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ERC Consolidator grant 2017 ARTTOUCH



Depuis 80 ans, nos connaissances
bâtissent de nouveaux mondes

Microneurography: Single unit recordings from touch afferents in humans

Rochelle ACKERLEY

Laboratoire de Neurosciences Sensorielles et Cognitives
CNRS – Aix*Marseille Université
Marseille, France



First experiments



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Aims:

- Investigate human physiology and compare it to animal physiology
- Relate nerve activity to sensations experienced

Hensel & Bowman (1960) *J Neurophysiol*

– Cut the skin to access the nerve

Knutsson & Widen (1967) *Nature*

- Percutaneous insertion, but used glass-coated electrodes

Vallbo & Hagbarth (1967) *Electroencephalogr Clin Neurophysiol*

- 'Microneurography'

Microneurography



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- Recording percutaneously from peripheral nerve
 - Started over 50 years ago in Sweden
 - Multi-unit vs. single unit
 - Afferent vs. efferent
 - Record vs. stimulate

“Microneurography is, in principle, a very simple technique, but in practice is quite demanding.”

Vallbo (2018) *J Neurophysiol*



Approach



Depuis 80 ans, nos connaissances
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- Subject is fully conscious, no anaesthetic
- Subject must remain calm and not move
- Tungsten electrode: hard, but semi-flexible
- Rounded end (tip $\sim 5 \mu\text{m}$)
- Manipulated by hand
- No cutting of the skin – cannot see where the electrode is
- Electrode is free-floating
- Demanding for the experimenter and subject
- Time consuming
- Ethical considerations



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Approach

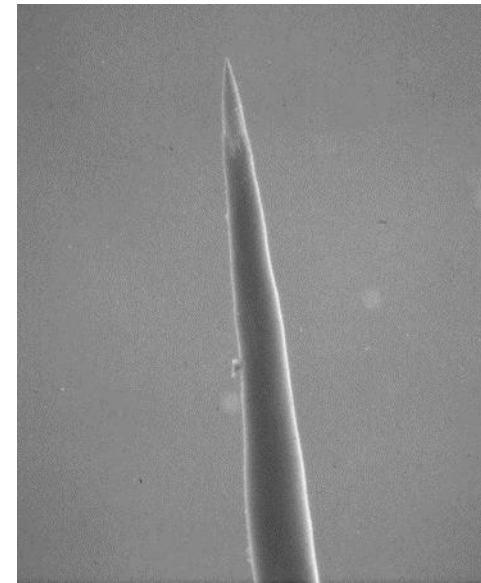
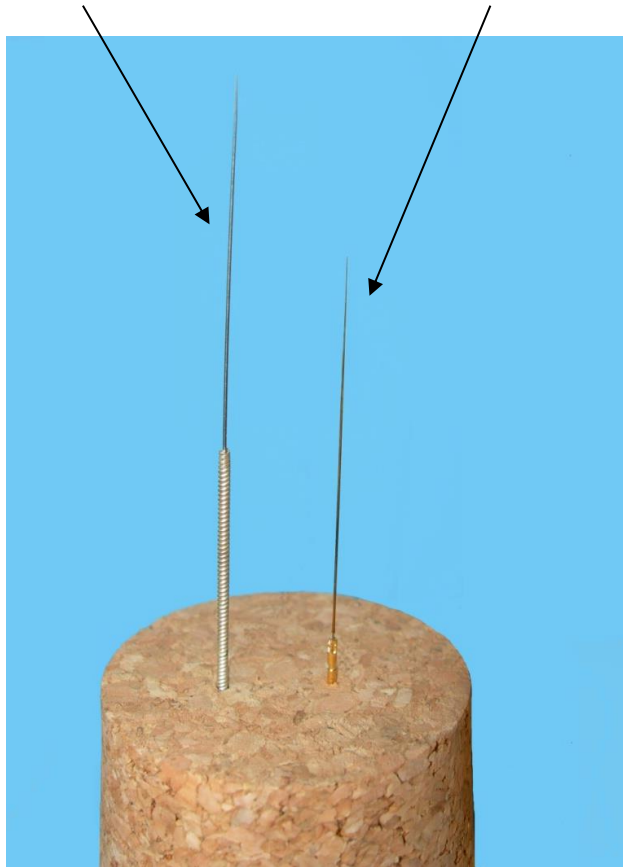


