What do NDEs tell us about consciousness?

Robert Mays and Suzanne Mays
April 7, 2009, revised April 18, 2009

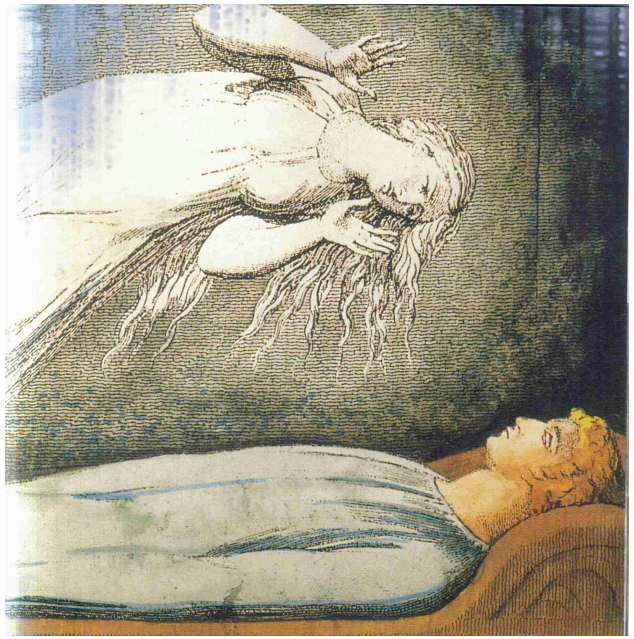
Copyright © 2009 Robert G. Mays and Suzanne B. Mays

What is a near-death experience (NDE)?

These are the typical elements of a near-death experience

- Coming close to death
- Feelings of peace
- Feeling separated from the body
- Hovering nearby and seeing your body

William Blake, *The soul hovering over the body.*



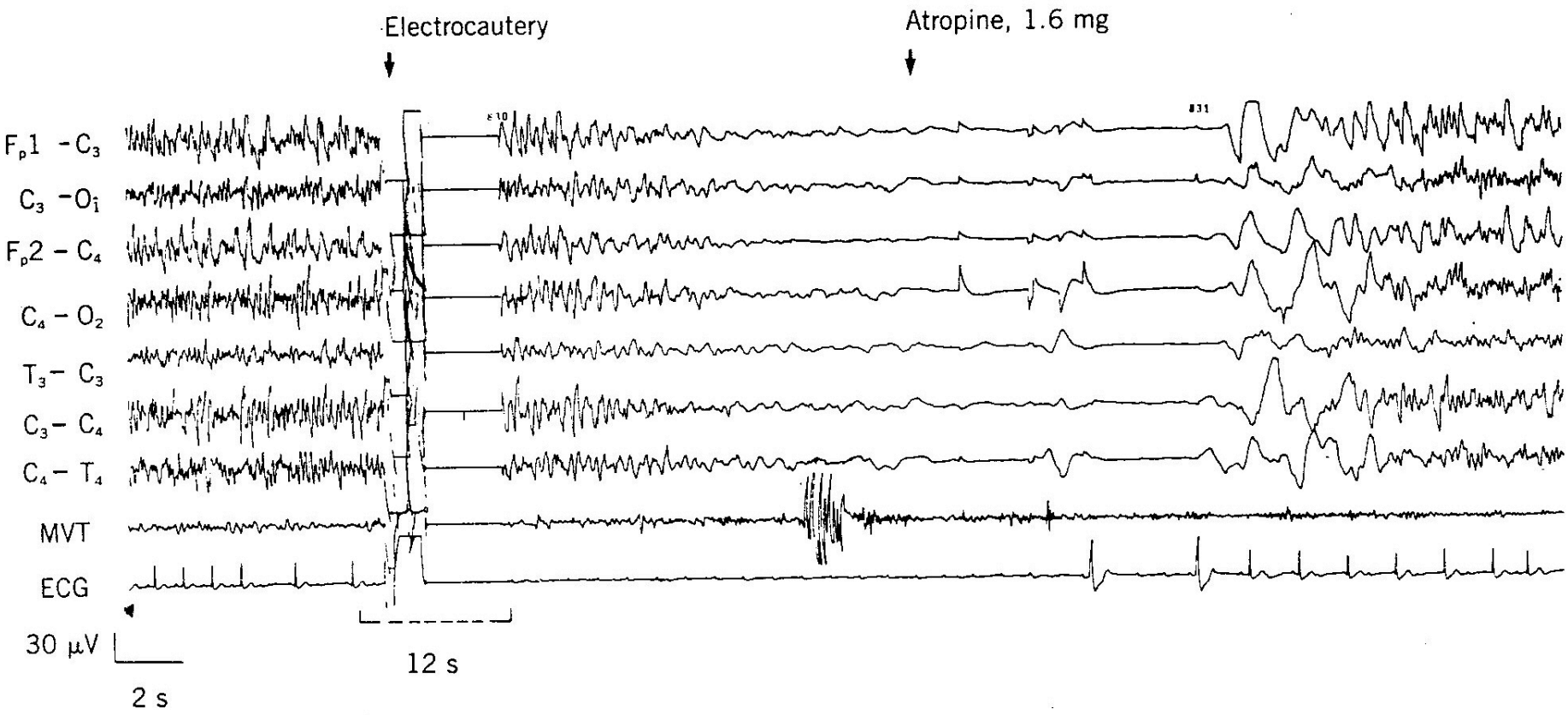
Hieronymus Bosch, *Ascent of the blessed (detail).*

