

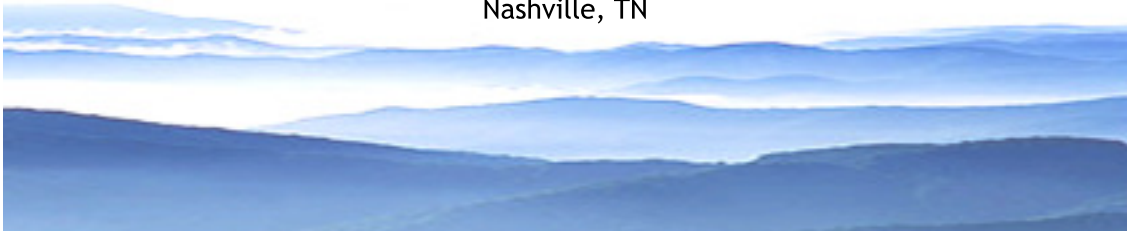
Tai Chi, somatic awareness and the “touch” cortex in the brain

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Somatic awareness in Tai Chi

- ▶ Today I'll describe two experiments that we have conducted that shed light on the effect of Tai Chi on the brain



Hand-brain connection in Tai Chi

- ▶ Both of the experiments focus on the connection between the cerebral cortex and the **hands and fingers...**
 - ▶ Experiment 1: Tai Chi and tactile acuity—looks at whether Tai Chi practitioners have enhanced touch sensitivity at the **fingertips**
 - ▶ Experiment 2: Mindfulness, somatic awareness and the brain—looks at the effect of mindfulness, which is a somatically focused form of meditation, on the brain

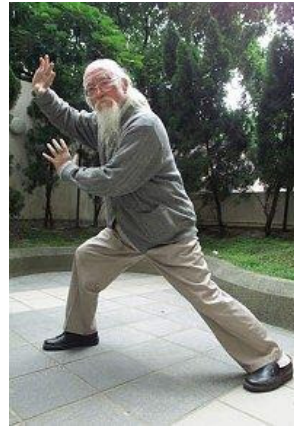


Pause to consider the Tai Chi ball

- Practitioners use the tai chi ball as a visualization that helps structure their practice
- They visualize feeling and moving a ball as they move through the form...
- If you are a practitioner, make a Tai Chi ball
- Is it easier to be aware of your hands and fingers than other body areas?



The science of Tai Chi



The science of Tai Chi: What we know from clinical trials in the elderly

Tai Chi

- ▶ Decreases fall risk
- ▶ Improves gait
- ▶ Improves proprioceptive awareness

What we don't know: is there something specific about Tai Chi that makes these outcomes possible?



Somatic awareness in Tai Chi: a potent hidden factor?



Tai Chi, somatosensory awareness and the brain: where do we begin?

- ▶ A practice manual gives us a clue



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- ▶ Tai Chi practitioners focus mental attention on the body's extremities including the finger and hands as they feel the Tai Chi ball while they perform static and moving postures



Tai Chi, somatosensory awareness and the brain: where do we begin?

The hand and fingers are special

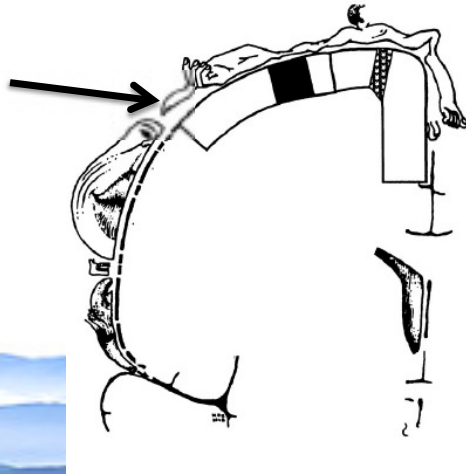
- ▶ A practice manual gives us a clue
- ▶ Tai Chi practitioners focus mental attention on the body's extremities including the finger and hands as they feel the Tai Chi ball while they perform static and moving postures



The hand and fingers are special....

What happens in the brain when you touch something with your hand or fingers?