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Acupuncture

Microneurography



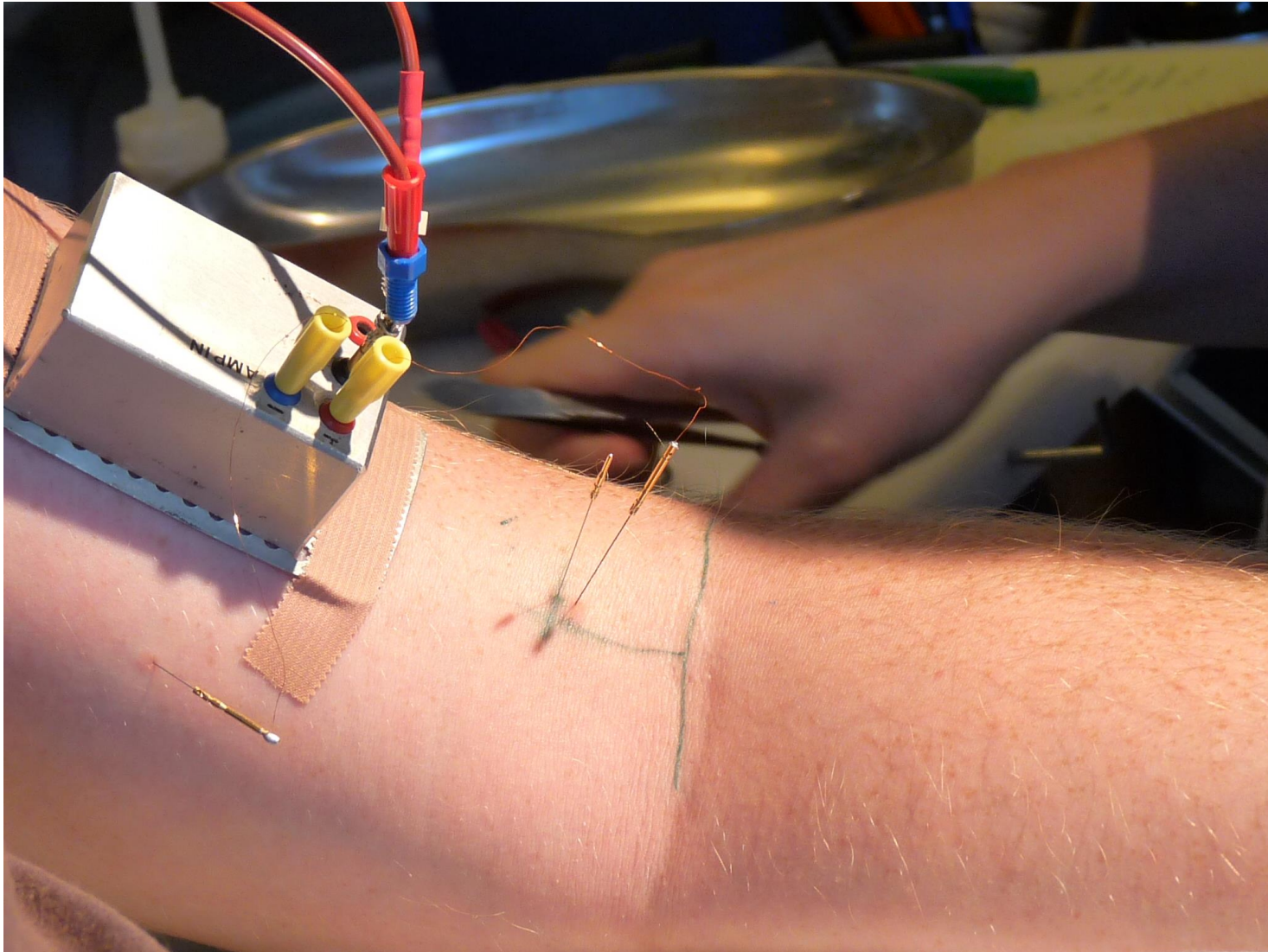
Coated tungsten
0.2 mm diameter
Electrode tip $\sim 5 \mu\text{m}$
 $\sim 300\text{-}500 \text{ k}\Omega$ impedance

Approach



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Needle_LowRes.wmv

Approach



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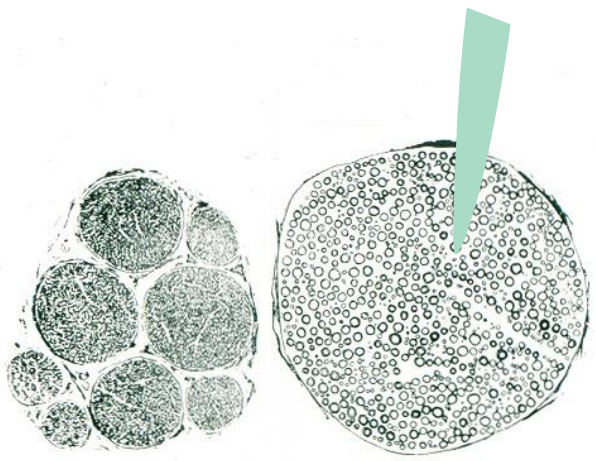
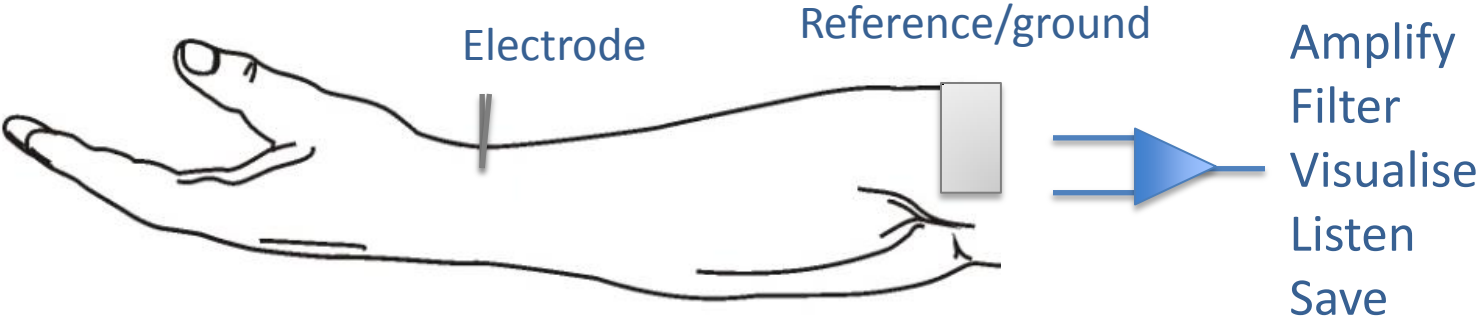
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Microneurography