- Traveling through a tunnel toward a light
- Meeting deceased relatives or friends
- Encountering a Being of Light or religious figure
- Having a “life review”
- Being told or choosing to return

Continuity of consciousness
during cardiac arrest

- EEG activity of a patient's brain was monitored during electrocautery procedure in one of the carotid arteries (62 year-old woman)
  - Next slide shows 7 EEG traces and the primary ECG trace
  - Prior to electrocautery being turned on, the EEG and ECG traces were normal
  - During electrocautery (12 sec), the traces were not recorded (electrical interference) but the patient's blood pressure dropped rapidly
  - Patient had gone into cardiac arrest: the EEG traces diminished to "flat line", probably 10 sec after the arrest
  - After atropine administered, heart beat resumed but electrical activity was very undefined, generally associated with unconsciousness or a confusional state
- In 10-20% of cardiac arrest cases, rather than becoming unconscious, patient has reported an NDE:
  - With heightened awareness, thought, memory formation and continuous conscious experience through what would be no brain electrical activity,
  - In some cases the patient reported perceiving -- accurately -- the *onset* of resuscitation
- How is it possible for consciousness to continue when there is no brain electrical activity??

Continuity of consciousness 2



Patient went into asystole during electrocautery procedure and was resuscitated after 27 sec

Moss, J., and Rockoff, M. (1980). EEG monitoring during cardiac arrest and resuscitation. *Journal of the American Medical Association, 244(24)*, 2750-2751.

Veridical perceptions in NDE-OBE

- During NDE, the NDEr may feel separated from the body in an "out-of-body experience" (OBE)
  - NDEr later reports perceptions of the physical environs
- During the OBE component of the NDE, the NDEr will:
  - Generally report observing objects, people and events in the world from a viewpoint outside the body (usually at the ceiling of the hospital room)
  - Sometimes report seeing things which they could not have seen from their body's position, even things occurring outside the room
- The NDE-OBE perceptions are generally "veridical" (that is, real and verified)

Veridical perceptions in NDE-OBE 2

- There are hundreds of accounts of *informally verified* veridical perceptions during an NDE-OBE
- Also, very few cases of *non-veridical* perceptions are reported (Holden, 2009)
- Still, there have been very few *formally verified* perceptions
  - Examples: surgeon “flapping his elbows”, therapist peeking around the curtain, nurse removed dentures during resuscitation
  - Less formally: nurse opening a vial unsafely in another room, penny seen on top of a cabinet
- AWARE study (AWAreness during REsuscitation, announced in 2008) will test this:
  - Cardiac arrest cases to be examined: 25 hospitals, 3 years, hidden images above patients' beds, perhaps 30 NDEs will include OBE component perceptions

