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Tactile intensity perception is shaped by temporal integration: evidence from single afferent recording and stimulation in humans

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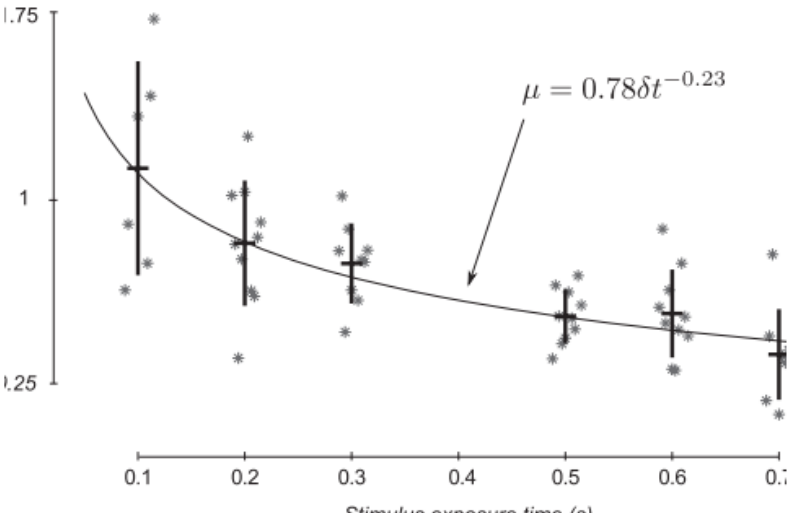
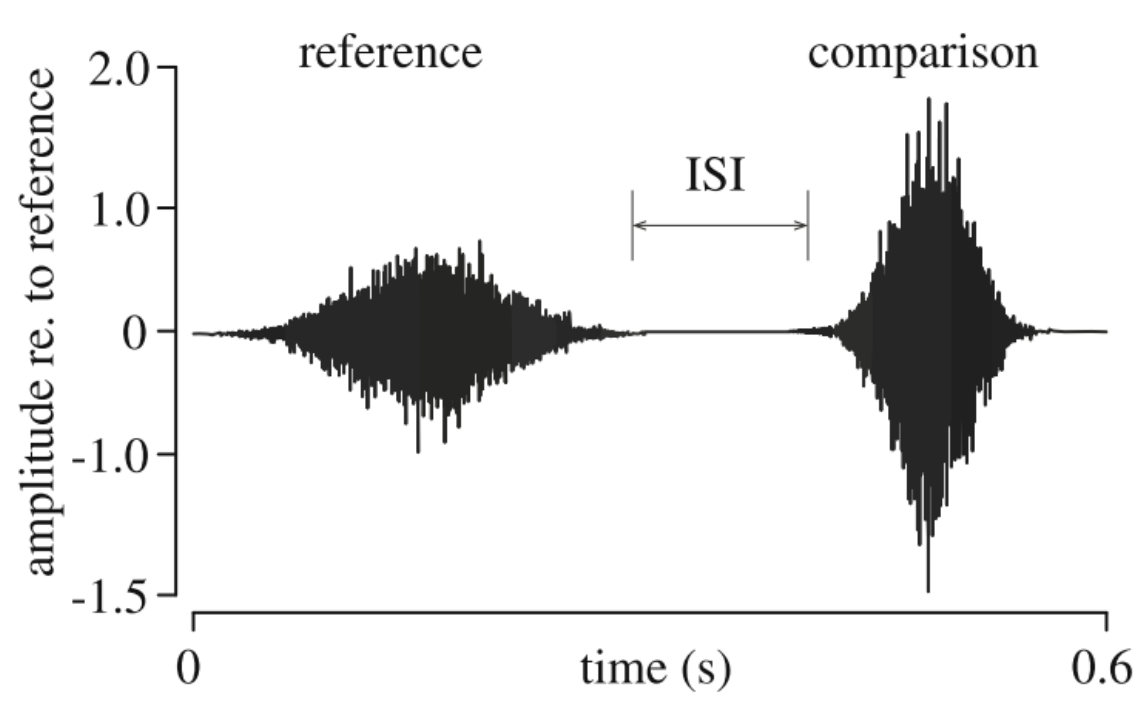
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Introduction