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Myelinated SA1 afferent



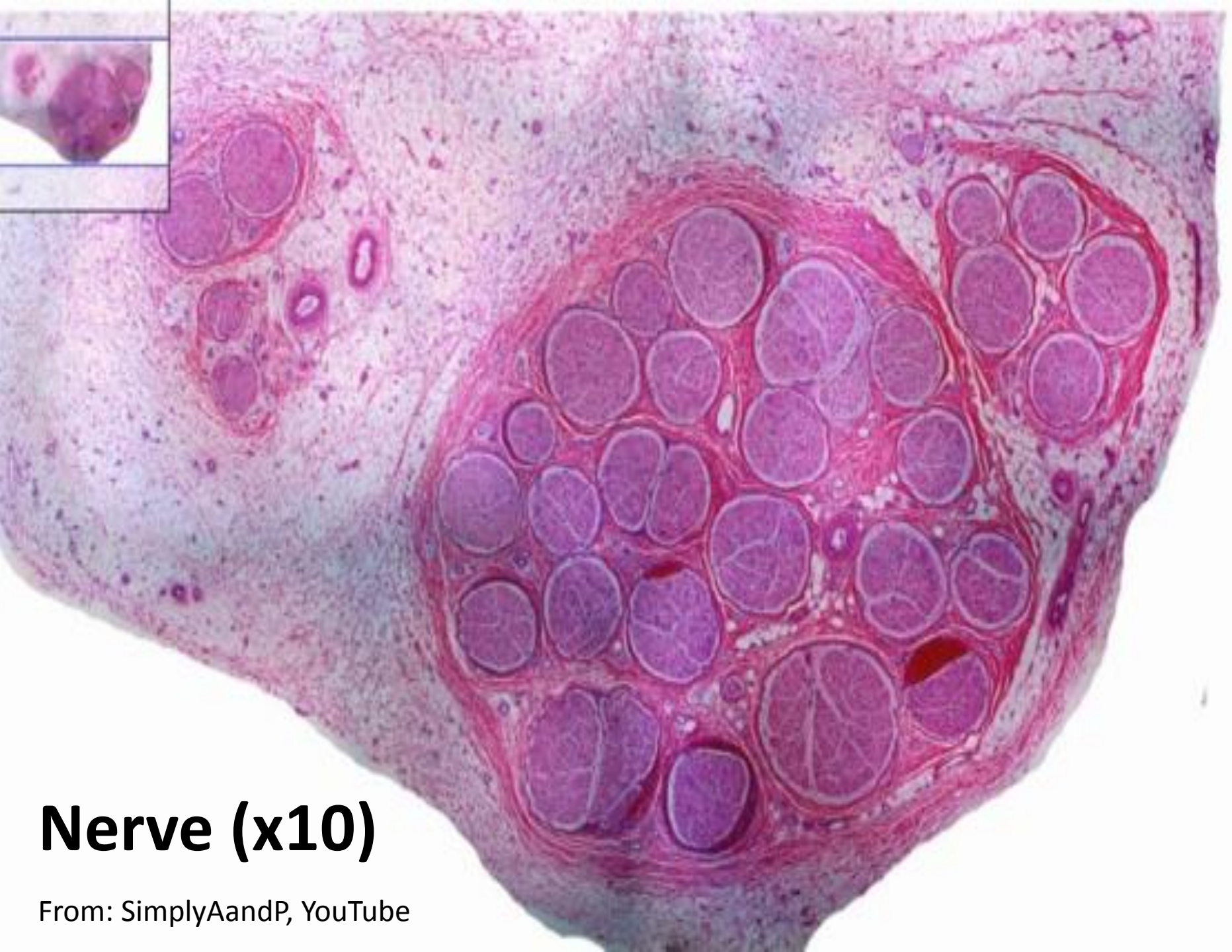
Touch