Phenomenology of the NDE-OBE

- We studied reports of the OBE component of NDEs:
  - Identified 11 major phenomenal aspects of the NDE-OBE (next slide)
- Overall gestalt is that the NDEr retains all cognitive faculties:
  - Perception, thinking, emotions, volition, memory, self-awareness
  - Some faculties (e.g., vision, will) are enhanced: implies NDEr is freed from constraints of physical body
  - The NDEr is free of physical disabilities and pain
  - The NDE-OBE “body” appears to be non-material, but has subtle interactions with physical objects
  - There is a continuity of conscious experience and memory: implies it’s the same person before, during and after the experience

Phenomenology of the NDE-OBE 2

1. Whirring sound, tingling feeling when leaving body
2. Hovering over body, disinterested in body, continuity of consciousness
3. Freedom from pain, freedom from constraint of body
4. Sense of a non-material body with normal body shape or ovoid
5. Infant and very young NDErs report being “adult size” with fully developed perception and thought
6. Freedom from physical defects and disabilities
7. Heightened sense of reality with full cognitive abilities, volition without physical limitations
8. Acute vision, 360 degree vision, “mindsight” (Ring & Cooper)
9. Can “see” their own “bodies” and those of fellow NDErs
10. Can hear ordinary sounds, “hear” telepathically, slight sense of resistance in passing through objects, can be “seen” by animals
11. On returning: in-body perspective, physical sensations return, memory of experience vivid and long held

Physical interaction in NDE-OBE

- A major question: if the mind is a non-material entity, how does it interact with the physical processes of the brain and body?
  - In order for the “mind” to influence the brain, it must interact in some way with the brain
  - But the mind is of a completely different “substance” than the brain, so how could it possibly interact? Even the NDE “body” appears to be non-material, easily passing through walls, etc. with no apparent interaction
  - This is the major objection to Cartesian dualism
- But the NDE literature includes a number of reports of NDErs interacting with physical processes
  - The interactions are *subtle*
  - Nonetheless, they appear to be *significant*

Physical interaction in NDE-OBE 2

Evidence of interaction:

- NDEr “body” appears to be a thing (a field) with a shape and location, can be luminous, with a luminous structure, can be seen by animals and fellow NDErs
- There is interaction with physical processes: light and sound
- There is interaction with physical objects: bob on ceiling, feel slight resistance when passing through objects, walls
- In rare cases (Storm) the NDEr can also have acute sense of touch, taste, smell
- NDEr “body” can interact with another person's body: the arm felt “gelatinous”, could tickle nose of another patient until she sneezed (did it 3 times)
- NDEr can “merge” with another person and see and feel what they are seeing and feeling (3 cases – young boy with sister, suicide victim with wife, George Rodonaia with wife)

These cases imply:

- *Interaction with* and *influence over* neural activity in the brain is possible.
- In particular, “merging” implies the mind readily joins with and interacts with the brain, even someone else’s brain.

What is consciousness?

Consciousness is our subjective experience, awareness

- David Chalmers' “hard problem”: physical processes can't explain the “quality” of subjective conscious experience
  - “Zombie” argument: there *logically* can be people with all the physical processes of a human being but lacking consciousness (i.e., consciousness is not logically necessary)
  - “Qualia” argument: why are our experiences just this way, how do we know whether another person sees colors the way we do?
  - “Unity of consciousness” argument: functional processes can’t explain the phenomenal unity of our conscious experience
- We pose the additional question: what *initiates* volitional activity if neurons are passive receivers of electrical impulses?
  - Global workspace theories do not have a good explanation for how this works
  - Conscious initiation of *endogenous mental activity* implies some *agency* that initiates the activity
  - Mental effort or “mental force” (Jeffrey Schwartz): OCD therapies suggest that a patient’s mental effort is needed to *overcome* fixed brain processes

NDEs and consciousness

What do NDEs tell us about how consciousness works?

Evidence from NDE-OBEs

1. Consciousness appears not dependent on brain function
2. Consciousness appears in fact to separate and operate with full cognitive faculties completely independent of the body
3. The separated consciousness appears unencumbered by the physical body and free of physical disabilities
4. The separated consciousness appears able to interact subtly with physical processes including neural processes in other people
5. There is a continuity of conscious experience from before separation to returning to the body

Therefore the conscious mind is a separate “entity” from the physical body.