Classical touch literature,

- Temporal Patterning= quality
- Firing rate=intensity

However, vibration perception measurements indicate this coding may break down at short durations

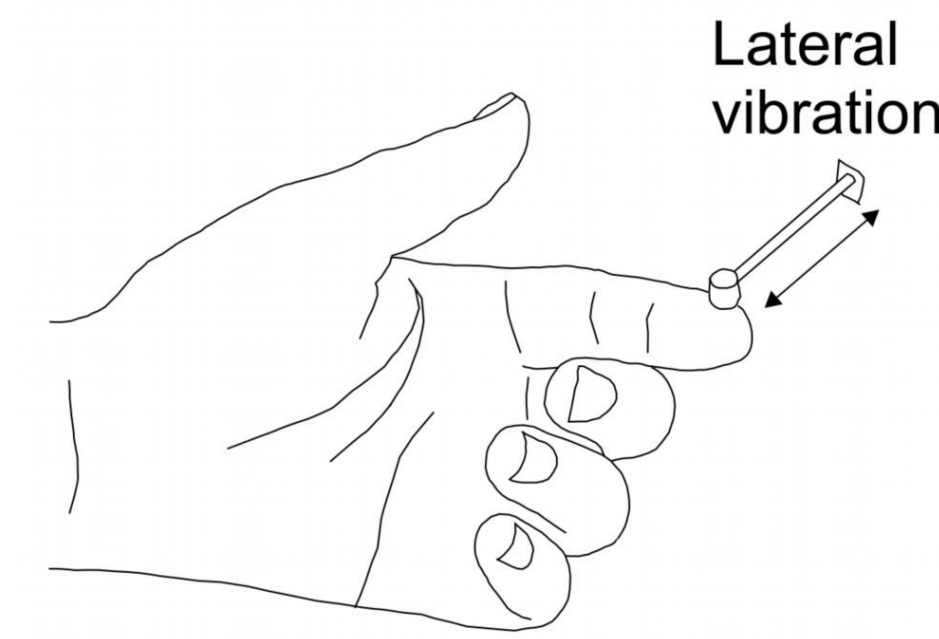


Shorter duration vibration can feel equivalent if the amplitude is increased ($\approx 200\text{ms}$)

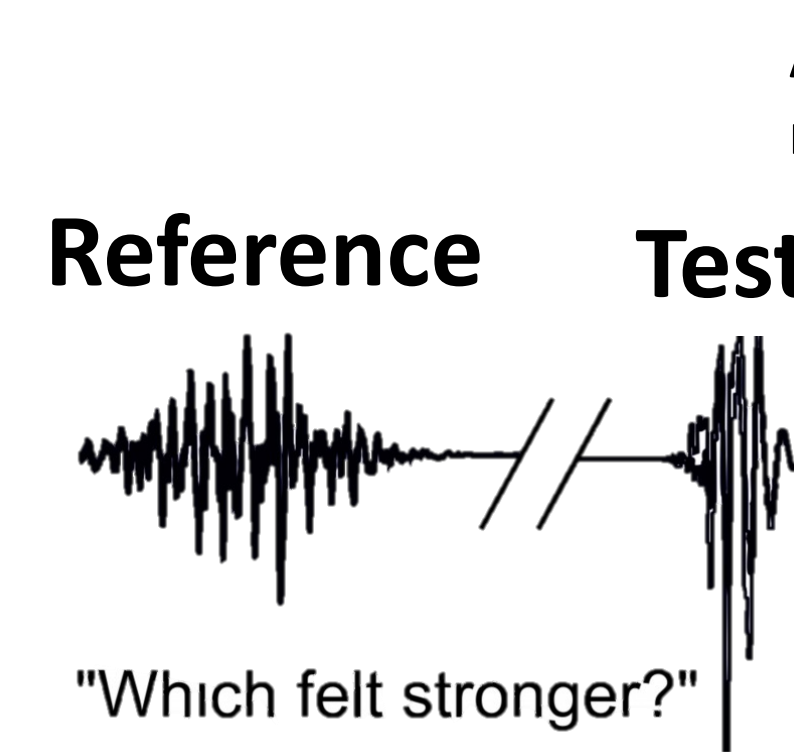
Bochereau et al., 2014)