Nerve spike



100 μ V

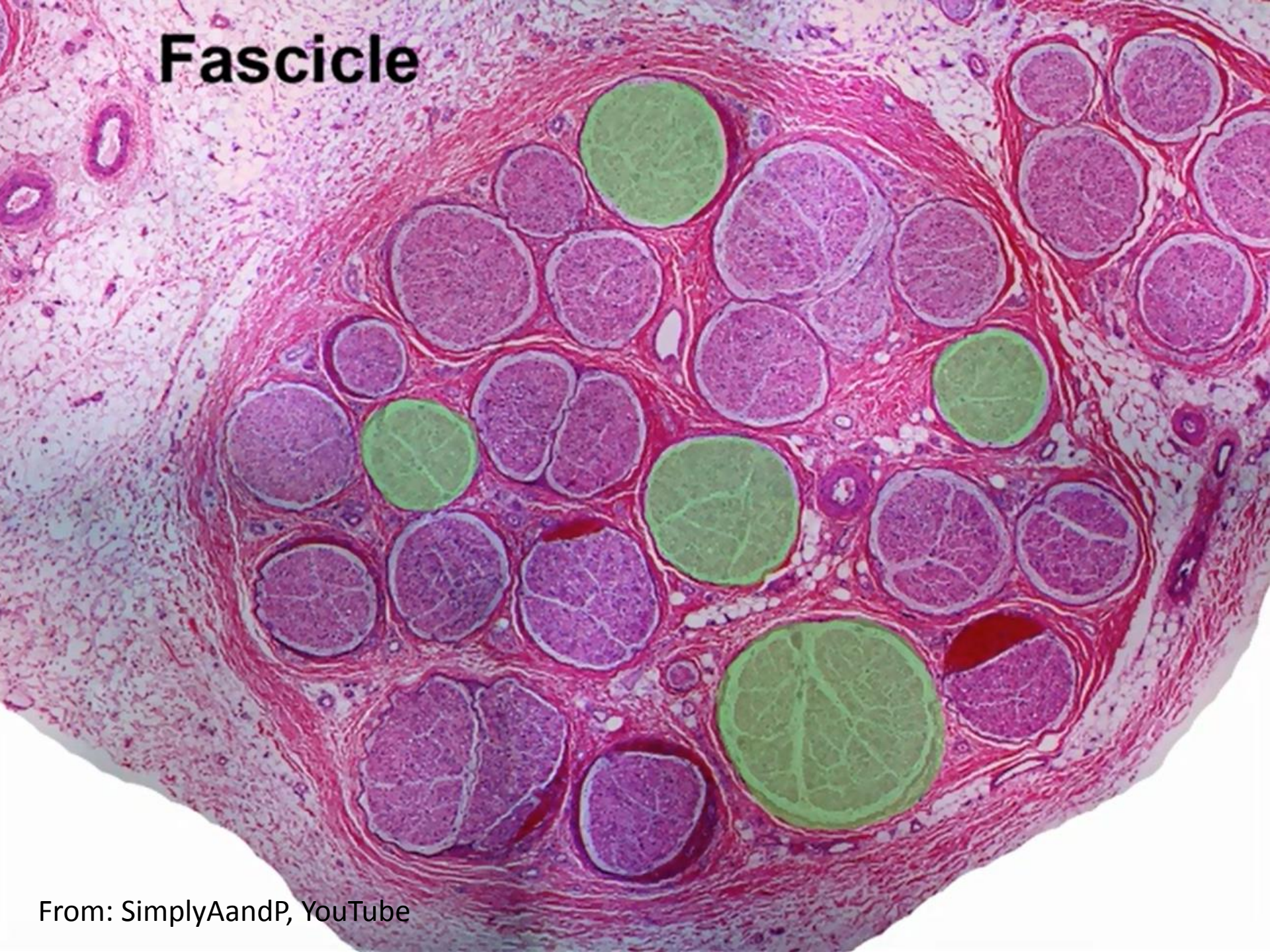
1 ms

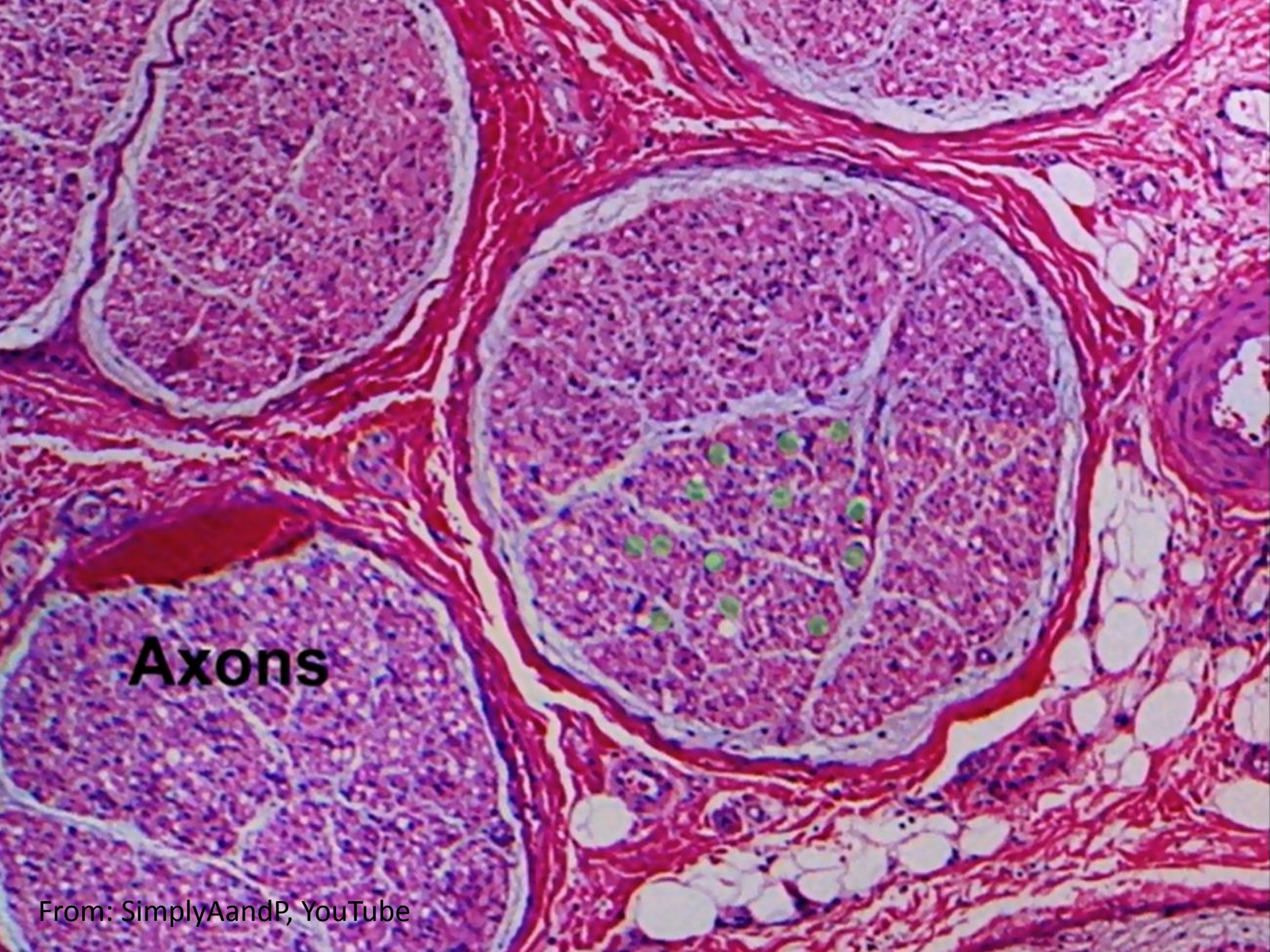


Nerve (x10)