Therefore in ordinary consciousness, the mind “entity” must unite with and integrate fully with the physical body and brain.

Mind and body

Near-death experience

Self-conscious mind
Separated, heightened awareness

Physical body
Comatose or clinically dead

Ordinary consciousness
Mind and body united

The human being is the integration or union of a *self-conscious mind* with a physical body

Mind versus body

What does each do?

Self-conscious mind

- Perception
- Thinking
- Volition
- Memory
- Feelings
- Self-awareness

From NDEs: the independent mind possesses all of the person's cognitive faculties. It is the seat of subjective conscious experience.

Physical brain / body

- Sense organs and neural connections
- Neural support for thinking
- Neural support for attention, motor actions
- Neural support for memory formation/recall
- Neural support for feelings
- Neural support for awareness in general and self-awareness

The brain provides the interface to the senses and the body, and through them to the world. It provides neural support for all cognitive faculties.

Union of mind and body

How does it work?

- The mind and brain are completely united -- there is no separation or “homunculus”
- The mind works *throughout* the body through the nerves
- The mind interacts *only* through the neurons: when there is no neural electrical activity we become unconscious
- Conscious experience occurs only when there is sufficient neural electrical activity for us to “come to awareness”
- The mind is the agent initiating thought activity and volition but we need the brain’s electrical activity to become aware of our thoughts and decisions
- There is an unusual relationship of the blood in neural electrical activity: there appears to be more blood flow to active brain sites than is warranted just for the neural electrical activity. This may be related to the operation of the mind.
- Memory “storage” is only in the mind not the brain, but memory formation and recall require neural activity in the hippocampus

Principles of mind-brain operation

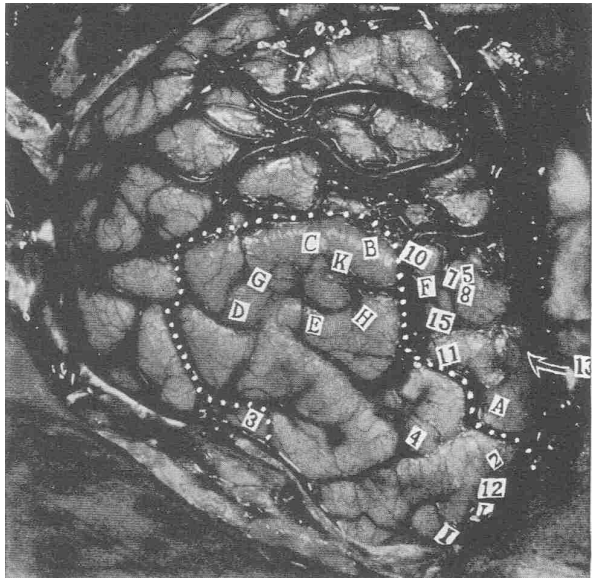
We have established several principles…

1. Brain electrical activity gives rise to consciousness
2. There is a process of “coming to awareness”
3. The mind follows the neural structures of the body
4. The “mind structure” maps to brain structures and functions
5. Cognitive function depends on brain structure
6. The mind plays an active role in brain development
7. Memory resides in the mind, not the brain

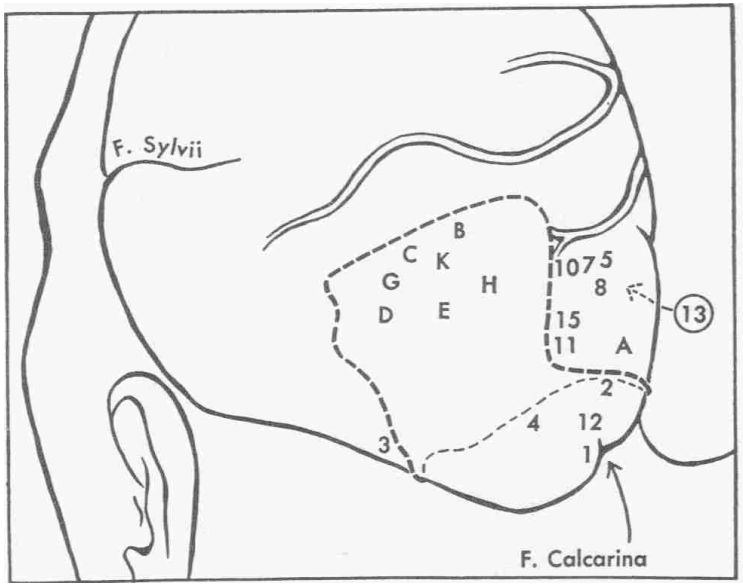
1. Electrical activity gives rise to consciousness