Somatosensory cortex
encodes touch stimuli felt
with **the fingers** in a
somatotopic map
("homunculus")—the
brain's primary map of
the finger



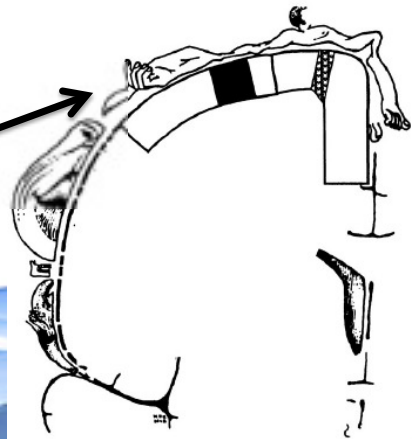
Two cool facts about somatosensory cortex
tell us why the hands and **fingers** are special



1. Somatosensory cortex (“homunculus”)— hands and fingers are massively over-represented



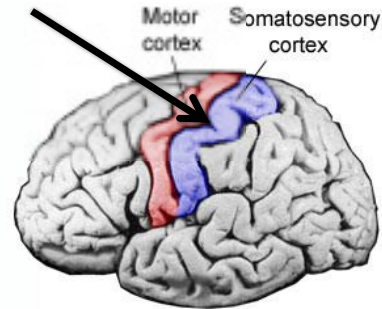
The Tai Chi ball takes advantage of this schema



2. Somatically focused attention changes the brains's map of the hand and **fingers**

- ▶ When you focus attention, over time, on your hands and fingers, you change the way your neurons fire...
- ▶ You may be able to change brain structure through practice (this has been shown in jugglers)

Figure F-3: Motor and Somatosensory Cortex



- ▶ **Enhanced tactile acuity** is directly related to brain changes (referred to as “cortical plasticity”) in the body map
 - ▶ Blind Braille readers
 - ▶ Professional piano players



EXPERIMENT 1: Determine whether tactile acuity is enhanced in Tai Chi players

- ▶ Unlike Braille or piano playing, the Tai Chi studied here involves very little direct touch-based practice with the fingertips (practice is described in depth by BK Frantzis)
- ▶ If touch practice is not driving the effect, what might be the cause?

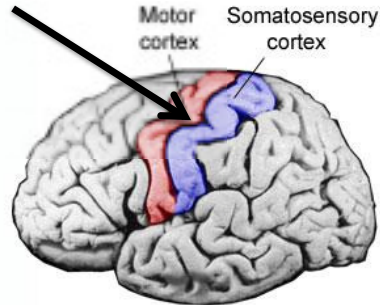


Somatically focused attention changes the brain **in the brain's primary finger map**

We already know that

- ▶ When you pay attention to your finger while it's being stimulated you cause short term changes in your finger map (Braun et al 2002)

Figure F-3: Motor and Somatosensory Cortex



Methods: Subjects

▶ *Subjects.*

- ▶ 14 TC subjects were recruited from a local Tai Chi studio (Brookline Tai Chi) where instruction is offered in a standardized TC curriculum.
- ▶ 14 control subjects were recruited from the community and matched for gender and age (+/- 2 years).



Exclusion criteria

- ▶ In both groups, exclusion criteria included:
 - ▶ Calluses at the test site (the right index finger),
 - ▶ History of rheumatologic disorder,
 - ▶ Neurological disorder,
 - ▶ Recent trauma to the right upper extremity.
 - ▶ History of hand drumming



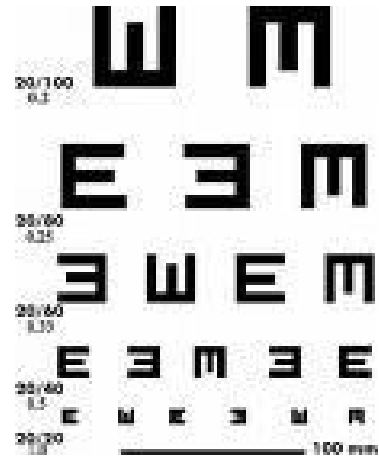
Tai Chi inclusion criteria

- ▶ Had to have practiced for over two years
 - ▶ Average of 3 sessions per week
 - ▶ Each session lasting 40 minutes or more.



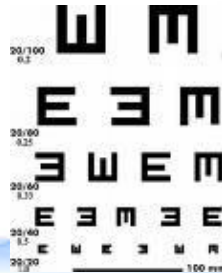
Testing tactile acuity at the fingertip

- ▶ Think of tactile acuity as the “vision” associated with the tips of your fingers
- ▶ Tactile acuity is tested using a kind of “vision test”



Tactile acuity

- ▶ Tactile spatial acuity at the fingertip - measured with tactile gratings
- ▶ Tactile spatial acuity at the fingertip is highly related to measures of sensory cortical function



