

## Dynamic Reorganization of Referred Sensations by Movements of Phantom Limbs

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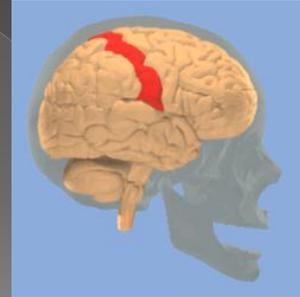
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Visiting Scholar  
 Studies: central post-stroke pain (CPSP), and how the brain generates one's body image

## Background to paper...

What is the function of the postcentral gyrus?

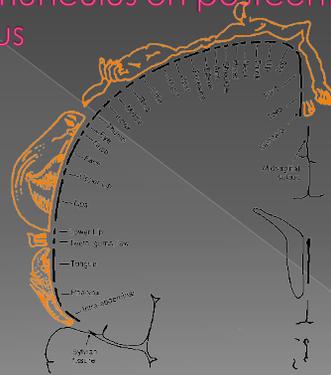
Postcentral gyrus



Primary somatosensory cortex

cortex that correlates to somatic (bodily) sensations ?

Homunculus on postcentral gyrus



How does this relate to phantom limbs?

What is a phantom limb?

- Continued experience of sensations and presence of a missing limb after amputation
- This experiment shows the overlapping of these areas when amputation occurs, and consequently the convergence of somatic sensations in two specific regions of the body

## Descriptions of phantom limbs

- **Painful** and difficult (sometimes impossible) to voluntarily move
- **Movable** and not painful
- **Paralyzed**

Ramachandran 1996

## What is 'Learned Paralysis'?

- Before amputation, the arm is paralyzed: every time that a sensory message was sent from the motor cortex to the arm, the brain continually received contradictory feedback that the arm was not moving.
- the brain 'learns' that the arm is fixed in that position. Therefore, **when the arm is amputated the brain still 'thinks' the arm is fixed in the previous position.**

(Ramachandran, 1996)

## Mirror Box

Figure 1. The mirror-box. A mirror is placed vertically in the centre of a wooden or cardboard box whose top and front surfaces have been removed. The patient places his normal hand on one side and looks into the mirror. This creates the illusion that the phantom hand has been resurrected.

(Ramachandran, 1996)



What 'kind' of phantom did D.S. have?

Reference fields?

## Reference Fields (RF)

- “sensory stimuli applied to the ipsilateral face are felt as referred sensations to the missing (phantom) arm, often producing a topographically organized map of the hand on the face with **clearly delineated digits described as ‘reference fields’ (RFs)**” (Ramachandran et al. 2010)

How are these ‘Reference Fields’ formed?

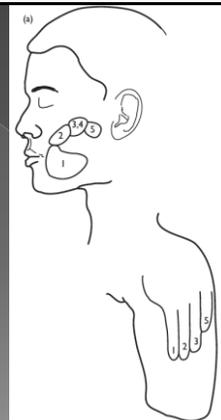
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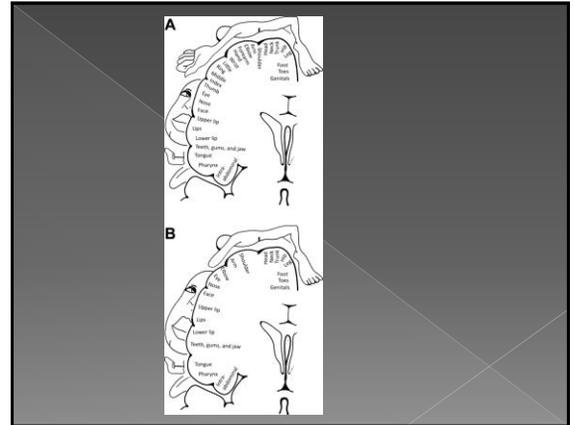
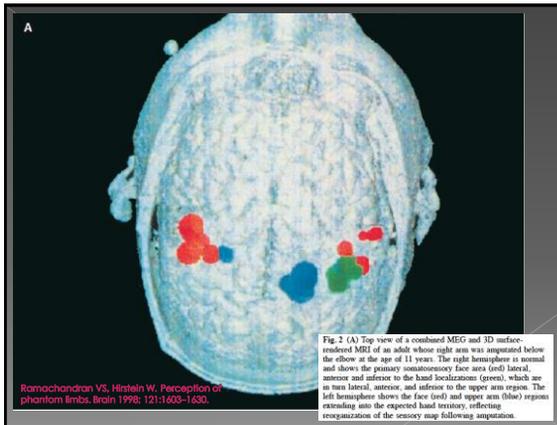
- “After arm amputation, the sensory input from the face [and shoulder region in the cortex] which normally projects only to the [corresponding] area, **‘invades’ the vacated territory corresponding to the denervated hand**”

How were they able to show this?

