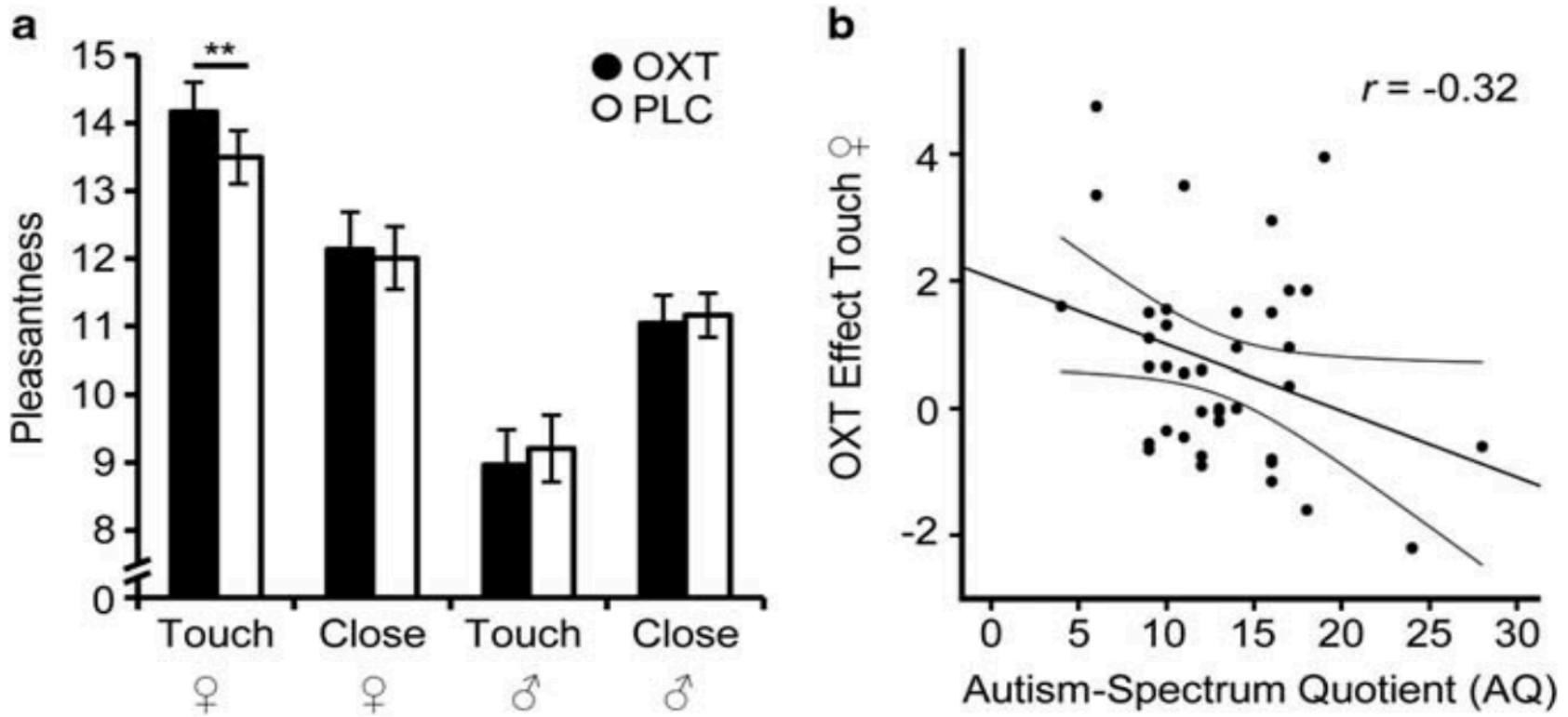
Gazzola et al. (2012). Primary somatosensory cortex discriminates affective significance in social touch. Proceedings of the National Academy of Sciences

Same paradigm with OXT / placebo nose spray



Impact of OXT on perceived pleasantness of touch in heterosexual males



Scheele et al. (2014). An oxytocin-induced facilitation of neural and emotional responses to social touch correlates inversely with autism traits. Neuropsychopharmacology