Duration affects perceived intensity for short stimuli
Aim: Identify peripheral neural mechanisms of this integration

Study 1- Perception



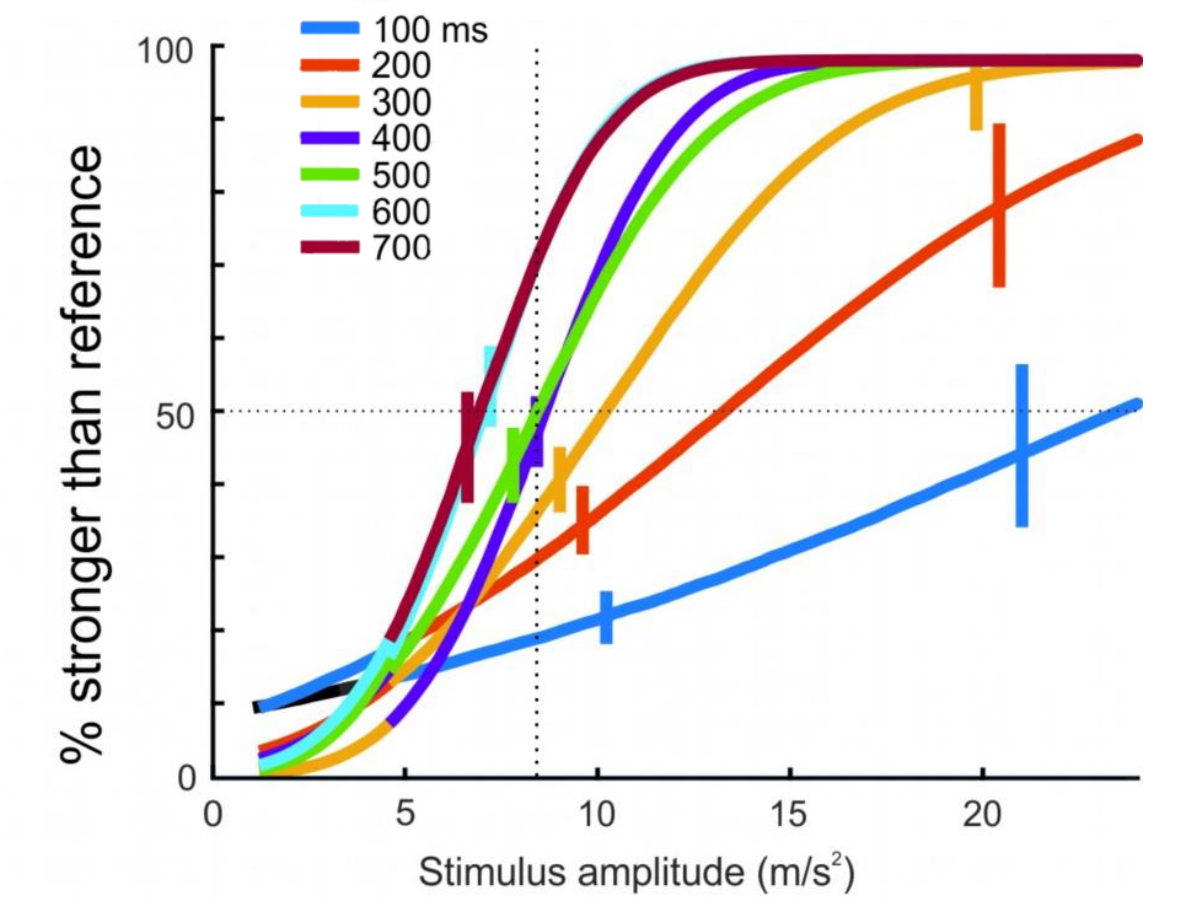
Lateral vibration applied to fingertip with fine sandpaper coated probe (contact force = 40mN)



