

# Adapting Touch Screens to Human Touch

November 12, 2014



A New Dimension of Touch



# Tactus in Action (VIDEO)



<http://vimeo.com/56879525>



- Pioneering company making dynamic tactile user interfaces
- Strong patent portfolio: 75 granted patents and applications
- Seed funded in 2010, over \$25M raised to date
- Fabless business model: material sales and licensing
- First manufacturing partner is Wistron:
  - Building panel production line
- Customer traction in multiple markets:
  - Smartphones, Tablets, and Laptops

# Market: Mobile Device Challenges



What's ESSENTIAL?

Is it GOOD now?

#1: Battery life

65%

35%

#2: Screen size

54%

76%

#3: Ability to  
type easily

48%

32%

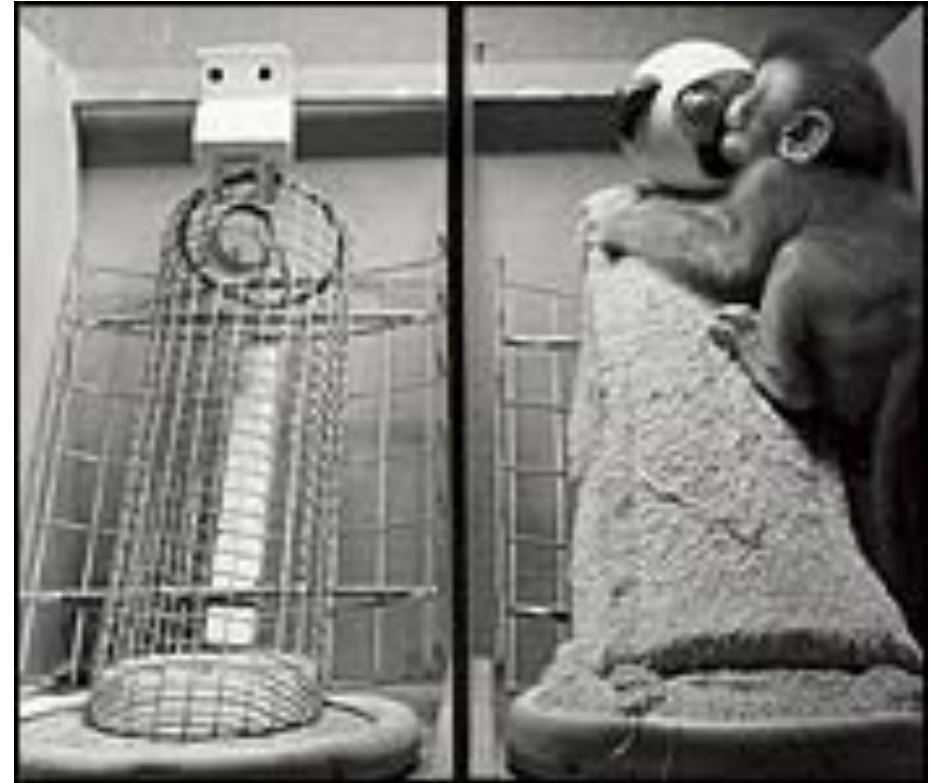
Ranked above: price, appearance, camera quality, phone quality, and more

SWIFTKEY SURVEY OF OVER 22,000 INDIVIDUALS; PUBLISHED MARCH 2014  
<http://www.swiftkey.net/en/blog/typing-experience-tops-price-and-call-quality-in-swiftkey-survey/>  
(used with permission)





# We *Need* Touch



Prof. Henry Harlow  
University of Wisconsin  
(1950's)

# Touch = Emotion and Connection



## Love & Affection



# Touch = Emotion and Connection



## Compassion



# Touch = Emotion and Connection



## Trust & Commitment





# Touch = Emotion and Connection



## Companionship



# Touch = Emotion and Connection



## Determination



# Touch = Emotion and Connection



## Friendship





# Touch = Emotion and Connection



## Celebration





# Touch = Emotion and Connection



Creativity



# What Feels (Good) ?



## Types of mechanoreceptors in your fingers

- *Meissner corpuscles (RA-1)*
  - Changes in texture, skin slip  
low freq. vibrations ~ 50 Hz
- *Pacinian corpuscles (RA-2)*
  - High freq. vibrations ~250 Hz  
across finger and hand
- *Ruffini corpuscles (SA-2)*
  - Tension deep in skin, skin stretch,  
sustained pressure, hand and finger position
- *Merkel discs (SA-1)*
  - High spatial resolution,  
curvature, edges and bars
- *Free nerve endings (Int. A)*
  - Pain, touch, pressure, and stretching