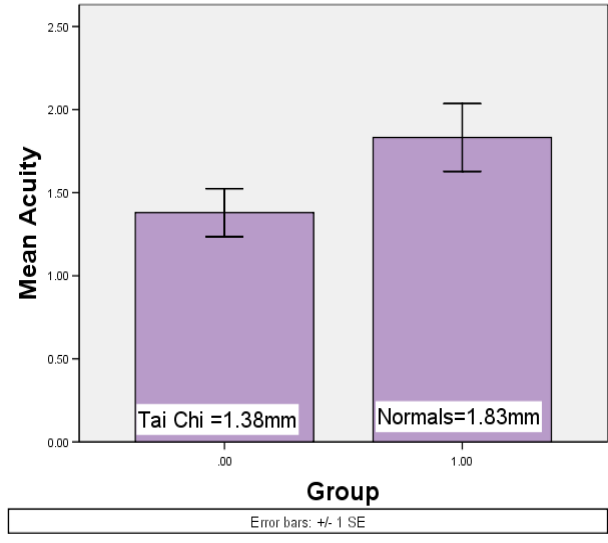
Study procedures

- ▶ The tactile spatial acuity threshold was determined for each subject
- ▶ Acuity = the ***smallest width*** at which a subject could distinguish between two different grating orientations
- ▶ Test conducted at the **right index finger**



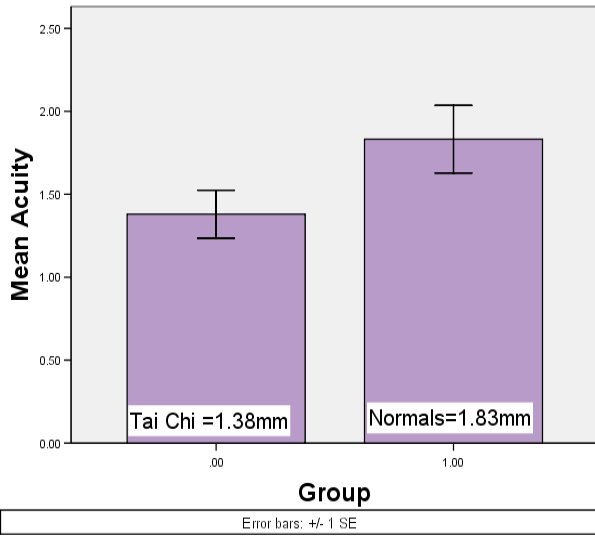
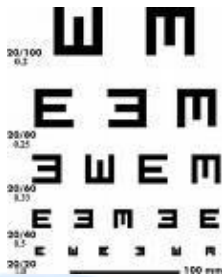
Results (lower is better)—index **finger** acuity

Figure 1: Tactile Acuity in Tai Chi vs Normals



Results (lower is better)—index **finger** acuity

Figure 1: Tactile Acuity in Tai Chi vs Normals



Younger vs older subjects (lower is better)—
older subjects got almost all of the benefit



Not a simple effect of exercise

Effect of exercise, TC practice on tactile acuity:
Regression analysis found no significant exercise effect on tactile acuity (hours/week $\beta = -.189$, $p < .411$) across the entire sample. The study also found no effect of *TC practice* (hours/week, $\beta = .391$, $p < .26$) on *tactile acuity* in TC practitioners



LIMITATIONS

- ▶ (1) This study is cross-sectional does not eliminate the possibility that persons with good tactile acuity are drawn, disproportionately, to practice Tai Chi
- ▶ (2) Because Tai Chi practitioners were only recruited from one school, we cannot say whether the effects observed here are due to the particular style being studied.



Our model

We hypothesize that it is the attentional focus of Tai Chi that, over long periods of time, elicits brain changes that enhance tactile acuity

This study is a first test of Tai Chi as a sensory attentional training program



Broadest implications of study

- ▶ *older subjects receive almost all of the benefit*
- ▶ Does learning how to focus somatosensory attention on the body during Tai Chi exercise spare the effects of aging on the sensorimotor system?



EXPERIMENT 2: Does mindfulness training enhance control over neurons in the **finger map** in the brain?



Mindfulness is based on Buddhist “Four Foundations of Mindfulness” Sutra

- ▶ Typical introductory practices focus on the body:
- ▶ Meditative body scan: Attending to a body part and then disattending and moving to the next body part
- ▶ Sitting meditation- focus on breath and breathing related sensation....