Pairs of vibration stimuli

Reference = $8\text{m}\cdot\text{s}^{-2}$, 400ms
Test = $2.5 \rightarrow 22.5\ 8\text{m}\cdot\text{s}^{-2}$

- Interleaved staircase psychophysical testing with adjustment of test amplitude
- Repeated at test durations of 100/200/300/400/500/600/700ms



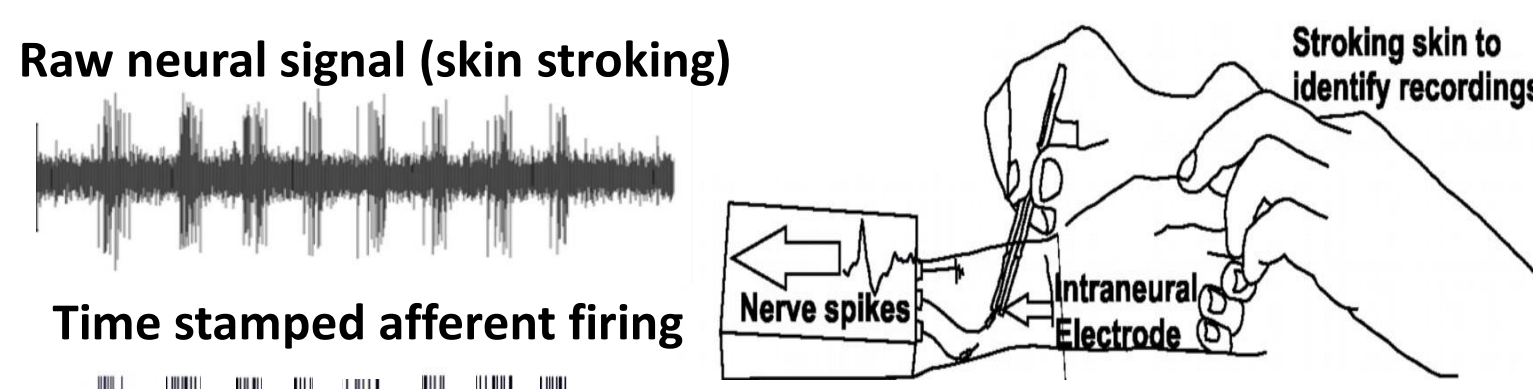
Amplitude required for equivalence is increased at short durations \rightarrow less adjustment for longer durations

Stimulus amplitude and duration both contribute to perceived vibration intensity for short bursts (<math><400\text{ms}</math>)