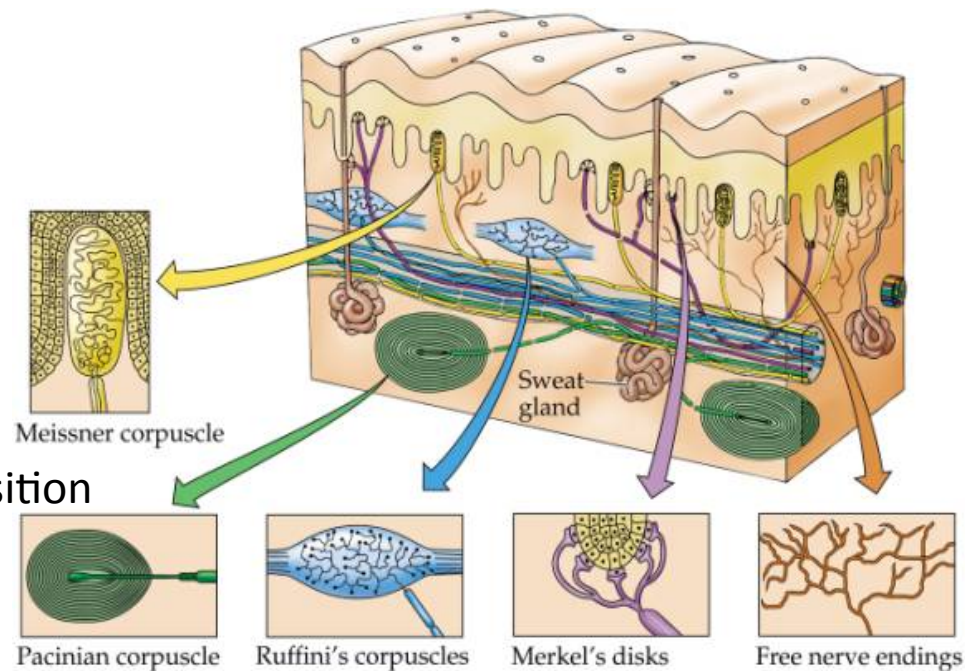


Image taken from <http://www.rci.rutgers.edu/~uzwiak/AnatPhys/ChemicalSomaticSenses.htm>

# What Feels (Good) ?



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Vibration

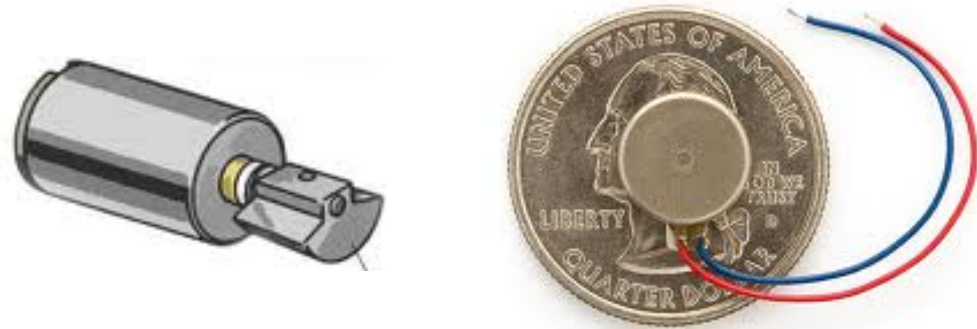
Electrostatic Attraction,  
Ultrasonic

Physical Structures:  
Mechanical Keyboards, Tactus



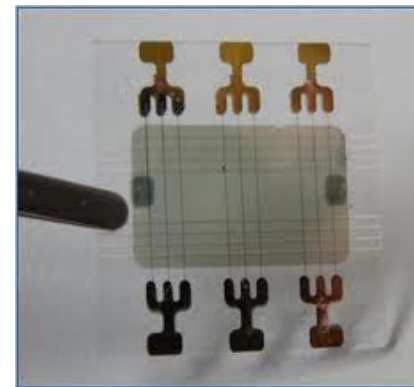
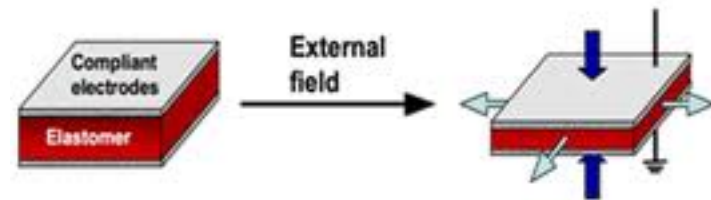
## ■ Sources