Our mindfulness study

- ▶ We looked at the effects of the 8-week Mindfulness Based Stress Reduction (MBSR) designed by Jon Kabat Zinn on the brain
 - ▶ 8 week training program components include:
 - ▶ **Body scan meditation**
 - ▶ **Mindful Yoga**
 - ▶ **Sitting meditation**



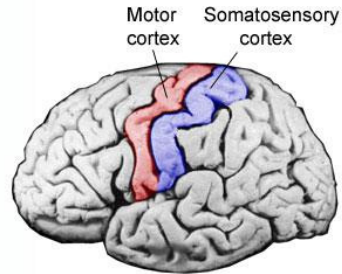
MBSR shown in clinical trials to relieve pain and distress in many conditions

- ▶ Long term question: Does changing the way a person attends to her body actually reduce her pain or distress?



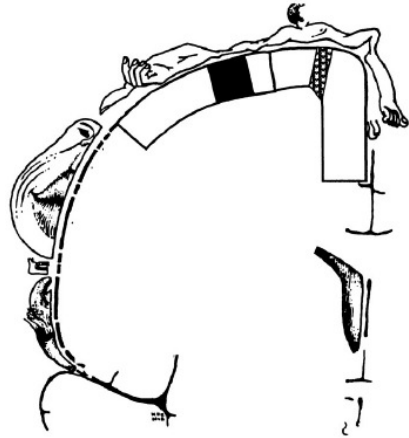
Somatosensory Cortex is active in mindfulness meditation

Figure F-3: Motor and Somatosensory Cortex



Primary somatosensory cortex

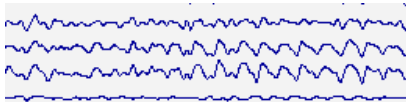
alpha rhythm (8-13 Hz) is
cardinal feature of the
primary somatosensory
cortex map



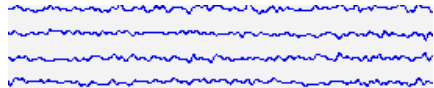
Alpha rhythm as volume control

Alpha rhythm and the brain

High amplitude=high
power=blocked
sensory transmission
to cortex =
disattention

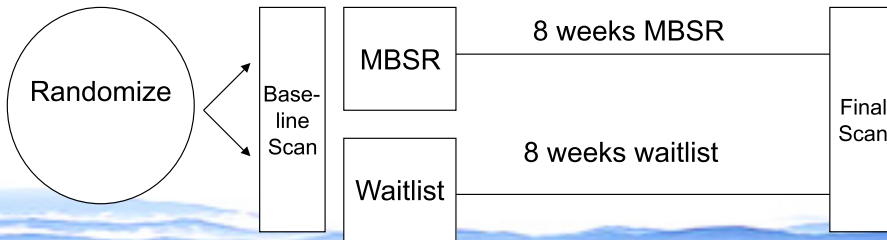


Low amplitude=low
power = sensory
transmission to
cortex = sensory
attention



Our study design

- ▶ RCT: Randomize 14 normal healthy people into 2 groups: MBSR vs controls
- ▶ After 8 weeks, compare **alpha rhythms in the fingemap** elicited by somatosensory attentional cueing task



- ▶ Do mindfulness meditators have better fine control of the alpha rhythm in the finger map?



- ▶ Magnetoencephalography (MEG)
 - ▶ High temporal and spatial resolution recordings of brain activity
 - ▶ Uses SQUID magnet to record the brain's faint magnetic fields
 - ▶ Copper lined chamber
 - ▶ Super conducting quantum interference devices

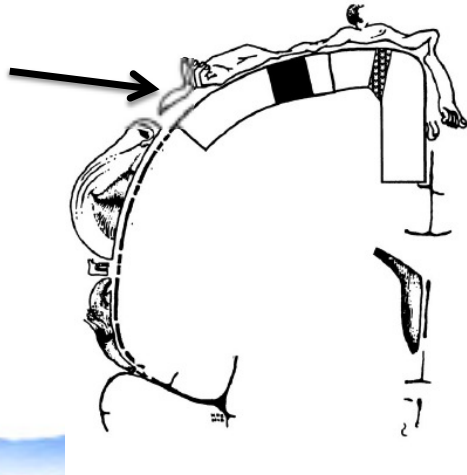


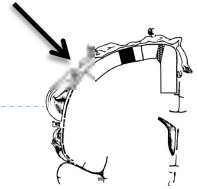
Our design

- ▶ Cue subject to focus on “hand”, “foot” or “either”
- ▶ Allow brief (1-2 second) period during which alpha rhythm is measured
- ▶ Stimulate finger or toe