- Electrical brain stimulation (Penfield, others)
  - Stimulating different areas of the cortex: 1) produces various sensations, movements, feelings, 2) inhibits movement or speech, or 3) has no apparent effect
  - Sensations: tactile, visual, auditory; usually fragmentary
  - Movements: simple twitching/jerking, uncoordinated; or the “urge to move”
  - Memories: fragmentary, “out of the blue”
  - Appear to be imposed or added to patient’s experience by the surgeon
- Displaced or excessive brain electrical activity = pain
  - Phantom limb pain or other unusual forms of pain
  - Seizures: uncontrolled electrical discharges
- Implies: when there is brain electrical activity, there is consciousness

Electrical brain stimulation



Left posterior hemisphere with points stimulated



Context of photo

Note calcarine fissure

Numbered points produced a positive response, letters are areas of abnormal electrical discharges. Dotted region was excised to control patient's epileptic seizures.

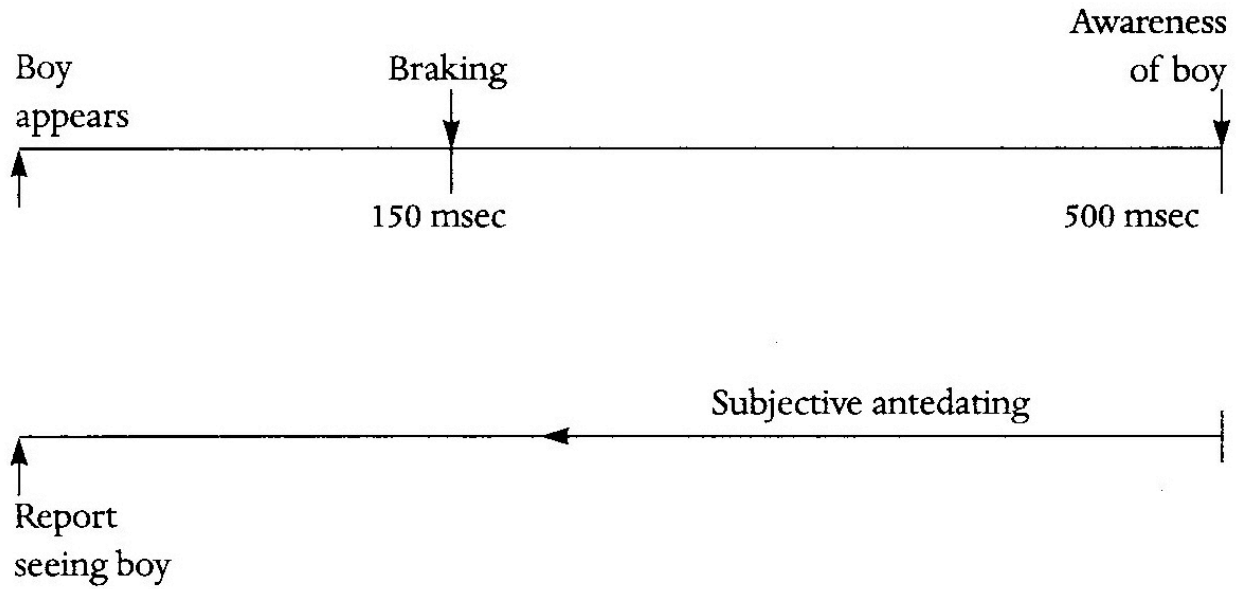
Wilder Penfield patient C.J. (18 year old male): left occipital lobe was stimulated with the patient conscious, to identify the brain area causing seizures. Stimulations here caused visual perceptions.