- Off-axis motors
- Piezo actuators
- Electroactive polymers



## ■ Location

- Single vs. Multi-source
- Edge vs. center



# Texture Simulation (Meissner + Pacinian)



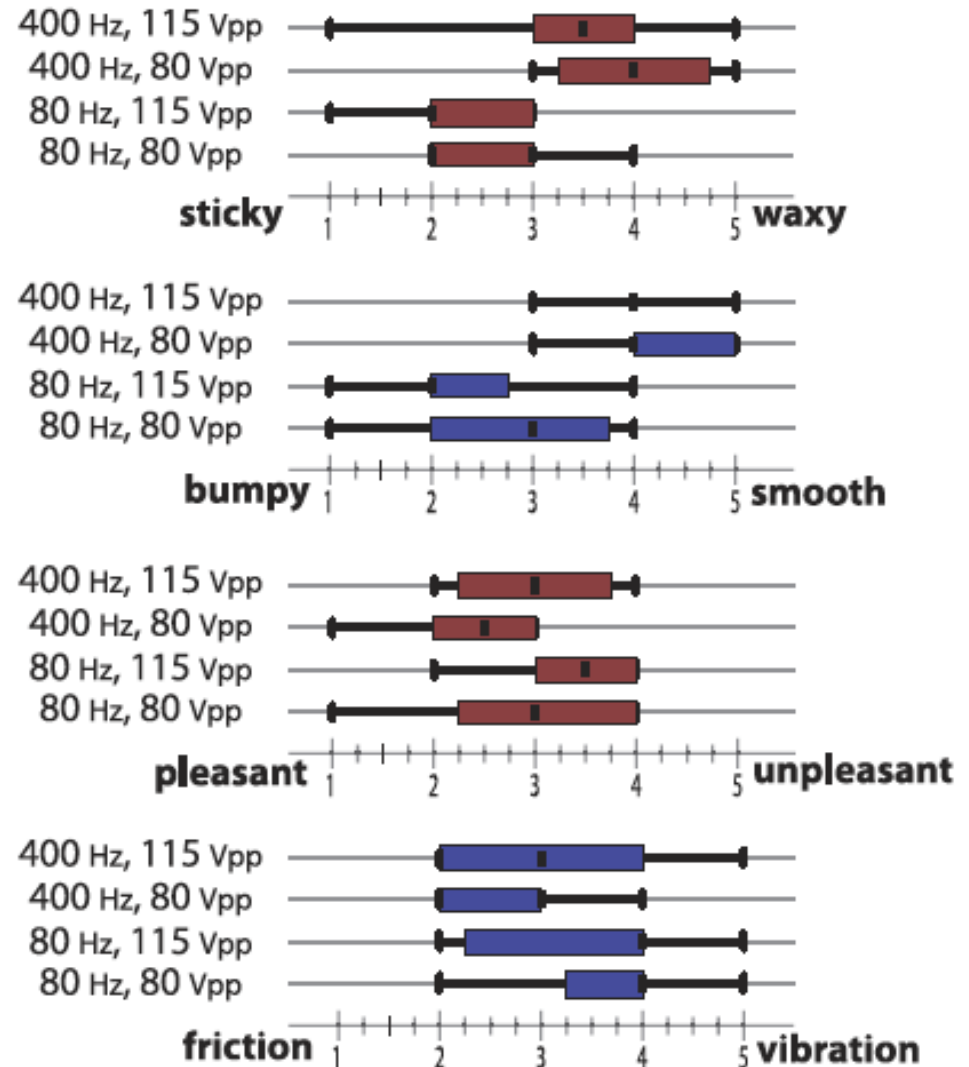
Ratings of stickiness, smoothness, pleasure, and friction as a function of vibration

Low  $\nu$   $\sim$  rough

Low  $\nu$ , High A  $\sim$  sticky

High  $\nu$ , High A  $\sim$  smooth

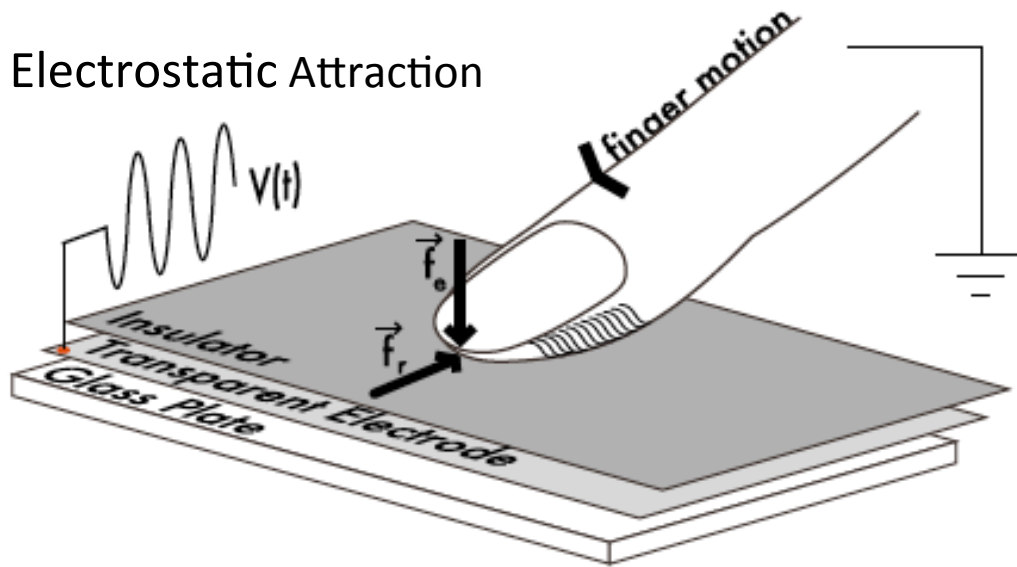
O. Bau, I. Poupyrev, et al., "TeslaTouch: electrovibration for touch surfaces," Proceedings of the 23rd annual ACM symposium on User interface software and technology (UIST '10), 2010, ACM, New York, NY, USA, pg. 283-292.