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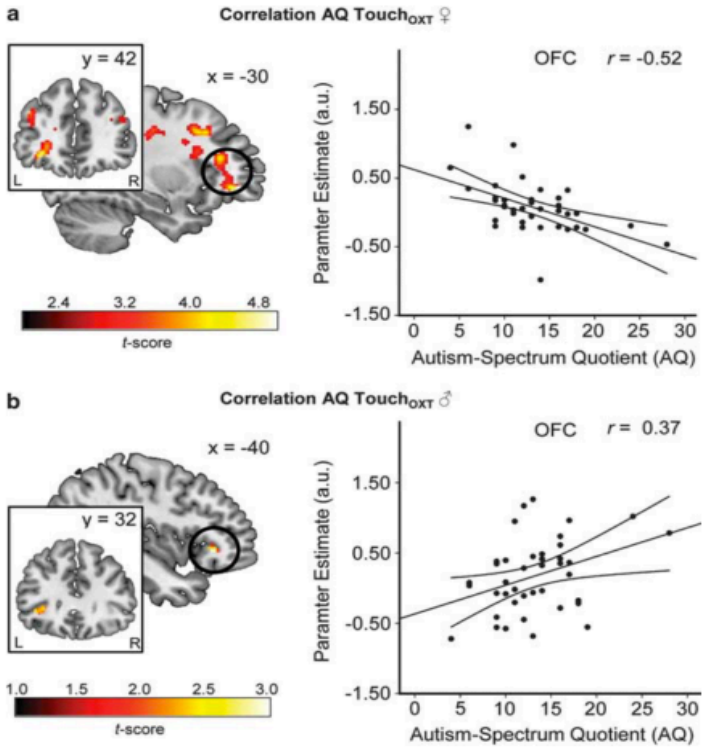


Figure 3 Autistic traits differentially moderate the neural response to female and male touch. Under oxytocin, neural responses to touch in the orbitofrontal cortex are negatively correlated with autistic traits in the female touch condition (a) and positively correlated in the male touch condition (b). AQ, autism-spectrum quotient; L, left; OFC, orbitofrontal cortex; OXT, oxytocin; PLC, placebo; R, right.

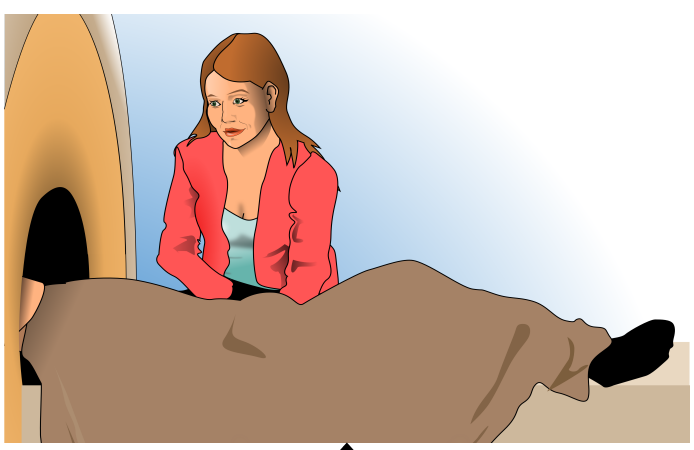
Scheele et al. (2014). An oxytocin-induced facilitation of neural and emotional responses to social touch correlates inversely with autism traits. Neuropsychopharmacology