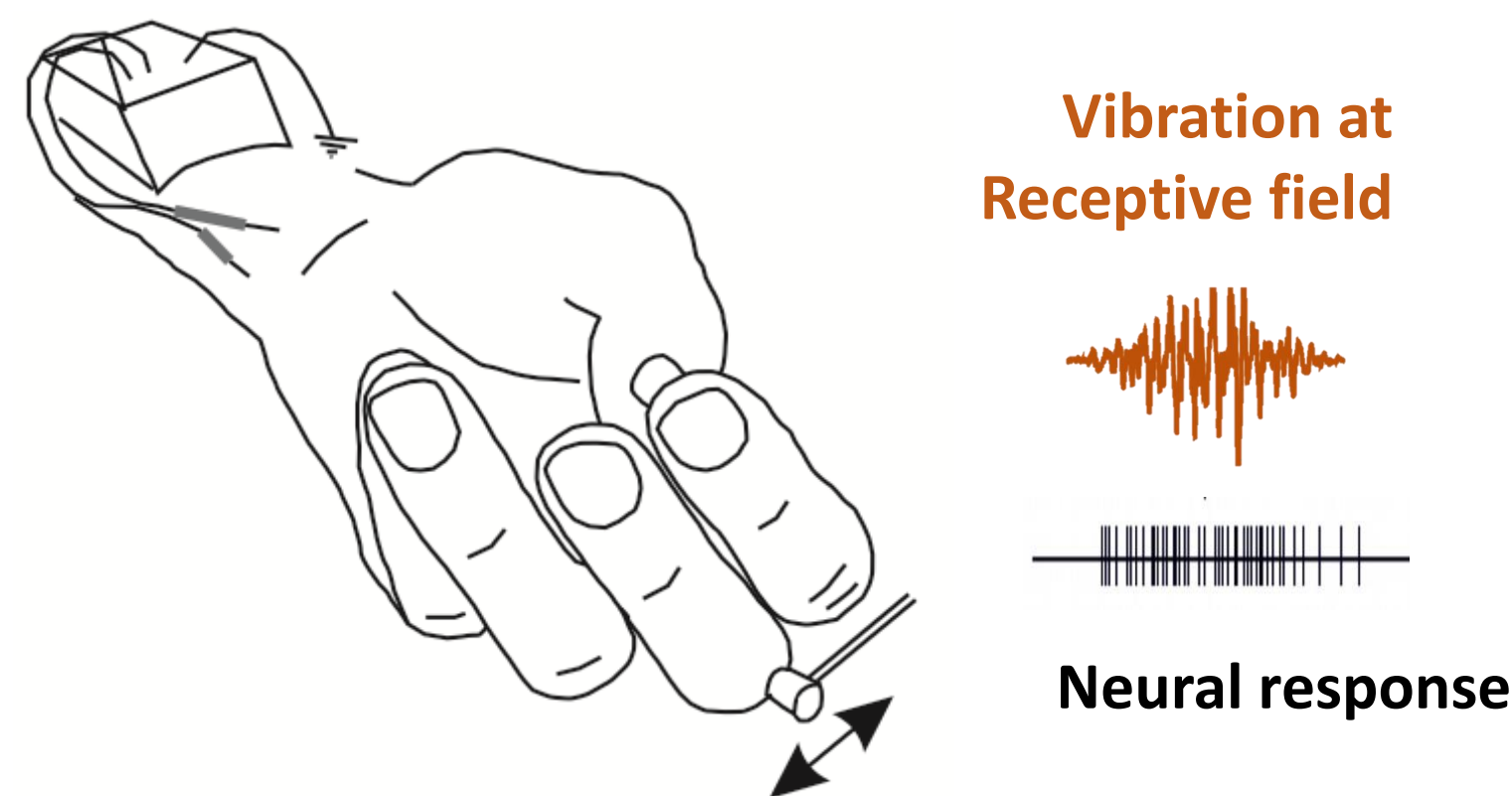
Study 2- Afferent firing vs. Perception

Human microneurography

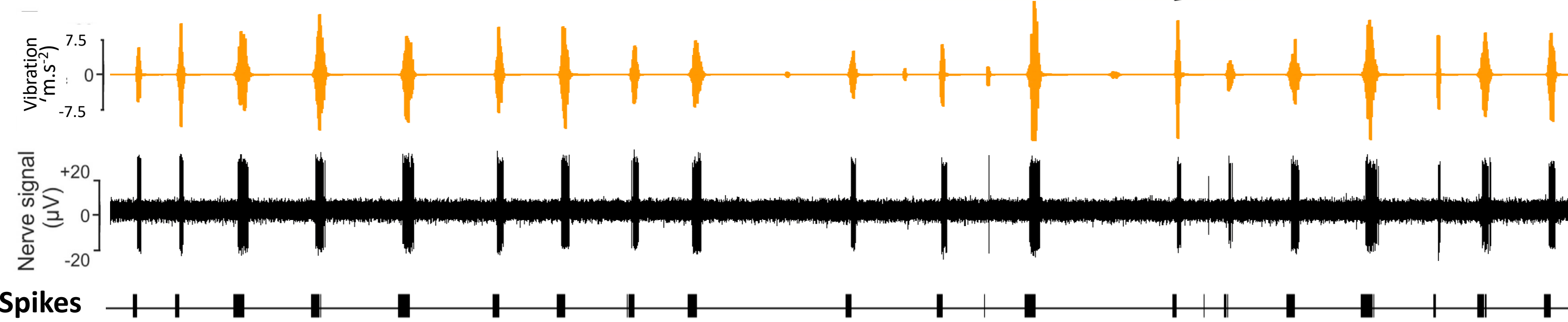
Microneurography allows the recording of activity in single mechanoreceptive afferent fibers in human subjects