From: SimplyAandP, YouTube

Fascicle





Axons

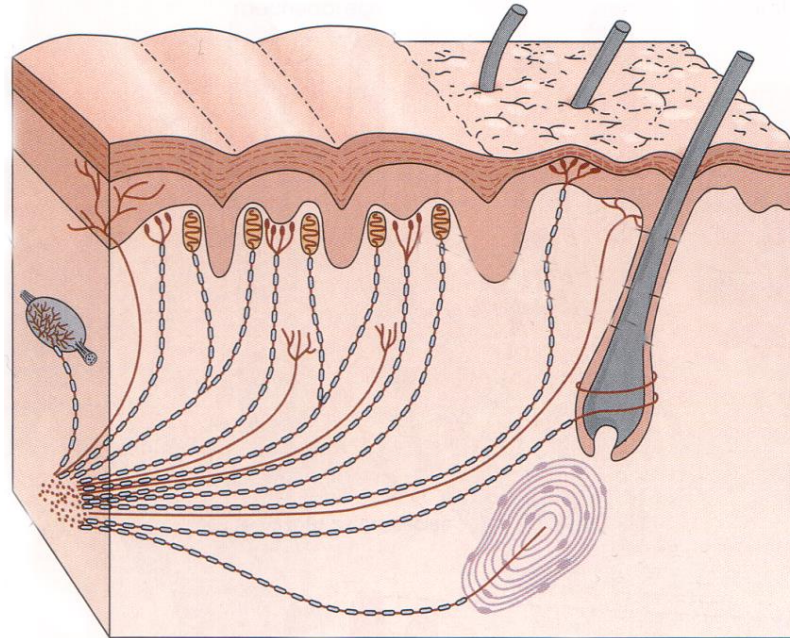
Mechanoreceptors



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Glabrous skin

Meissner, FA1
Merkel, SA1
Pacini, FA2
Ruffini, SA2



Hairy skin

Merkel, SA1
Pacini, FA2
Ruffini, SA2
Hair units
Field units
C-tactile

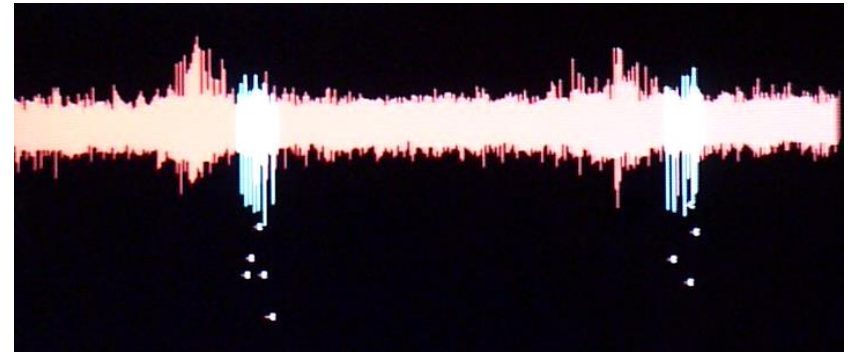
Thick, myelinated, fast-conducting, $A\beta$ afferents

Thin, unmyelinated, slowly-conducting, C-tactile (CT) afferents

In the nerve



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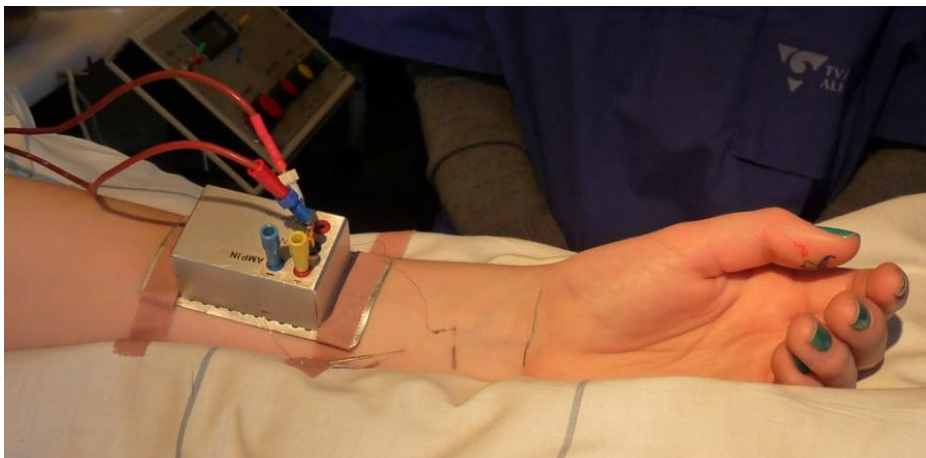
Thumb_LatAnteBrach.wmv



Hair_RTS_1.mov



ABeta_Cfibre_cut.wmv



Studies into affective touch



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- Hairy skin contains **C-tactile (CT) afferents**, thought to encode **positive affective/pleasant touch**

'Affective touch hypothesis'

Olausson et al. (2010) *Neurosci & Biobehav Rev*; McGlone et al. (2014) *Neuron*

- Hairy skin more suited to convey affective touch
Ackerley et al., 2014a, b, Front Neurosci
- Use more **emotional** language for touch on hairy skin
Ackerley et al., 2014a, Front Neurosci

CT afferents (n = 8 papers)



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- Slow conduction velocity ≈ 1 m/s
- Respond to <2.5 mN force
- Small receptive field (~ 15 mm²)
- Respond well to gentle, slow, moving stimuli
- Respond poorly to rapid events and vibration
- Fatigues with repeated stimulation
- Show afterdischarges that outlast mechanical stimulus
- Found in hairy skin