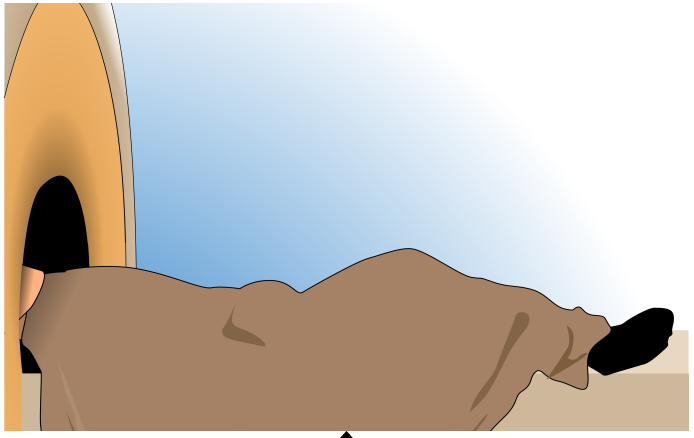
Pleasant social touching in PET

51-min social touch scan

2-hour decay break

51-min baseline scan

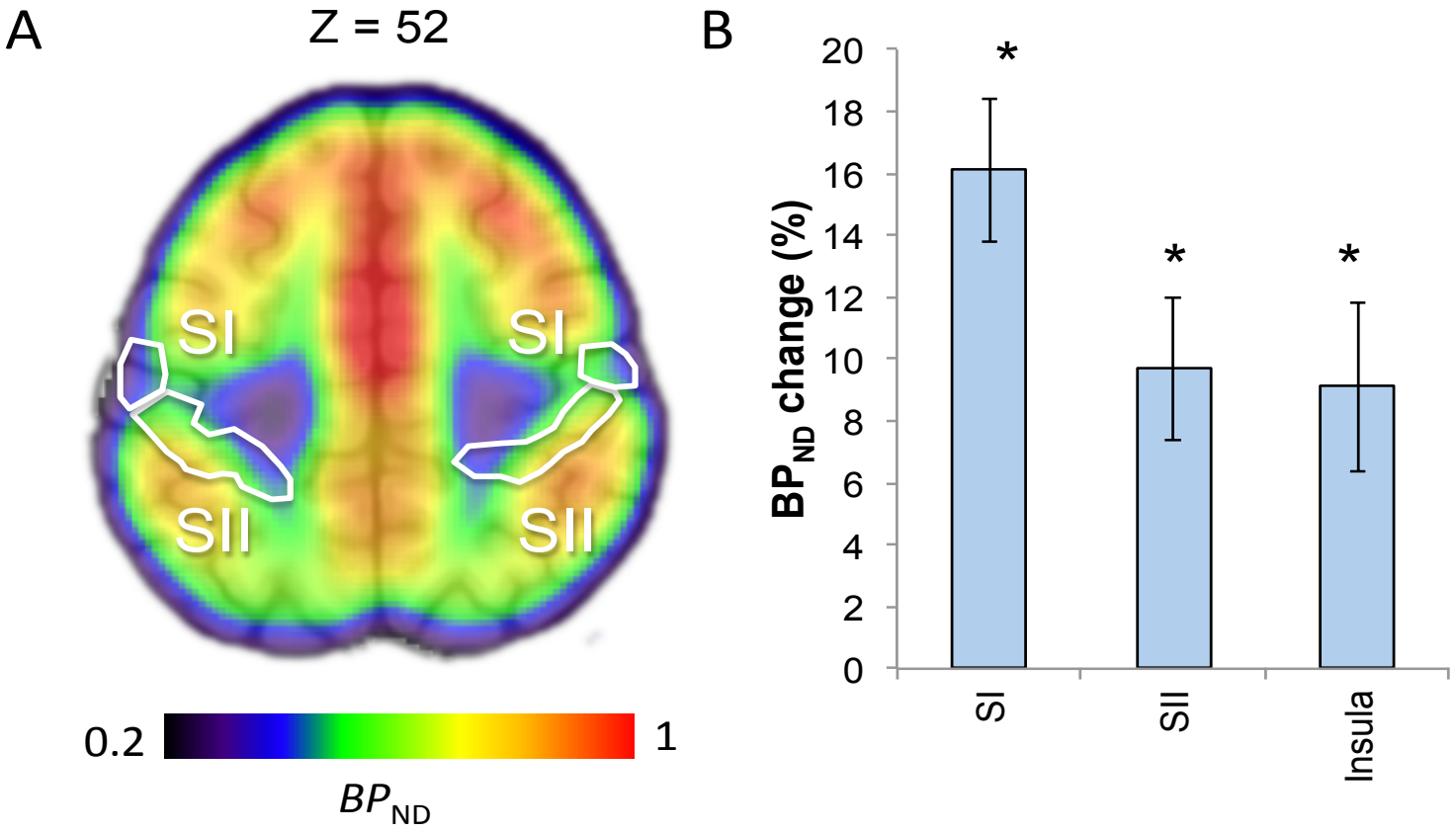