Different types of mechanoreceptive afferent identified and characterized



All 70 stimuli from Perceptual testing



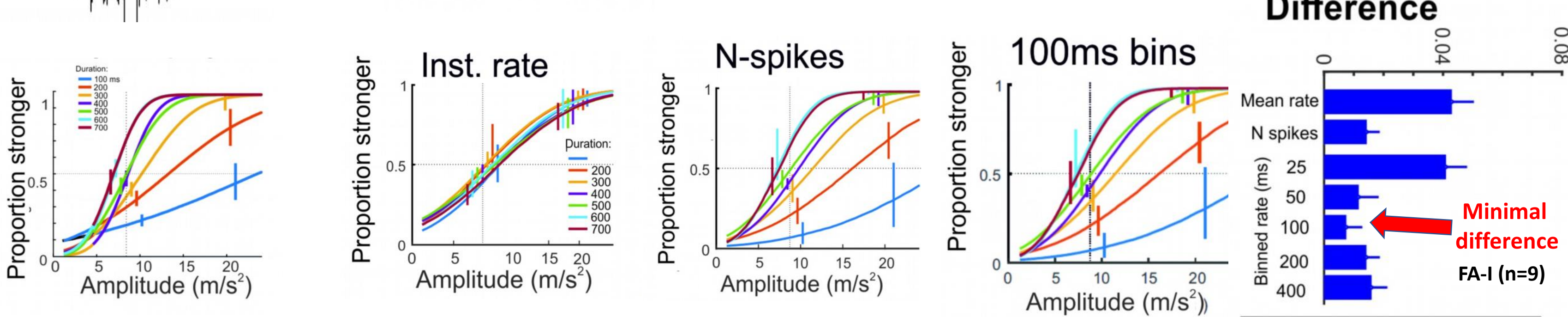
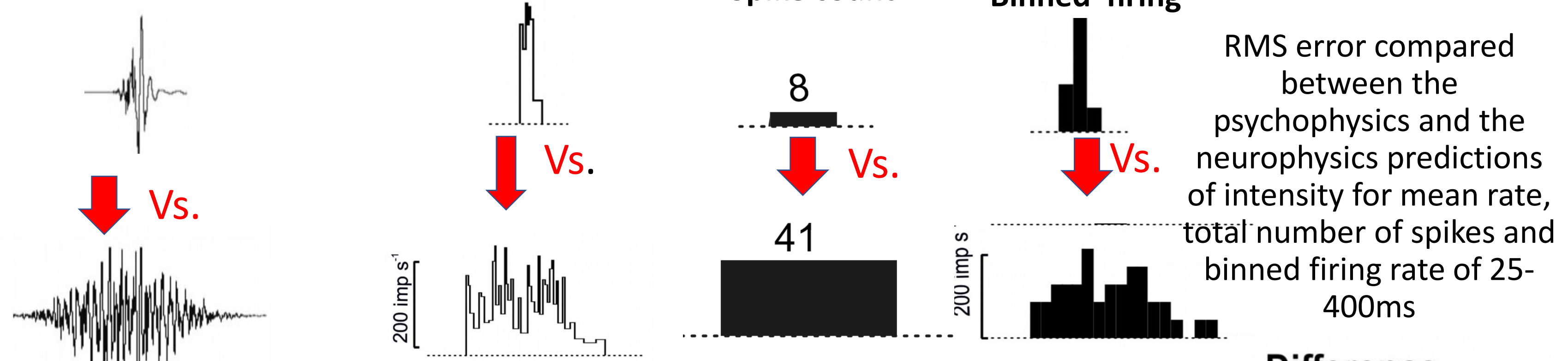
Psychophysics

Paired vibrations delivered for perceptual intensity

'Neurophysics'

Paired trains of neural activity compared using various parameters for decision parameters to replicate the psychophysics

