

vPPTR 2020 symposium:
*Novel insights on thermo- and hygro-
sensory functions across different
species (including humans)*



European
Research
Council



ERC Consolidator grant 2017 ARTTOUCH

Touch and temperature interactions at the level of the single afferent in humans

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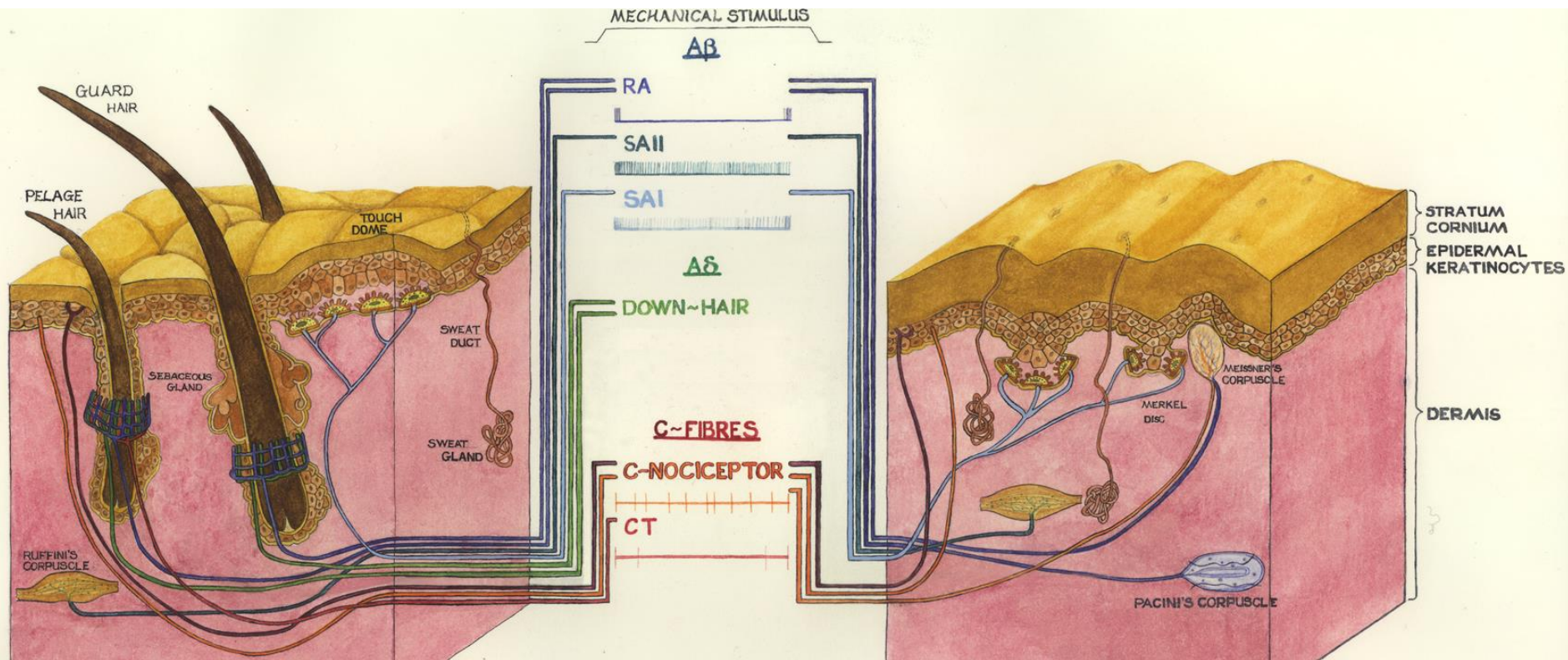
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Touch + temperature

- ▶ With touch comes temperature
 - ▶ **Neutral** – little sense of temperature, as similar to skin temperature (28-34°C)
 - ▶ **Increase** – warm, hot, painful
burning, hairy, dry, cosy, rough, scratchy, dirty, sticky
 - ▶ **Decrease** – cool, cold, painful
wet, slippery, smooth, numb, fresh, clean
- ▶ Temperature can:
 - ▶ Modify touch
 - ▶ Add an affective component to touch

Mechanoreceptors in the skin



Hairy skin

Glabrous skin



Ackerley et al (2016).