- Point 1: two wheels, mostly red and blue, more on the left side
- Point 2: ball of light, all colors, on the left side
- Point 5: thought he saw a long white mark, off to the right
- Point 7: large spots in the right eye, white

Penfield, W., and Rasmussen, T., *The Cerebral Cortex of Man: A clinical study of the localization of function.* New York: Hafner Publishing Co., 1950/1968.

2. There is a process of “coming to awareness”

- Libet’s “time-on” principle
  - About 1/2 sec (500 msec) of brain electrical activity is required before we can become aware of a sensation, regardless of content
  - We adjust for this delay by “antedating” our subjective sensations back to their actual time



Example: while driving a car, the driver sees a boy dart out into the road and reacts initially subliminally

Libet, B., *Mind Time: the temporal factor in consciousness.* Cambridge, MA: Harvard University Press, 2004.

2. Coming to awareness 2

- Sensations are first subliminal
  - Visual stimuli that are presented too quickly for conscious awareness are nevertheless “seen” and “interpreted” if the subject is forced to answer
  - Subjects show greater accuracy for longer presentation times
- Implications:
  - There is subliminal cognitive processing (detection, recognition) which occurs prior to awareness
  - We can process and react to emergencies before we become conscious of them
- We propose:
  - All conscious experience requires at least 500 msec of brain electrical activity
  - The mind processes the experience cognitively even prior to awareness
  - We can be (emotionally) affected even if the experience remains subliminal

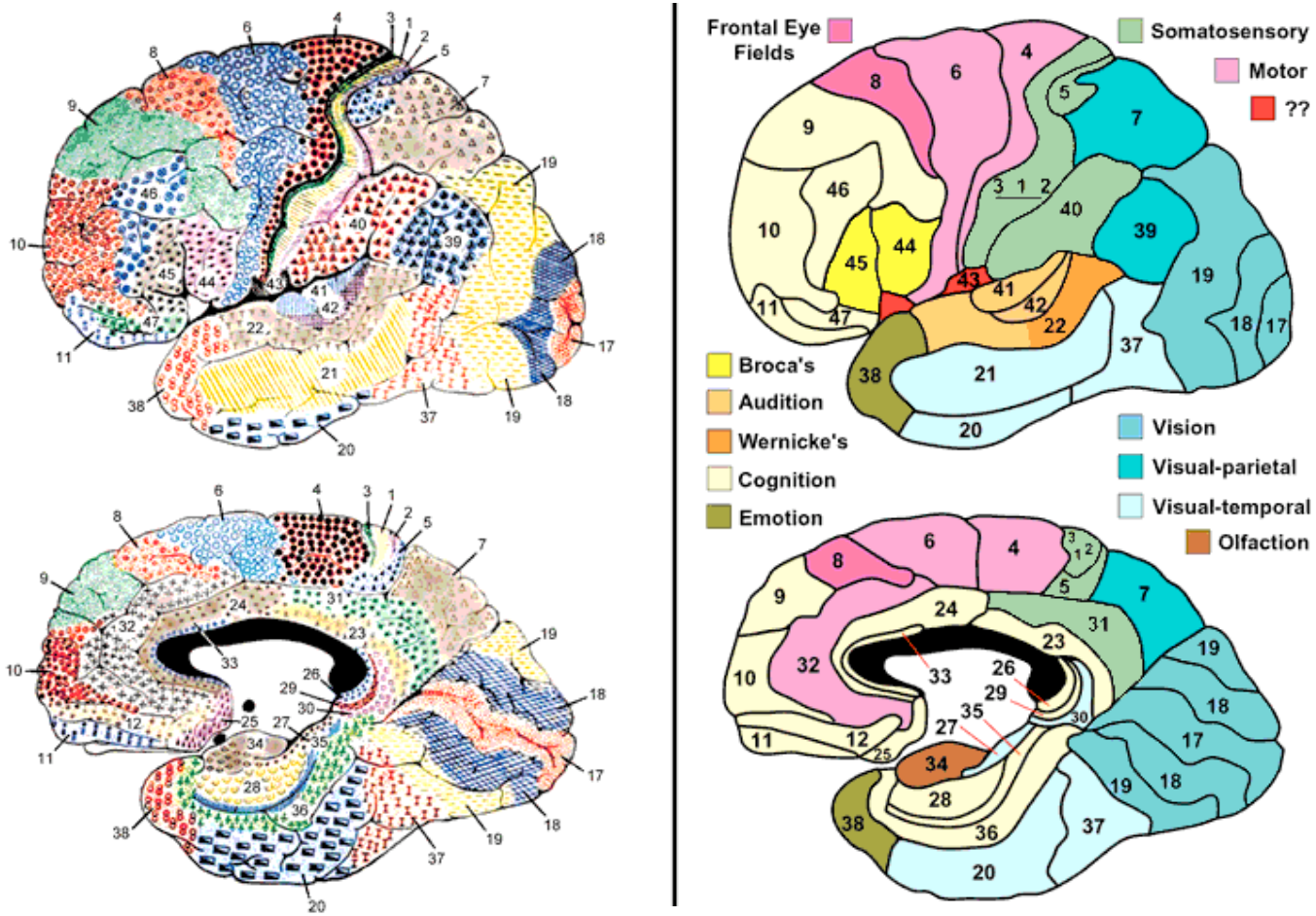
3. Mind follows the neural structures of the body