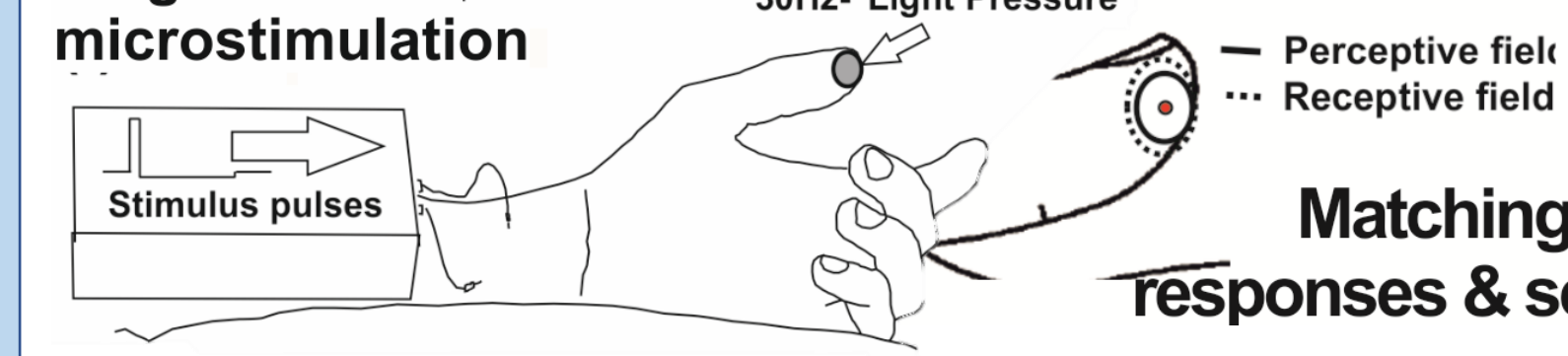
Firing rate Spike count Binned firing



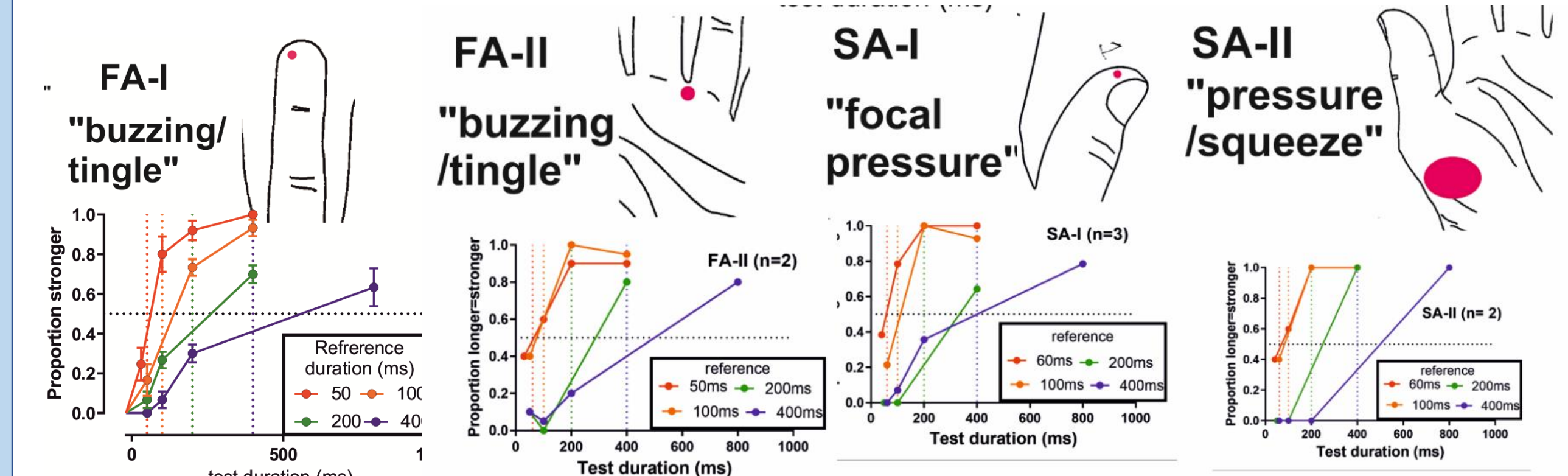
Intensity predictions based on afferent firing integrated over 100ms windows gave the best match to the perceived vibration intensity