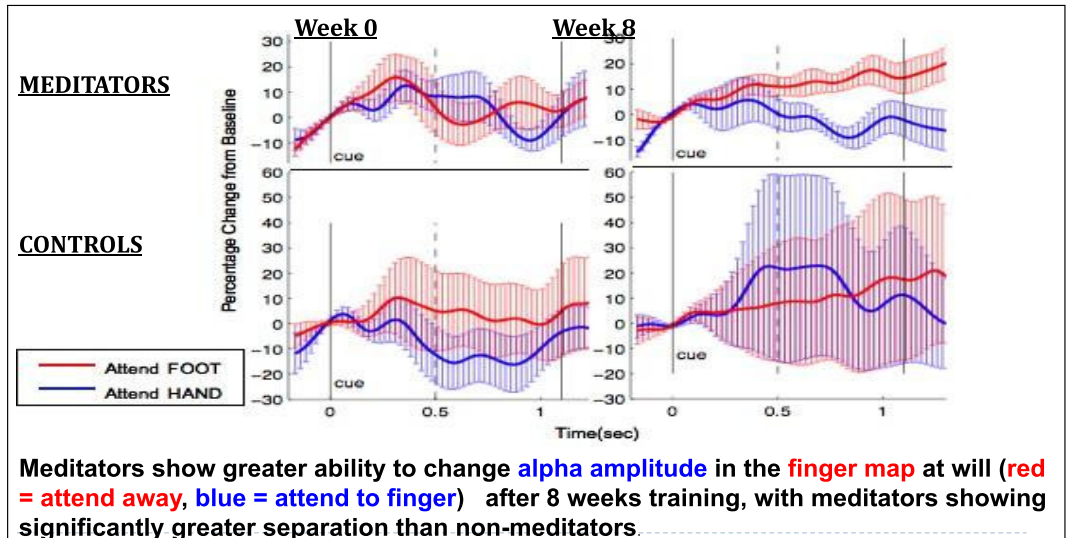
- ▶ Locate primary **finger map** in the brain
- ▶ Compare **alpha rhythms** in **finger map**





RCT results: MBSR vs Control group

ALPHA POWER in the **finger map**



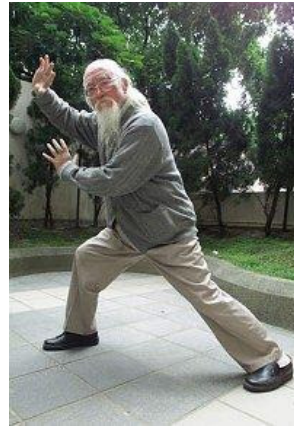
Mindfulness Meditation increases fine control over neurons in the finger map: clinical relevance

- ▶ May be important in
 - ▶ Chronic pain
 - ▶ Fatigue
 - ▶ Depression



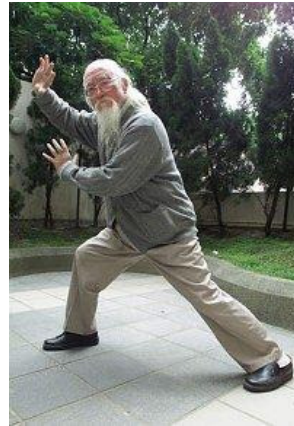
Alpha rhythm, Tai Chi and aging

- ▶ Do Tai Chi practitioners have better fine control over the alpha rhythm?
- ▶ Does this control extend beyond the hands and fingers to include the feet and other body areas?



Brain rhythms, Tai Chi and aging

- ▶ Does brain rhythm control explain
 - ▶ Decreased fall risk
 - ▶ Improved gait
 - ▶ Improved proprioceptive awareness
 - ▶ Enhanced sense of touch



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Stay tuned!



Tai Chi ball

When you visualize the
Tai Chi ball in your
practice, you can think
about the hand-brain
connection



Collaborators

Special thanks to Brookline Tai Chi studio (Dan Klieman and Marie-Helene Jouvin)

- ▶ **Neuroscience mentor**
 - ▶ Christopher Moore, MIT
- ▶ **CAM mentor**
 - ▶ Ted Kaptchuk
- ▶ **Brain rhythm collaborator**
 - ▶ Stephanie Jones, MGH
- ▶ **Other collaborators**
 - ▶ Ronnie Littenberg
 - ▶ Rachel Wasserman
 - ▶ James Carmody
 - ▶ Sara Lazar
- ▶ **Research Assistants/Grad Students**
 - ▶ Kate Wan
 - ▶ Anna Wexler
 - ▶ Jessica Shaw
 - ▶ Joel Villanueva
 - ▶ Dominique Pritchett
 - ▶ Vanessa Chen