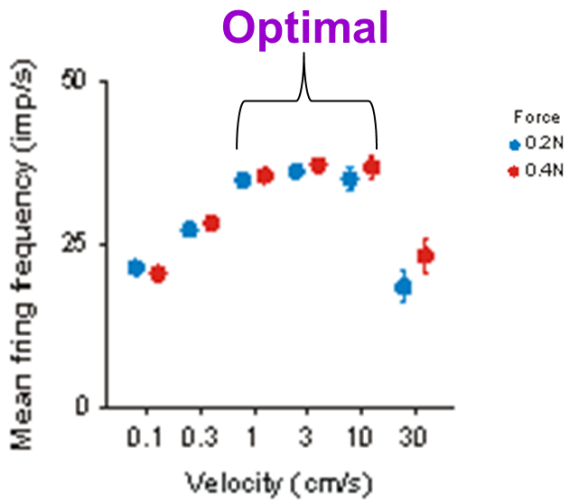
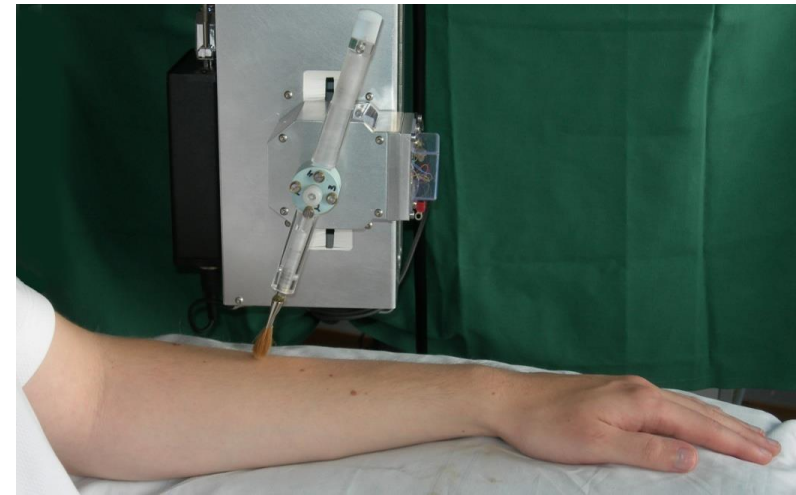
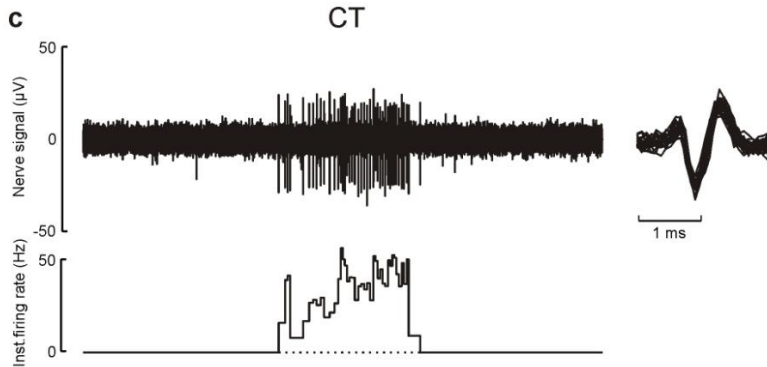
*CT afferents are not suited for discriminative touch (intensity, timing, localisation), but seem to encode **positive (pleasant) affective touch***

CT afferents respond well to stroking



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3 cm/s
0.4 N

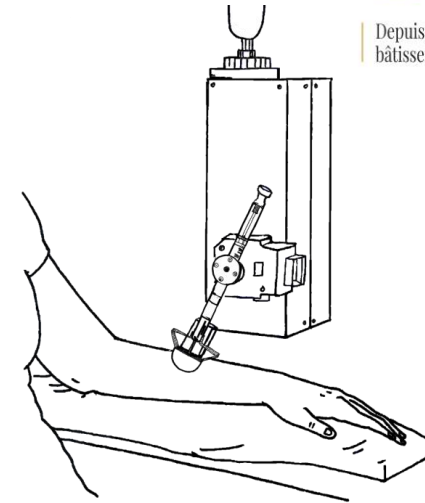
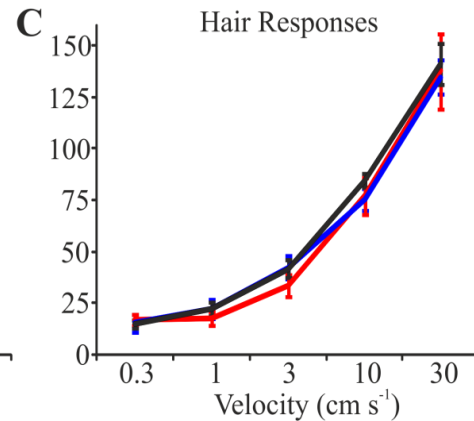
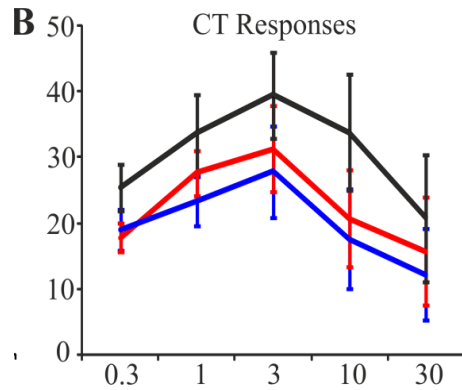


Coding of stroking velocity -
CT afferents have a preferred speed

CT temperature preference

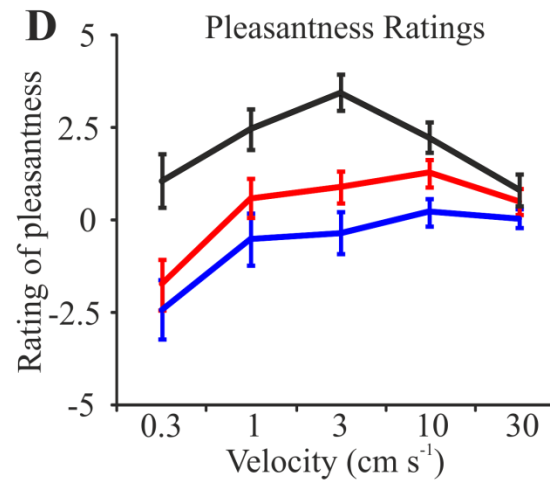


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Stroking temperature

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



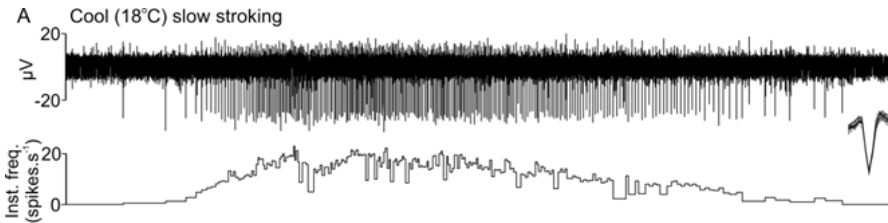
Preferred speed and
temperature of touch