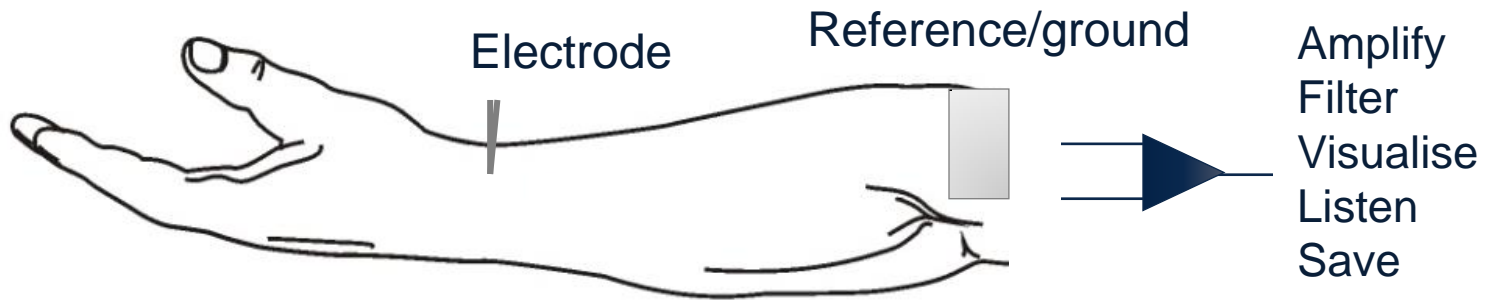
The Touch Landscape, in "Affective Touch and the Neurophysiology of CT Afferents"

Thermoreceptors in human skin

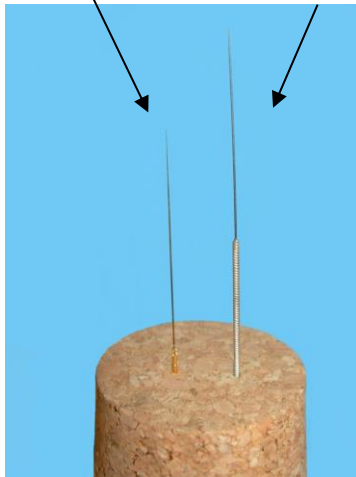
Class	Type	Preferred stimulus
Thermoreceptor	A δ cool	Touch and cooling
Thermoreceptor	C-cold	Cold $\sim 20^{\circ}\text{C}$; spontaneous from $\sim 30^{\circ}\text{C}$, respond down to 0°C Changes in temperature
Thermoreceptor	C-warm (?)	Low threshold $\sim 30\text{-}40^{\circ}\text{C}$ High threshold $>38^{\circ}\text{C}$
Nociceptor	A δ hot	Noxious touch/temperature
Nociceptor	C-mechano-heat	Touch with heat ($\sim 40^{\circ}\text{C}$)
Nociceptor	C-mechano-heat-cold	Touch with heat ($\sim 40^{\circ}\text{C}$) or cold ($<20^{\circ}\text{C}$)