# Friction Control Systems (Meissner + Pacinian + Ruffini)



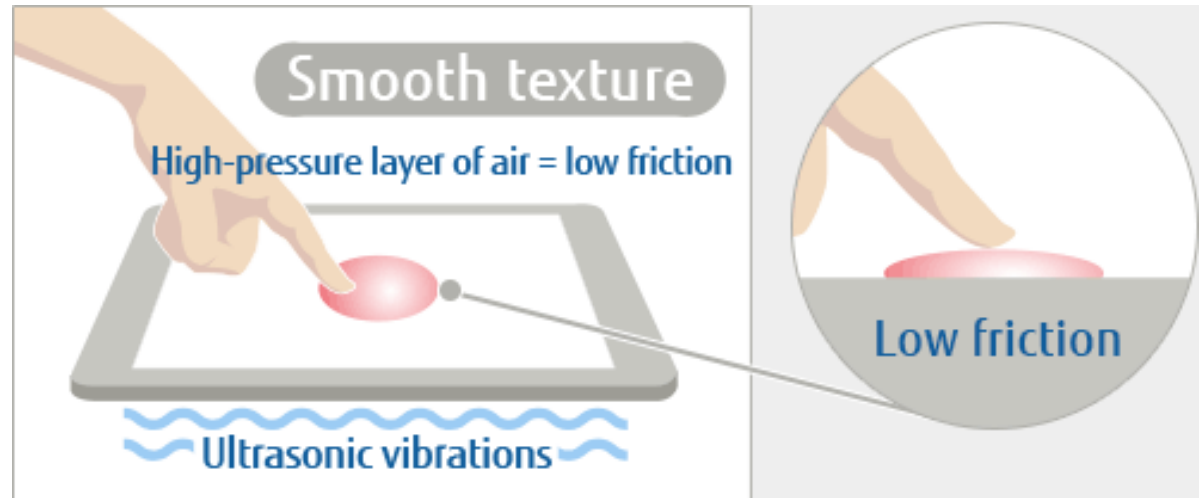
## Electrostatic Attraction



Images taken from:  
O. Bau, I. Poupyrev, et al., "TeslaTouch: Electro-vibration for Touch Surfaces," Proceedings of the 23rd annual ACM symposium on User Interface Software and