Study 3- Single afferent intraneural microstimulation

Single afferent microstimulation



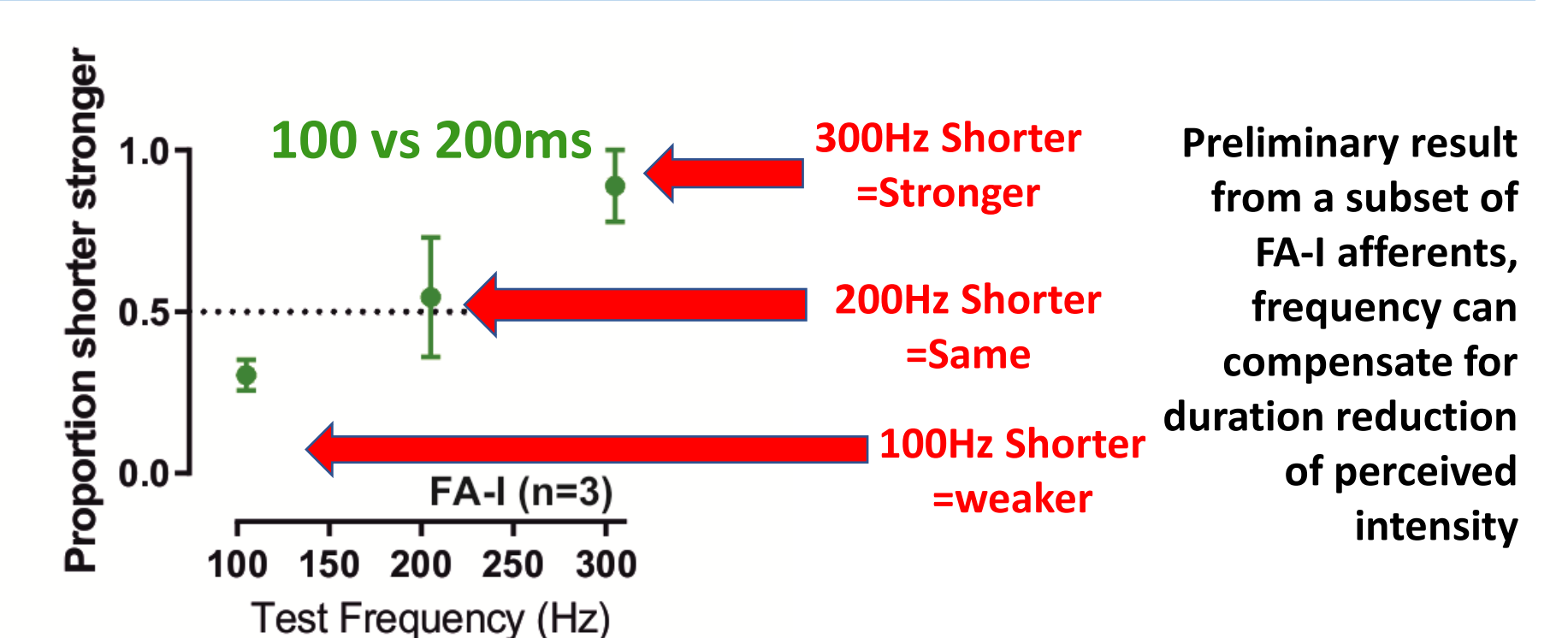
Protocol 1: Variable Durations, fixed frequency
2AFC Variable duration paired stimulation (100Hz)



Subjects report clear effect of duration on perceived sensation intensity in all classes of afferent (shallower indentation perceived for SA units)

Protocol 2: Fixed durations, variable frequency

200ms vs 100ms
100Hz vs 100/200/300Hz
"Which felt stronger?"



Adjustment of frequency at short durations created perceptual equivalence

Conclusions and future perspectives

- Tactile intensity perception is integrated over short time windows
- Afferent firing/stimulation over 100-200ms best predicts perception
- Intraneural stimulation duration can reliably manipulate intensity
- Novel method of duration manipulation for electrical sensory feedback

Funding/support