How were they able to show this?

- 8 sessions in one day
- light touch: tip of a blunt pencil
- cool stimulus: cotton bud simply dipped in ice water





What was the hypothesis of the study?

## Hypothesis

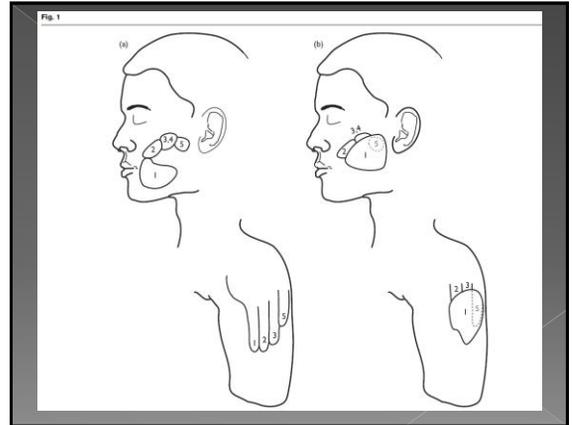
- They wondered whether changes in RF topography would occur if the patient were to move his phantom to alter its posture from this resting position

How did they test this?

## Methods

- For each of the 8 sessions that were performed on D.S. :
- First: mapped reference fields while in rest position (full pronation)
- Second: mapped reference fields while in the active position (thumb opposed against fifth finger – partially supinated)
- This was done on the face and shoulder the and identical results were found each time
- After 2 months D.S. returned to undergo 10 sessions in one day

# Results



What was the difference they found between the "at rest" reference field and the "active" reference field in regard to touch and cold stimulus?

- The difference:
- The change in topography was limited to touch stimulus.
  - A  $2 \times 2 \times 2$  analysis comparing RFs (thumb/pinky) to phantom position change (rest/movement) yields a significant difference of reported locations to light touch.

## Results

Table 1 Total number and type of stimuli applied across all sessions to each reference field (RF) located on the ipsilateral side of the face, as indicated in Fig. 1, the position of the phantom hand during each, and the phantom digit to which the stimulus was referred

Stimulus (position of phantom)	Reference fields (see Fig. 1)	Number of trials	Phantom digit to which stimuli referred (%)
Light touch (rest - Fig. 1a)	1	18	Thumb (100%)
	2	18	Index (100%)
	3,4	18	Middleling (100%)
	5	18	Little (100%)
Light touch (movement - Fig. 1b)	1	18	Thumb (100%)
	2	18	Index (100%)
	3,4	18	Middleling (100%)
	5	18	Thumb (100%) and little (isolated - 100%)
Cool (both rest and movement - Fig. 1a)	1	36	Thumb (100%)
	2	36	Index (100%)
	3,4	36	Middleling (100%)
	5	36	Little (100%)

## Conclusion

- RFs are dynamic – not static
- First demonstration of both rapid and large-scale alterations of plasticity of cortical topography
- Cool stimulus referrals dissociate from light touch and reference fields remain unchanged after movement of the phantom.

## Bibliography

- ◉ <http://cbc.ucsd.edu/lab.html>
- ◉ <http://cbc.ucsd.edu/research.html>
- ◉ Ramachandran VS, Hirstein W. Perception of phantom limbs. Brain 1998; 121:1603–1630.
- ◉ Ramachandran V, Rogers-Ramachandran, D (1996) Synaesthesia in phantom limbs induced with mirrors. Proc R Soc Lond B Biol Sci; 263:377-86.

## Videos on mental trickery regarding senses:

- ◉ <http://www.youtube.com/watch?v=sxwn1w7MJvk>
- ◉ <http://www.ebaumsworld.com/video/watch/81807750/>