Technology (UIST '10), 2010, ACM, New York, NY, USA, pg. 283-292.

and

"Haptic interface of the future," Fujitsu Journal, April 15, 2014.





# Texture Simulation (Meissner + Pacinian + Ruffini)

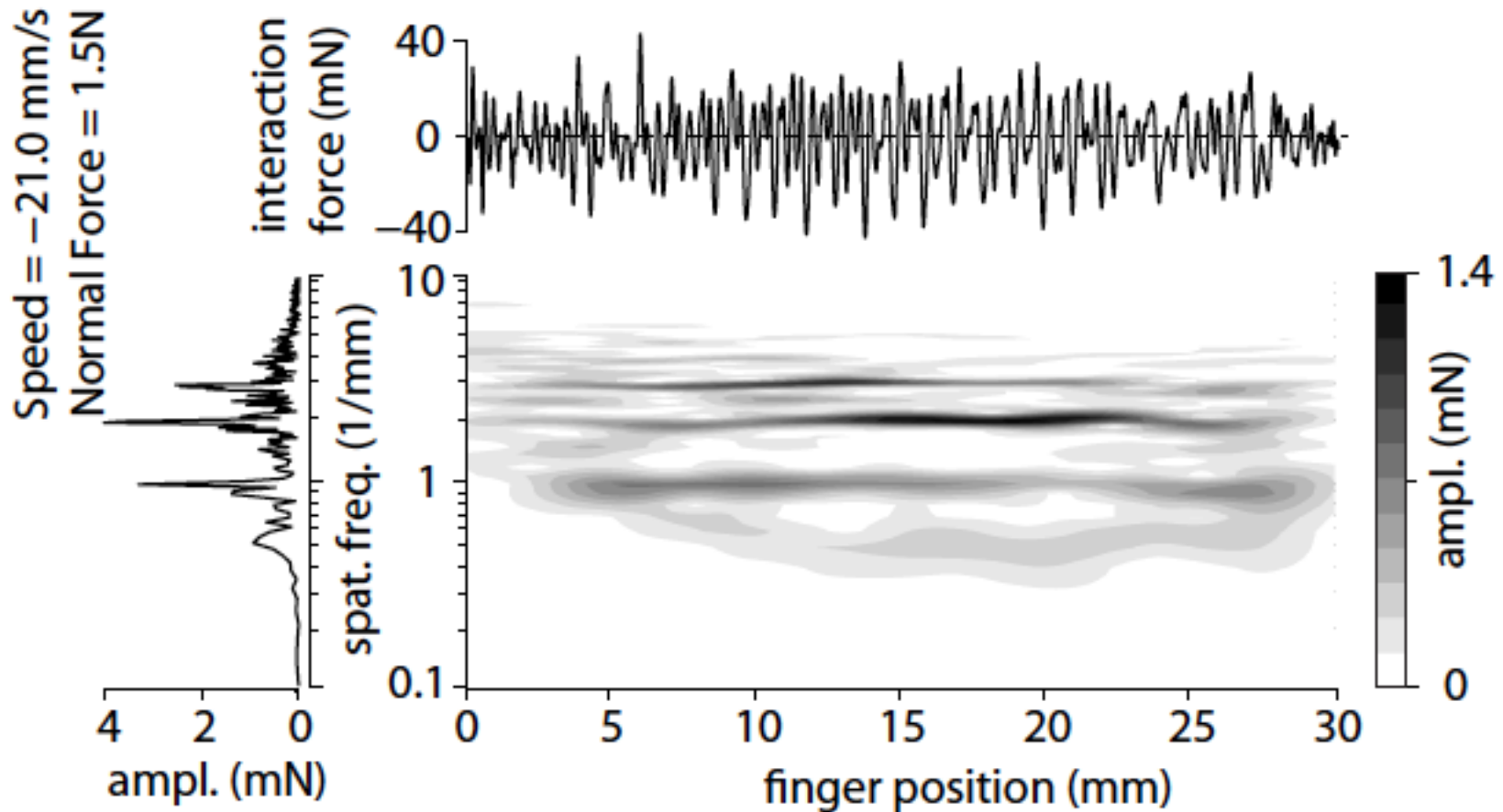
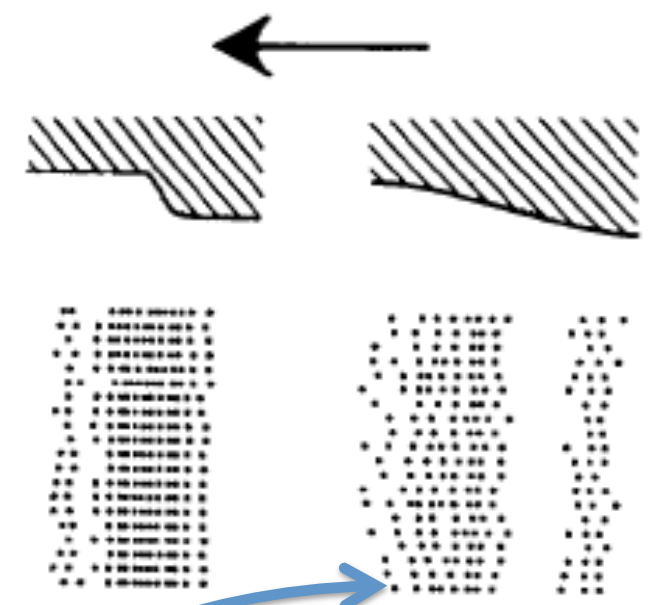
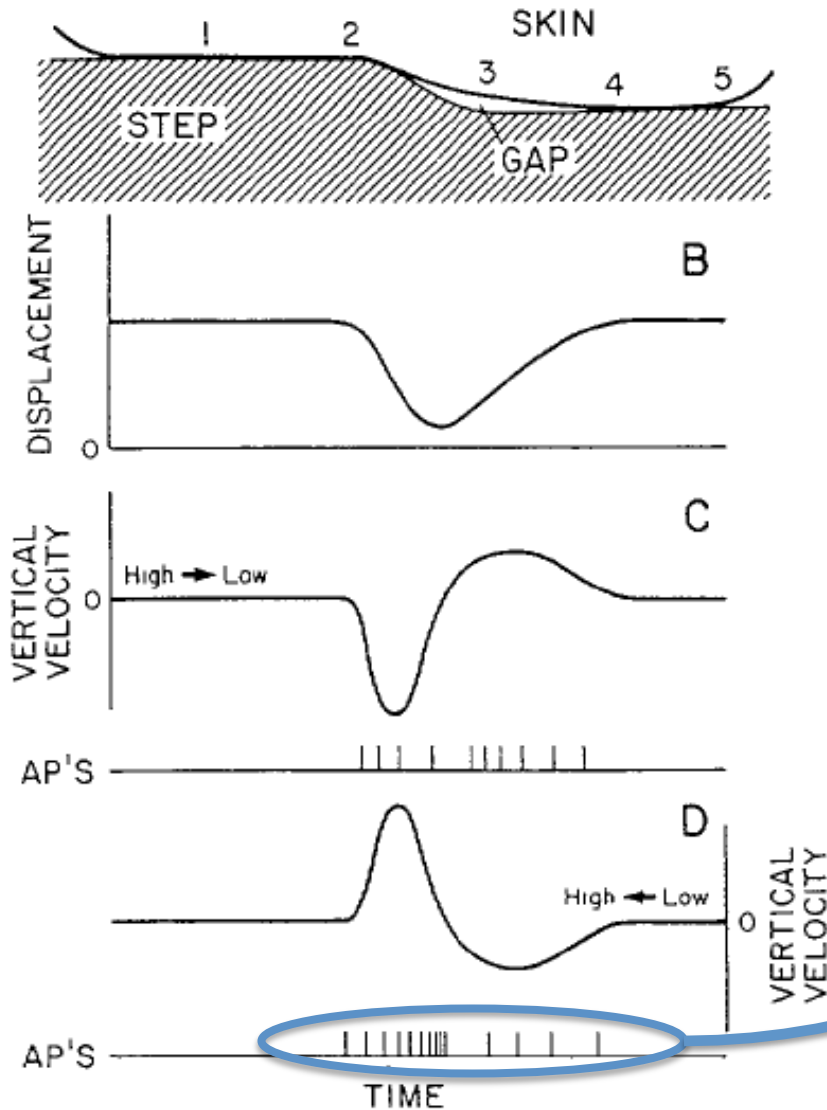