Adriaensen et al (1983) J Neurophysiol
Ackerley & Watkins (2018) J Neurophysiol

Microneurography



Microneurography Acupuncture

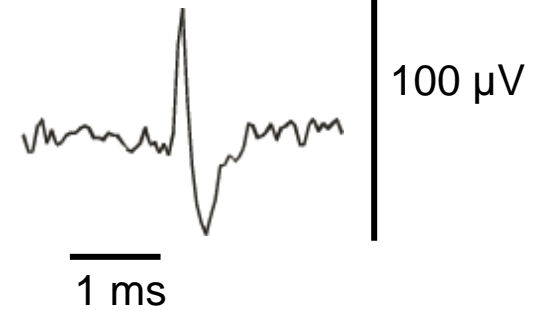


Single SA1 afferent

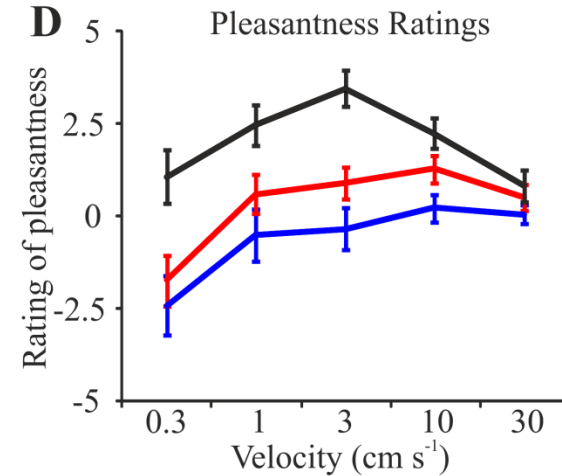
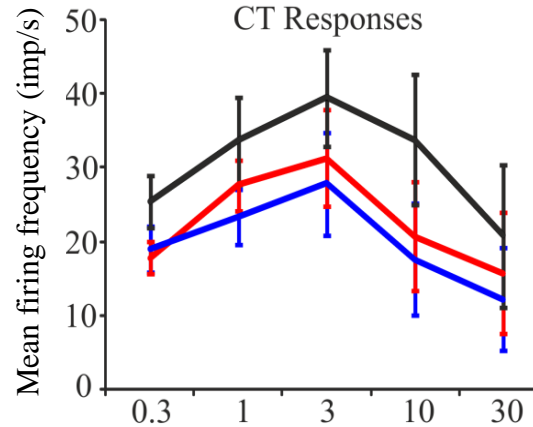
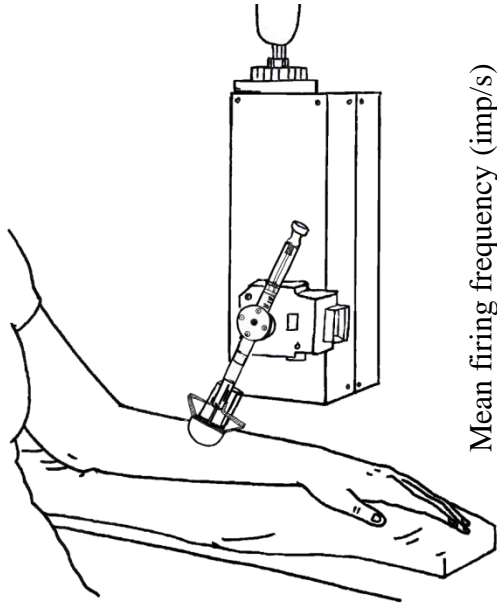


Touch

Nerve spike



Affective touch: a human caress



Ackerley et al. (2014) *J Neurosci*

Preferential responses to the **speed** and **temperature** of touch

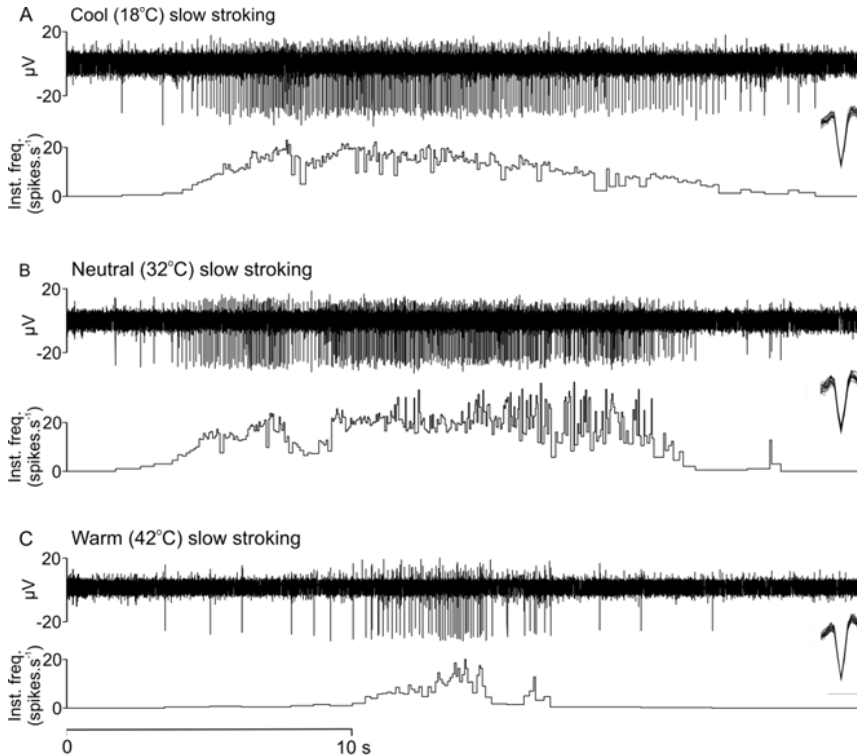
C-tactile (CT) afferents encode positive affective/pleasant touch