Slow (0.3 cm/s) thermal touch

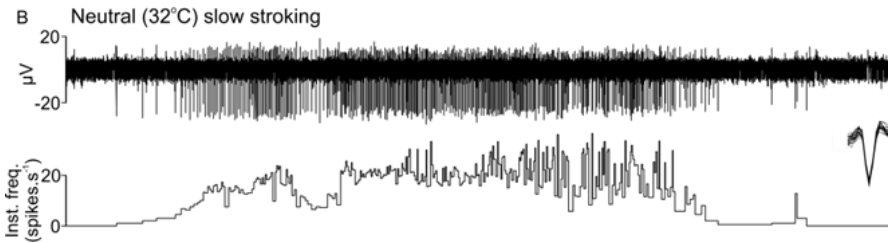


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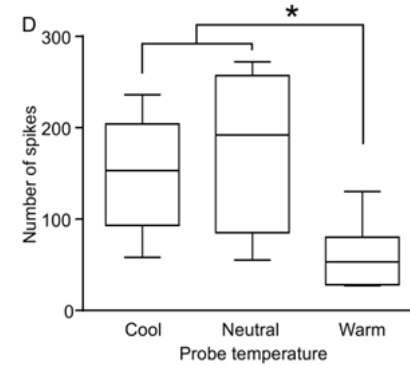
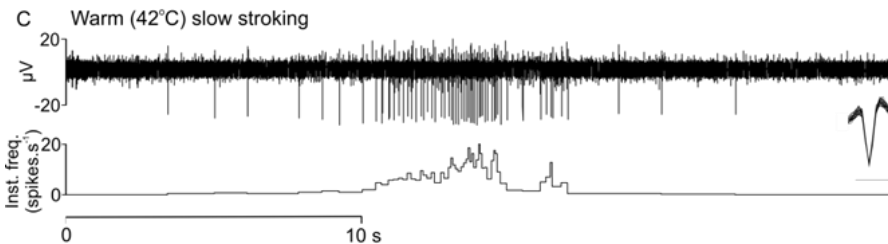
18°C



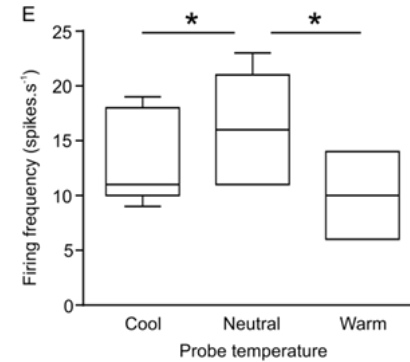
32°C



42°C



Number
of spikes



Firing
frequency

Neutral slow stroking produced highest firing,
but responses **supressed with warmth**

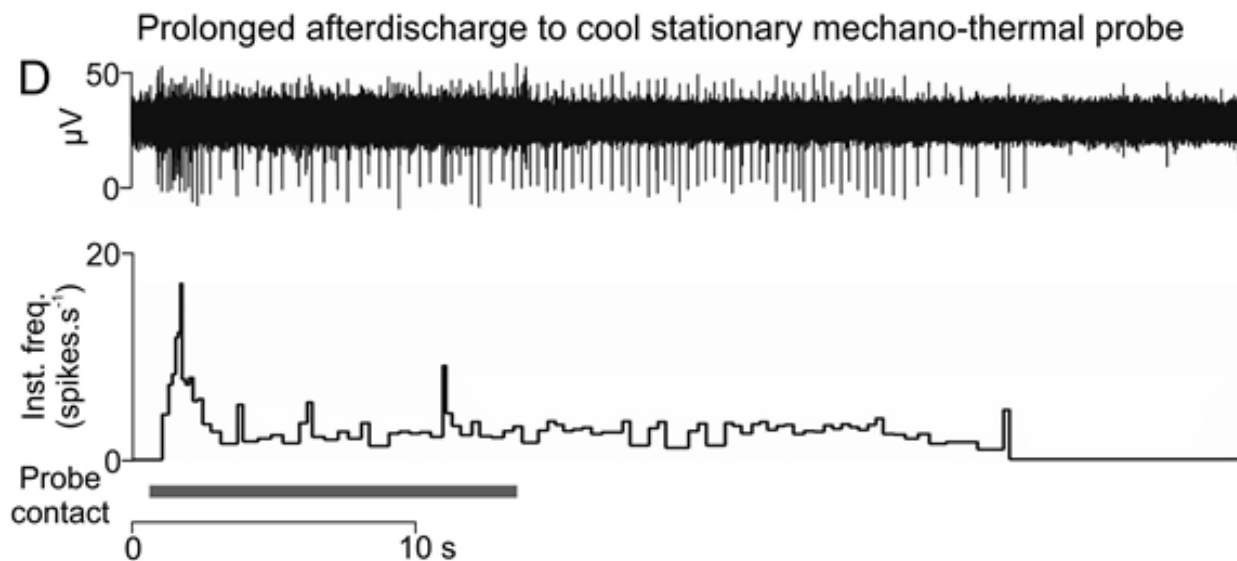
CT temperature responses



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Virtually no response to radiant cooling/warming