Figure taken from: M. Wiertelwski, "Reproduction of Tactual Textures: Transducers, Mechanics, and Signal Encoding," Biomechanics, Universite Pierre et Marie Curie, Paris VI, 2011.

# Example: Meissner Corpuscle Response



LaMotte and Srinivasan, "Tactile Discrimination of Shape: Responses of Rapidly Adapting Mechoreceptive Afferents to a Step Stroked Across the Monkey Fingerpad," J. of Neuroscience, June 1987, pg. 1672-1681.



**It's Complex:**  
neighboring nerves  
respond differently





- Proprioception involves proprioceptors
  - Ligamentous receptors
    - Type 1 (small) – low threshold, SA – static and dynamic
    - Type 2 (medium) – low threshold, RA – dynamic
    - Type 3 (large) – high threshold, SA – dynamic
    - Type 4 (very small) – high threshold /pain
  - Stretch receptors (muscles)
    - Golgi tendon organ – contraction
    - Muscle spindle – stretch
  - Cutaneous receptors
    - SA-2 (Rufinni)
- Conscious vs. subconscious
  - Uses different neural pathways in the spine

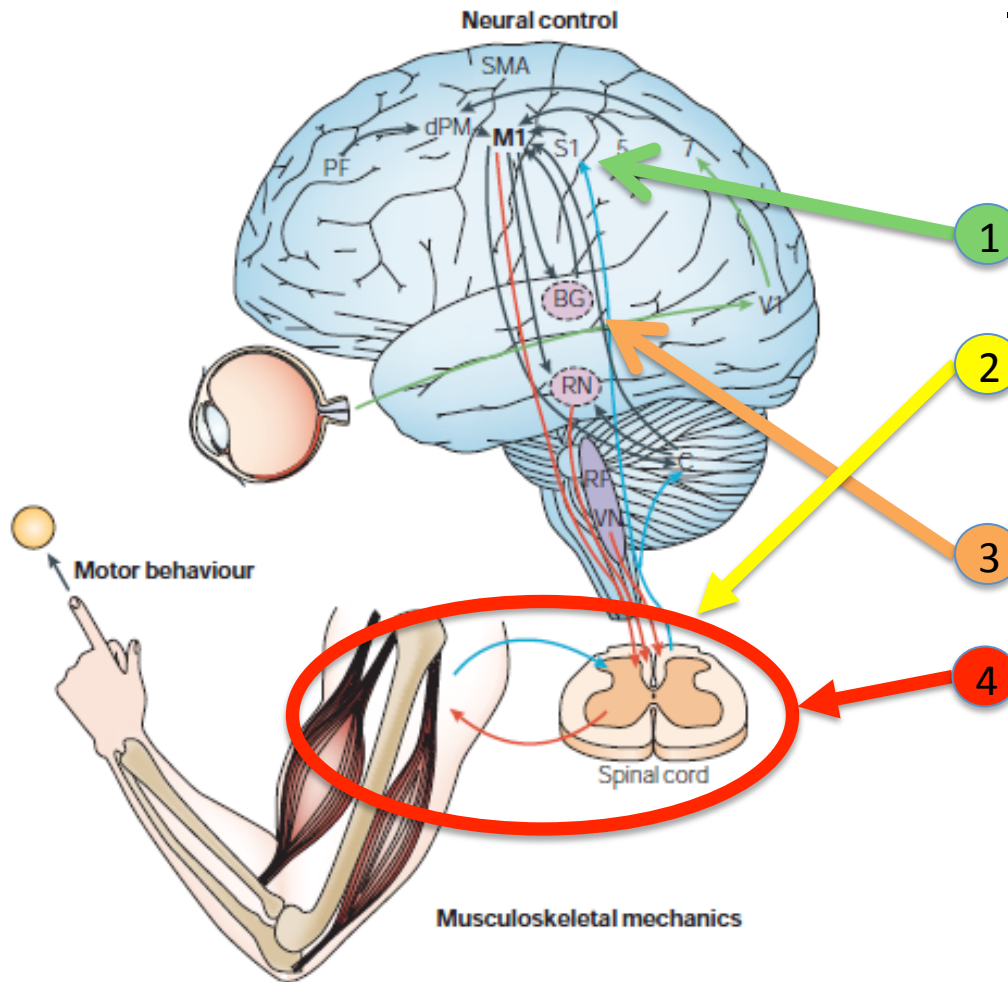
# Muscle Memory (Ruffini)



## Repeated Motion

Proprioception

Mechanoreceptors



1

At first, focused attention

Right vs. wrong motion

2

Strengthens neural pathways

Brain

Spinal cord

3

Becomes a “memory”

Trigger / Cue

4

Subconscious implementation

Image copied from: Scott SH, 2004, *Nature Reviews Neuroscience*  
V1 = visual cortex; S1 = somatosensory cortex for touch;  
M1 = motor cortex; PF = prefrontal cortex for action goals and planning;  
BG = basal ganglia for automatic action;  
C = cerebellum for smooth coordination;  
VN = vestibular nuclei for balance.

# Muscle Memory (Ruffini)



Prerequisites	Flat Screen	Mechanical Keyboard
Is there a repeated motion?	No	Yes
Is there a reference point?	No	Yes
Can one distinguish between good and bad technique?	No	Yes

# Muscle Memory (Ruffini)



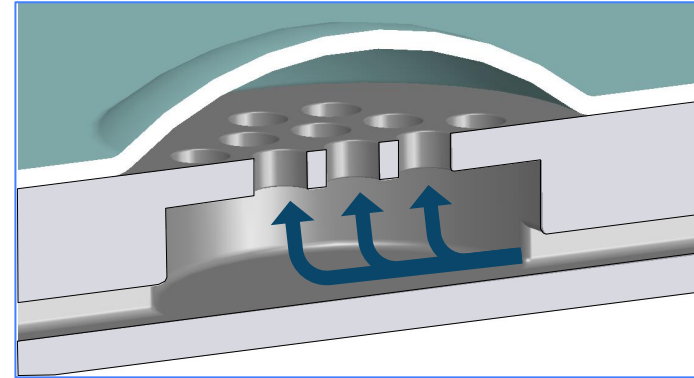
Prerequisites	Flat Screen	Mechanical Keyboard	Tactus Keyboard
Is there a repeated motion?	No	Yes	Yes
Is there a reference point?	No	Yes	Yes
Can one distinguish between good and bad technique?	No	Yes	Yes