Stroking temperature

- Cool 18°C
- Neutral 32°C
- Warm 42°C

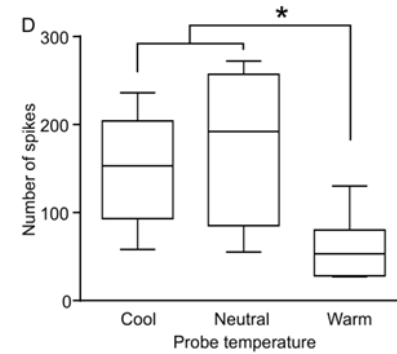
Temperature and CTs

Cool

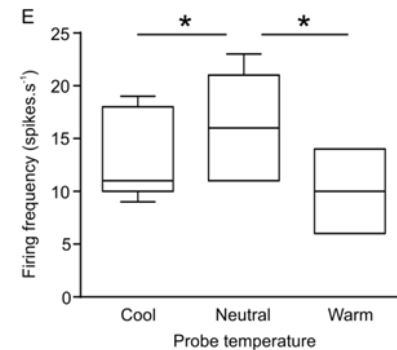


Neutral

Warm



Number of spikes



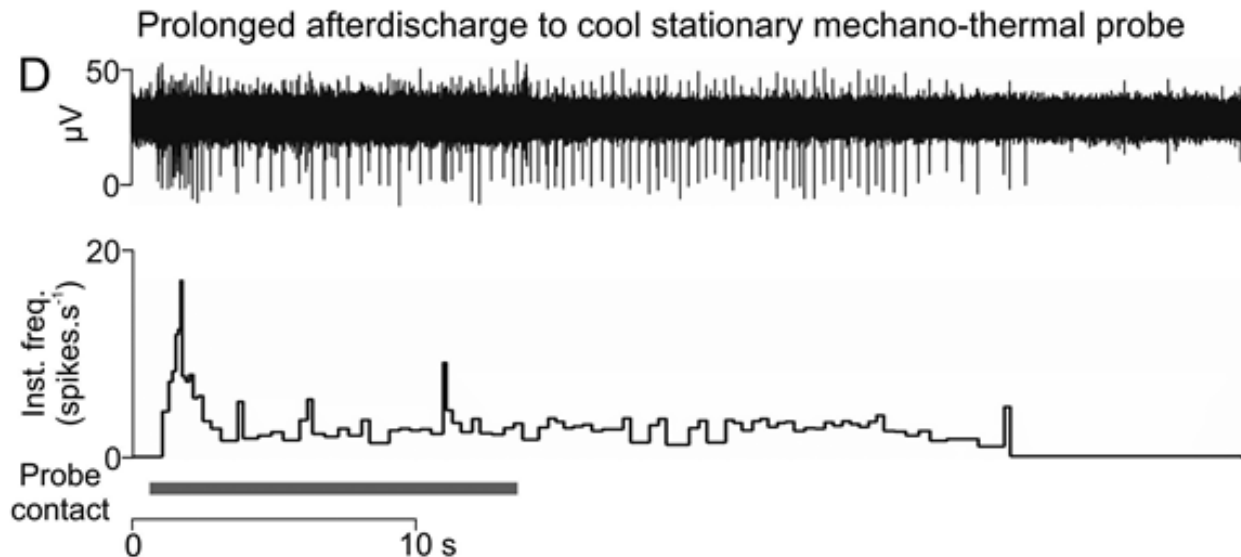
Firing frequency

Warming decreases all CT activity, but cooling can produce prolonged activity at low frequency

Cooling is more complicated

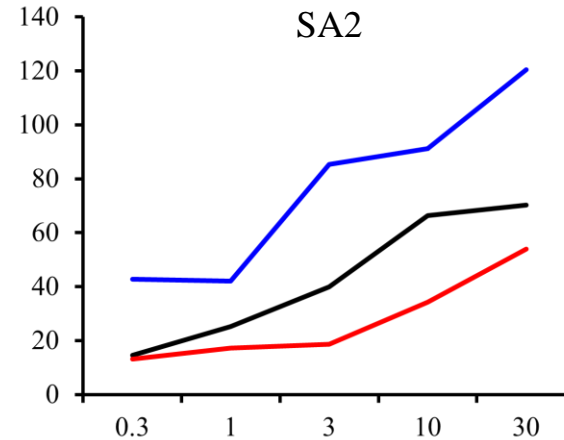
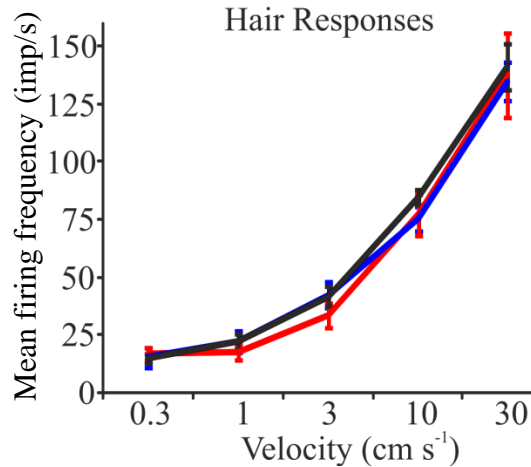
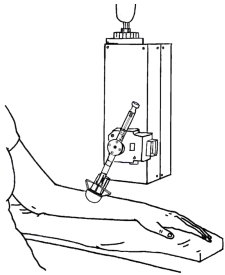
Virtually no response to radiant cooling/warming