Order counterbalanced across participants

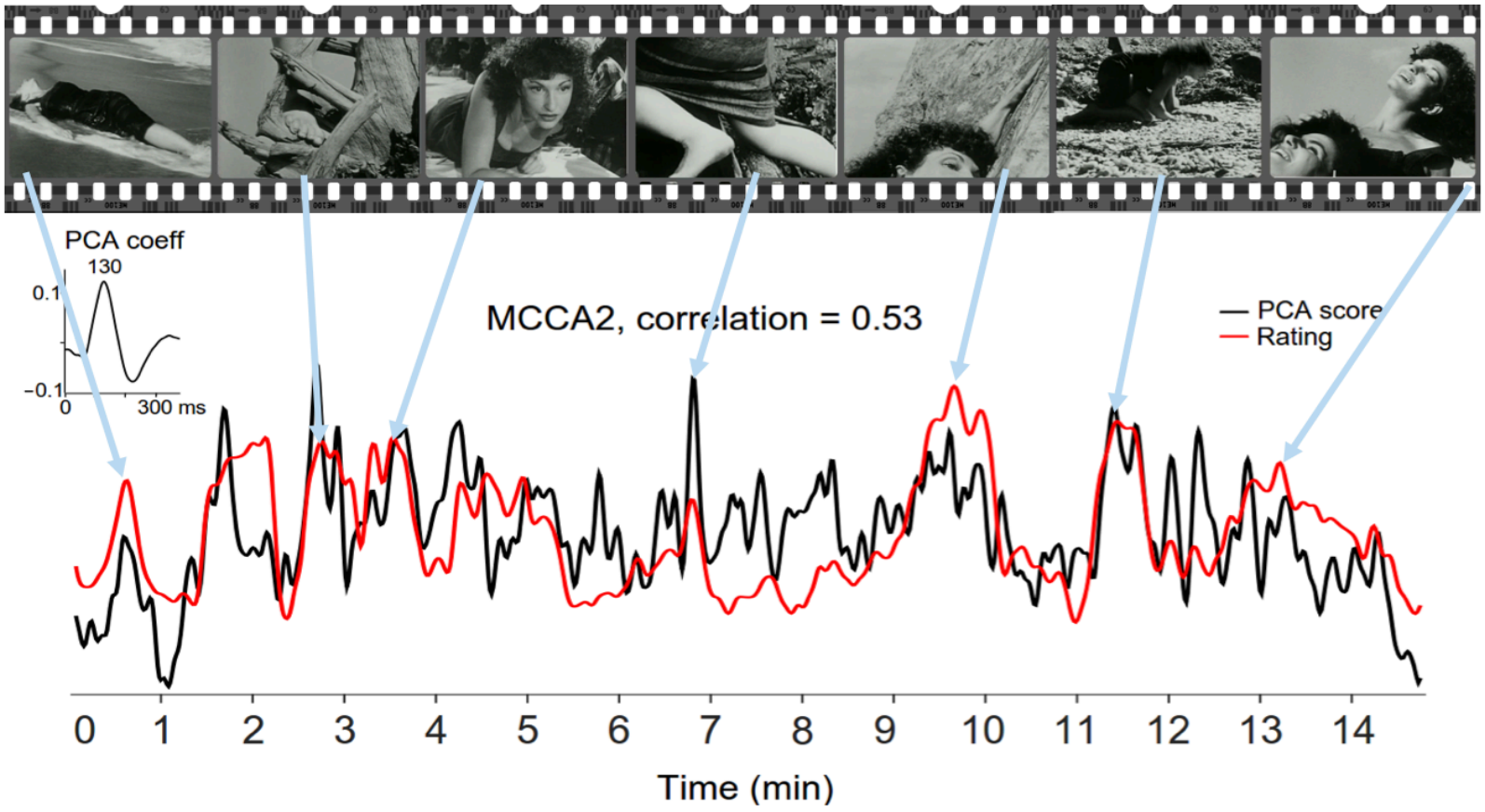
Nummenmaa et al. “Social Touch Modulates Endogenous μ-opioid System Activity in Humans“, in review