- Consciousness of tactile sensation first arises through brain electrical activity, in the somatosensory cortex
  - Electrical brain stimulation is felt in the body location which is mapped (“projects”) to the brain location stimulated
- Yet we *feel* the sensation at the particular location in the body
  - Cutaneous rabbit phenomenon: tactile sensation is felt on the arm even where not touched
  - Conscious sensation appears to happen “in” the brain but is “mapped” to the body
- We feel the sensation as having occurred at the time the stimulus actually occurred
  - Libet’s “antedating” (backward referral of sensation)
- Sensation appears to follow the nerve pathways
  - Phantom limb sensation and pain
- These phenomena suggest that the “mind-body” follows the neural structure of the physical body

4. “Mind structure” maps to brain structure

- Brain structure: there are different regions in the brain with unique cell structures
  - Mapped out in 1909 by K. Brodmann: called “Brodmann areas”
  - The different regions have a different cellular structure of the top cortical layers
- Brain function: the brain’s *functional* areas generally follow the Brodmann areas, with some exceptions
- Interface between “mind functions” and the cortex
  - Neurological functions occur where the mind operates and interfaces with the brain
  - The mind-brain interface likely occurs in the upper layers of the cortex
- There is likely a coherence between brain function / structure and “mind structure”
  - Different “regions” of the mind “interface” with the different functional areas of the brain