# Technology: Dynamic, Tactile Touchscreens



**OPTICAL PERFORMANCE**  
TRANSMISSION = 92%  
HAZE = 1%

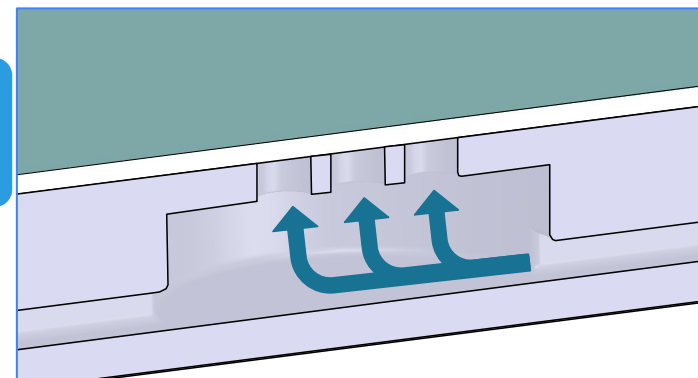
## BUTTONS ON



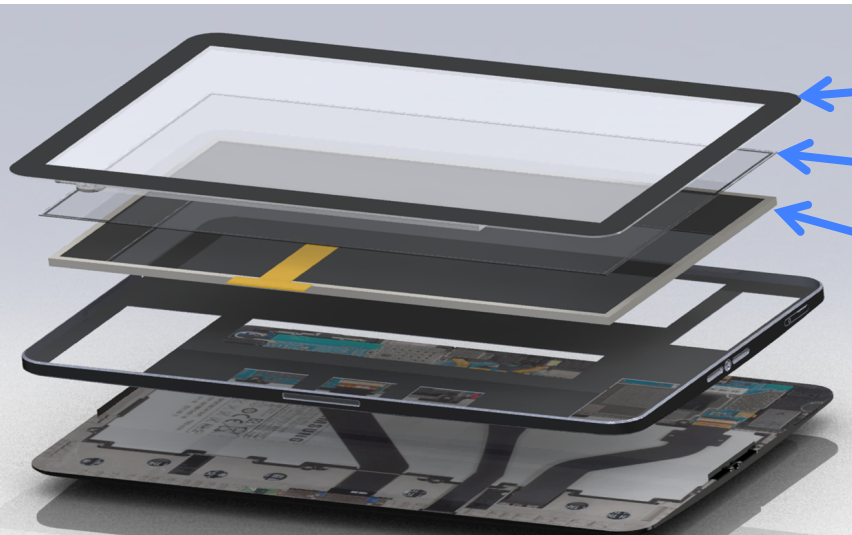
## ON-OFF CYCLE



- ONLY TIME POWER IS USED
- < 0.03mAh PER CYCLE
- < 1s TO CHANGE



## BUTTONS OFF



**TACTUS**  
**TOUCH SENSOR**  
**DISPLAY**

TACTUS ONLY REPLACES  
THE COVER LENS IN THE  
DISPLAY STACK

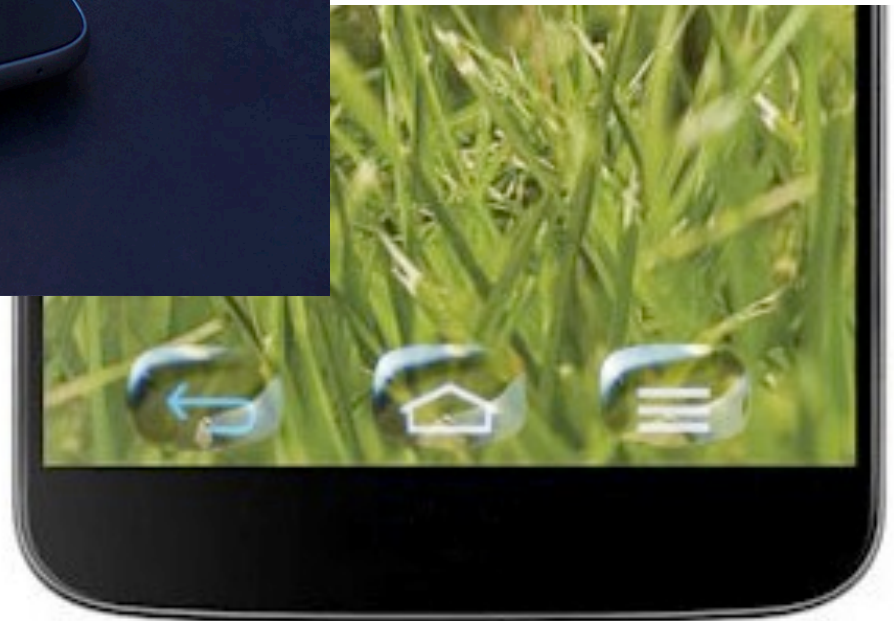
### TACTUS COMPONENTS:

PANEL: MULTI-LAYER PANEL + INDEX MATCHING FLUID

CONTROLLER: PUMP + DRIVE CIRCUIT + SOFTWARE

USER INTERFACE: FINGER-RESTING/INTERACTION SOFTWARE

# Tactus - Buttons

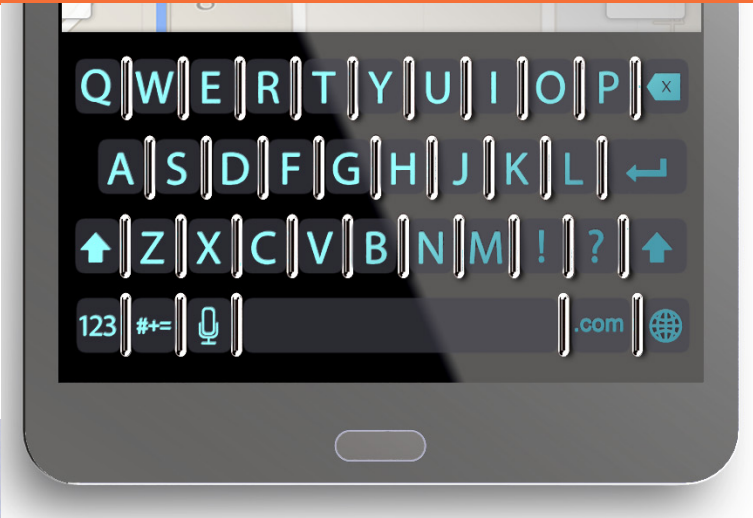


# Tactus - Buttons





# Tactus - Guides

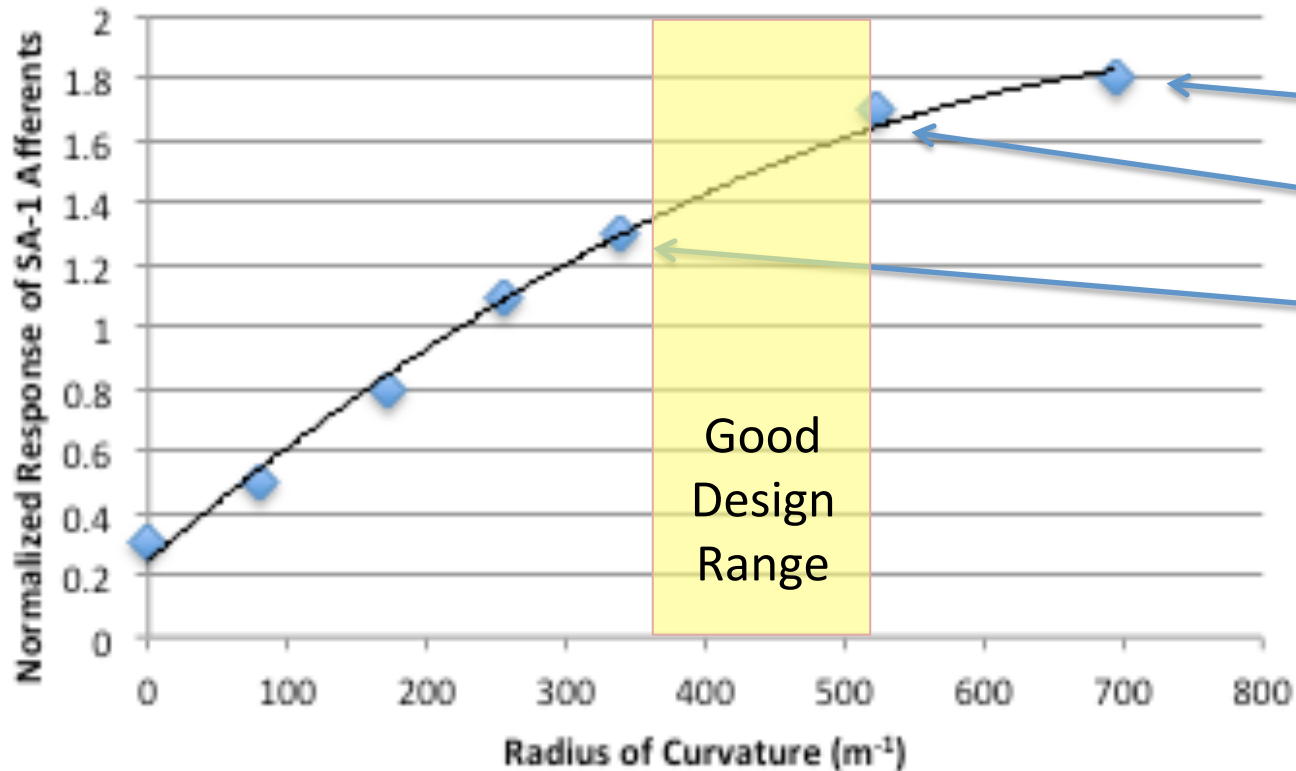






## Merkel Disk (SA-1) Radius of Curvature

## Tactile Guide Shape



1.5mm tall, 3mm wide

0.7mm tall, 3mm wide

0.4mm tall, 3mm wide

Good  
Design  
Range

# Comparative Usability Testing



- Independent, 3<sup>rd</sup> party usability study
- Tested Tablet *versus* Tablet + Tactus Keyboard Overlays

Factor	Criteria Applied	Participant Demographic Summary
Factors Applicable to iPad Mini Users		
Age (RV)	All iPad Mini users were screened for their age. Desired to include a mix of ages.	Ranged from: 19 to 57 years old Mean Age: 36 years old Median Age: 33 years old Standard Deviation: 11 years
Gender (RV)	All iPad Mini users were screened for their gender. Desired to include a mix of genders.	Female (47%) Male (53%)
Ethnicity (RV)	All iPad Mini users were screened for ethnicity. Desired to include a mix of ethnicities.	Asian (13%) Caucasian (27%) Hispanic (33%) Indian (7%) Mixed (7%) Pacific Islander (13%)
Occupation (RV)	All iPad Mini users were screened for their occupation. Desired to include a mix of occupations.	
Education (RV)	All iPad Mini users were screened for their highest level of education completed. Desired to include a mix of education levels.	High School Diploma (33%) Associates Degree (27%) Bachelor's Degree (33%) Master's Degree (7%)

Summary of Keyboard Tasks				
<b>Task</b>	Free Play	Typing Test	Email	Online Shopping
<b>Location</b>	Desk	Desk	Chair	Standing
<b>Posture</b>	Users's Choice	User's Choice	Reclining, 2 Hands	1 Hand
<b>Lighting</b>	Lights ON	Lights ON	Lights OFF	Lights ON
<b>Focus of Task</b>	Open-Ended Typing	Typing performance data	Using iPad While in Bed	Using iPad While Standing

**Result: Almost 70% preferred Tactus over regular iPad Mini**

# Coming Q1 2015



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