μ-opioid receptor availability changes in social touch condition



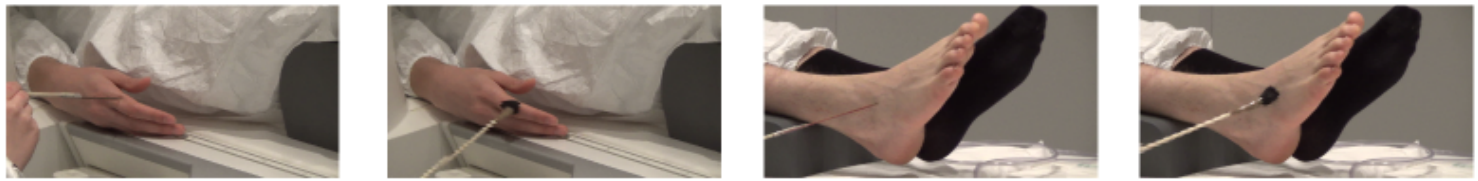
Nummenmaa et al. "Social Touch Modulates Endogenous μ-opioid System Activity in Humans", in review

Engagement with tactile contents of a movie correlates with functional state of SI

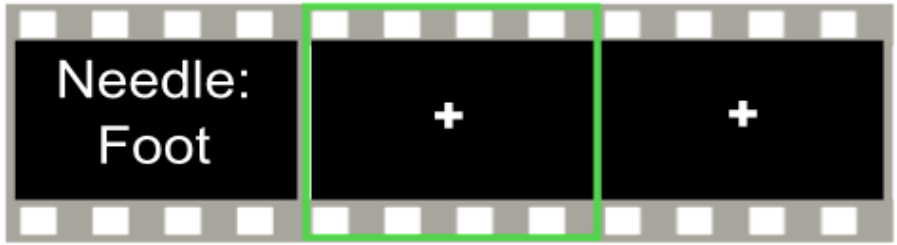


Shared neural signatures for felt and vicarious somatosensation

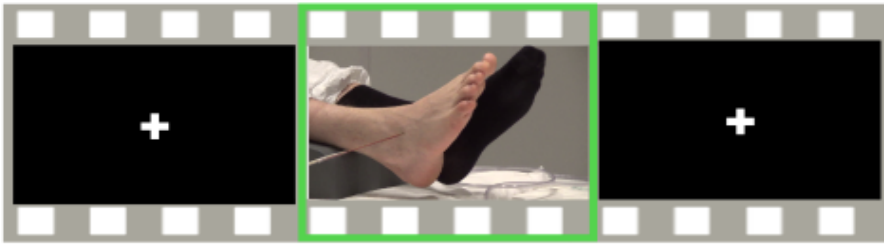
A) Four touch categories



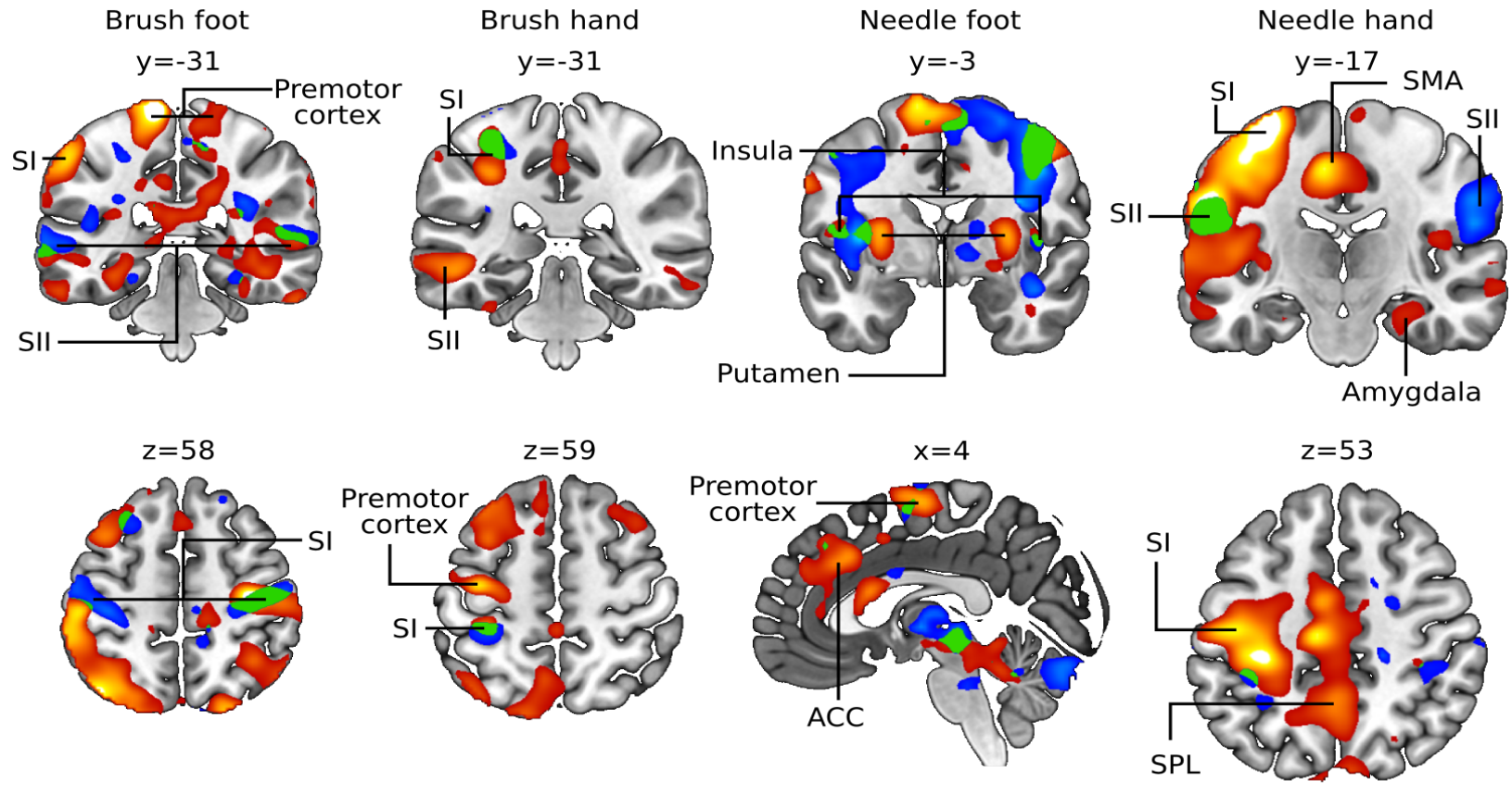
B) Experiencing touch



C) Observing touch

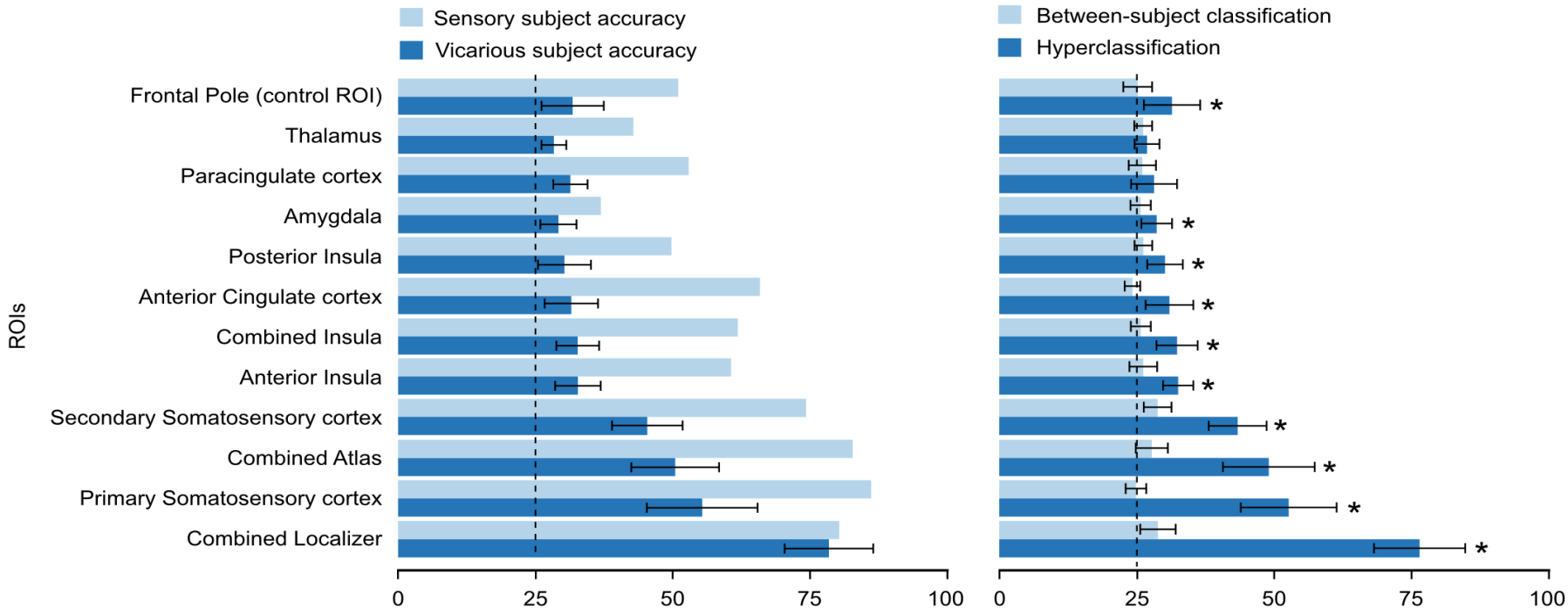