Cooling, then touch, produces afterdischarges



Ackerley et al (2018) J Neurophysiol

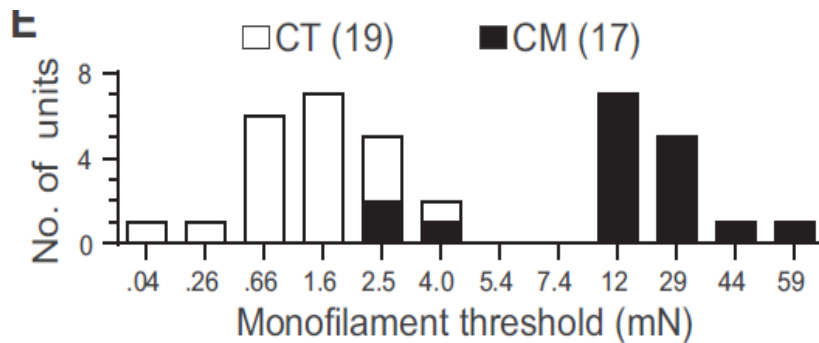
Not nociceptors



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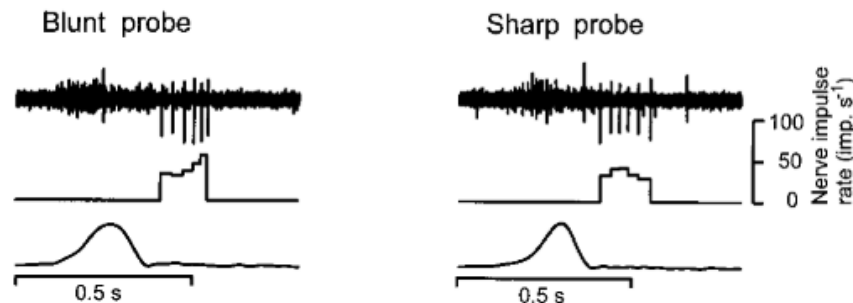
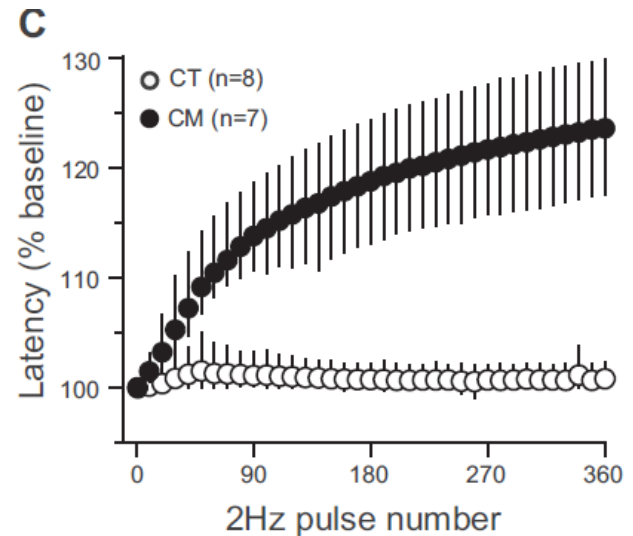
Physiologically distinct from nociceptive afferents

Low force activation threshold



Watkins et al (2017) J Neurophysiol

Do not slow conduction with repeated electrical stimulation



Vallbo et al (1999) J Neurophysiol

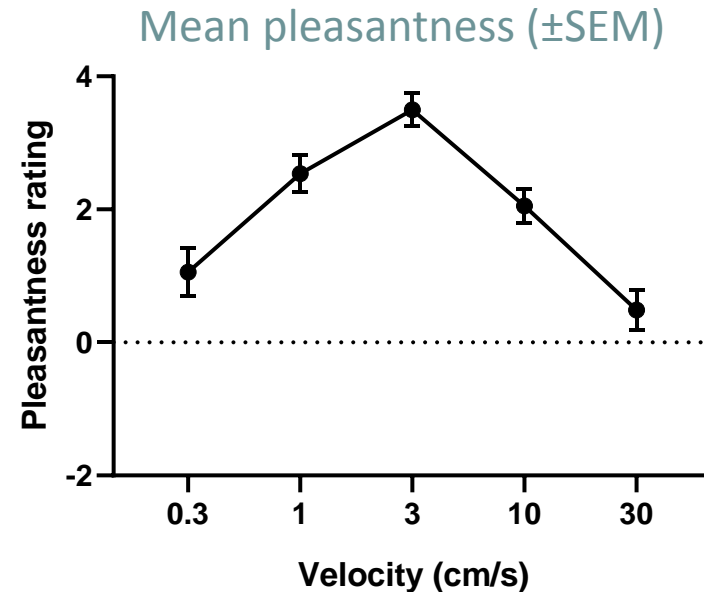
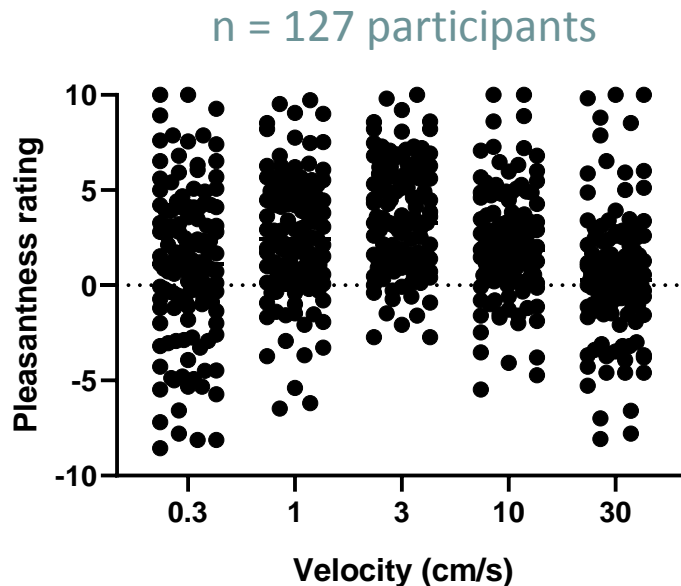
Respond equally
to sharp or blunt
stimulus

Do CTs also code *unpleasantness*?



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- ‘Correlation’ between CT firing and pleasantness
 - This is not direct with additional factors
e.g. temperature, different body site, add odour
 - Great variability in ‘inverted-U’ shape curve
- At lowest and fastest velocities – near unpleasant



Conclusions CTs



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- CTs are true low-threshold mechanoreceptors (not thermoreceptors, not nociceptors)
- Respond preferentially to **slow, gently touch at typical human skin temperature**
 - May promote conspecific interactions
 - May reflect thermal comfort, which is related to pleasantness
- *But what do CTs signal?*
 - Low-threshold touch
 - Not pleasantness directly
 - Why is there increased firing with cold?
 - Positive **and** negative affective signals?
 - Test stimuli of different affective quality

Microneurography



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- Record responses from single units
- Direct human physiology
- Link to perception
- Compare with animal work
- Combine with other techniques e.g. fMRI, MEG, EEG, psychophysics
- Takes skill and patience!
- Thank you!



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