Cooling, then touch, produces afterdischarges



Ackerley et al (2018) J Neurophysiol

Mechanoreceptor thermal responses



Ackerley et al. (2014) J Neurosci

Hair (n=4) and field (n=1) units showed no response modulation to temperature

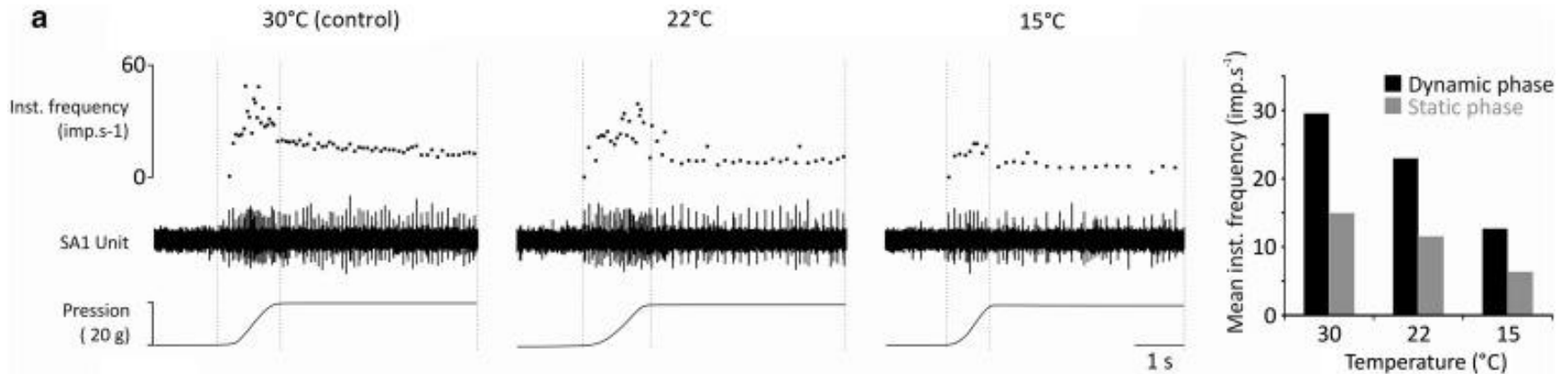
Stroking temperature

- Cool 18°C
- Neutral 32°C
- Warm 42°C

Extra data: SA2 unit (n=1) showed **increased** responses in cooling

Also: Konietzny (1984) Hum Neurobiol

Mechanoreceptor thermal responses



Bouvier et al (2017) J Invest Derm

Also: *Konietzny (1984) Hum Neurobiol*

SA1 unit (n=3) showed **decreased** responses in cooling

However, animal work shows SA1 dynamic cool sensitivity

Iggo & Muir (1969) J Physiol, Duclaux & Kenshalo (1972) J Physiol

Thermosensitive touch



- ▶ **Mechanoreceptors sensitive to cooling**
 - ▶ CTs – complicated, may signal state of skin, comfort
 - ▶ SA1 afferents – *decreased* responses to cool
 - ▶ SA2 – *increased* responses to cool
 - ▶ All mechanoreceptors insensitive/fire less to heat
- ▶ **Role in somatosensation?**
 - ▶ Touch with temperature gives complex signals
 - ▶ Change in skin elasticity, receptor properties?
 - ▶ May convey perceptions such as wetness, comfort, sweat
 - ▶ Combines with other somatosensory signals to convey richness in skin interactions