Lachat et al. Brain-To-Brain Hyperclassification Reveals Shared Neural Signatures for Felt and Vicarious Somatosensation, unpublished work



Brain regions showing significant activation during sensory (hot colours) and vicarious (cool colours), p < 0.05 (FDR-corrected). Green color shows overlap between sensory and vicarious touch.

Classification of stimuli within and between subjects



Classification accuracy. Chance-level accuracy is represented by a dashed line, which indicates 25%.

Disorders

Disorders and modified functioning of the sensory system

- Acute sensory neuropathy
  - for example patient G.L, lack Aα and Aβ fibers
- Hereditary sensory and autonomic neuropathy V (Norrbotten syndrome)
  - opposite of ASN, lack Aδ and C fibers
- Chronic pain patients
- Anorexia nervosa
  - CT-optimal stroking experienced as less pleasant by AN subjects than healthy controls
    Crucianelli et al. (2016). The perception of affective touch in Anorexia Nervosa. Psychiatry Research
- Autism spectrum disorders


"No touchy."

Take 5 mins to write down for yourself what happens in the clip, based on what you learned in this lecture. You can write about behavioral, sensory perception, and/or cortical level. Feel free to come and ask me if something was unclear!

Video from https://www.youtube.com/watch?v=wM75ulDRkhI