Brodmann's cytoarchitecture



Brodmann areas colorized and with functional areas mapped out

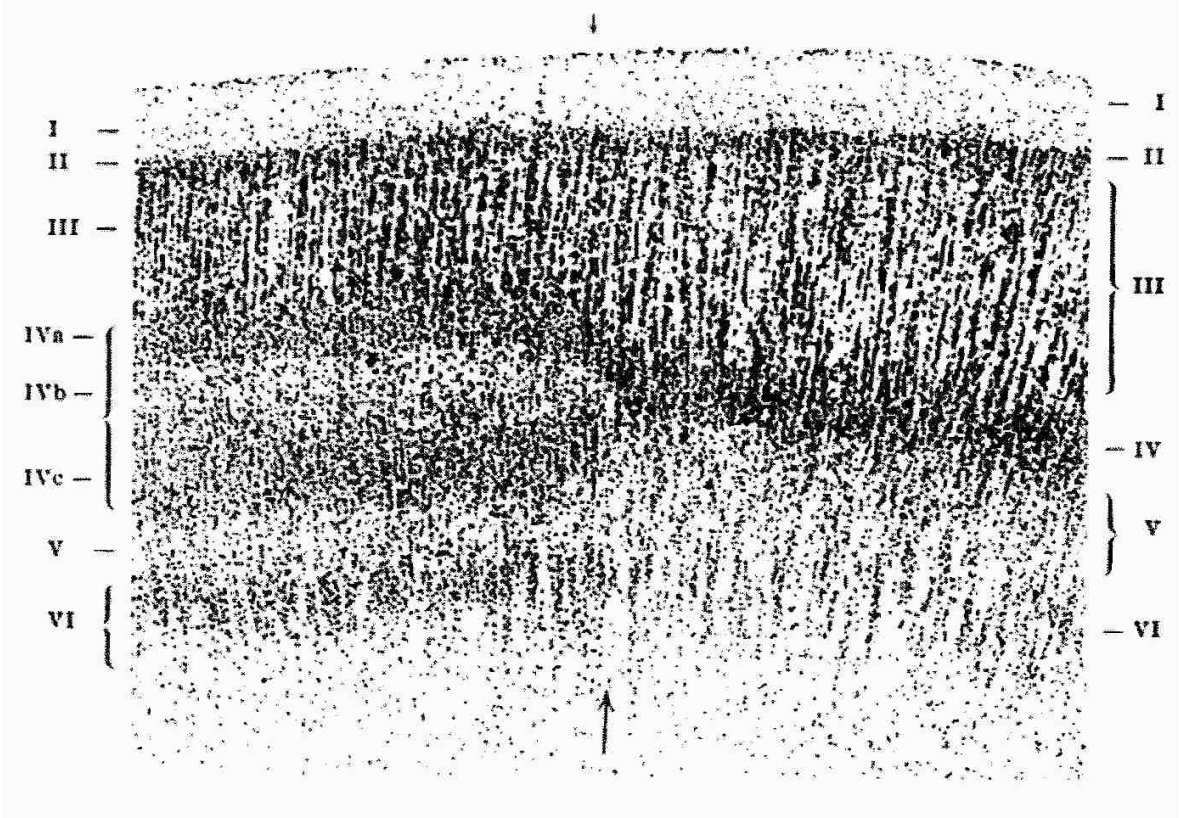
Brodmann areas are areas of different cortical cell structure. The areas do not strictly follow the sulci folds. The different Brodmann areas generally correspond to different functional areas of the brain.

from Mark Dubin - University of Colorado
http://spot.colorado.edu/~dubin/talks/brodmann/brodmann.html

Brodmann area transitions

Transition between area 17 and 18 in the calcarine sulcus

Note the difference in cellular structure of the top 6 layers of the cortex:
There is much more differentiation in area 17 than area 18.



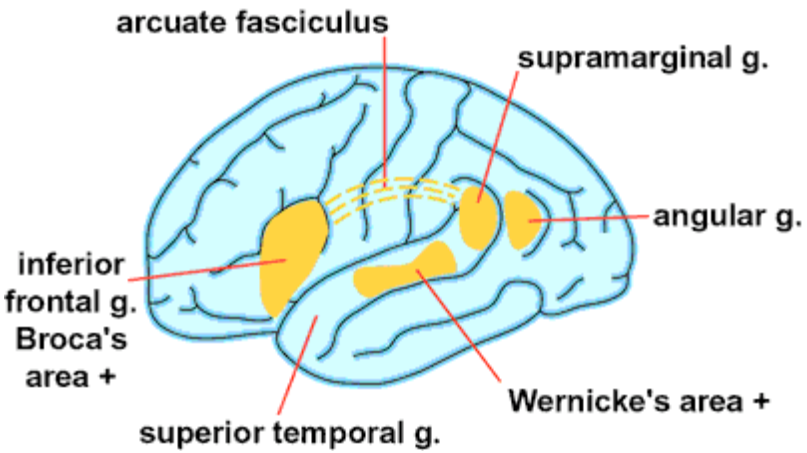
← Area 17 → | ← Area 18 →

From Brodmann, K. (1909/2006). *Localisation in the Cerebral Cortex.* Translated by L. J. Garey, Springer Science+Business Media.

5. Cognitive function depends on brain structure

- Brain damage leads to loss of function:

  Example: language areas
  A stroke in Broca's or Wernicke's area leads to aphasia
  (deficiency in speech production and/or comprehension)



- Brain plasticity
  - Involvement of cortical regions in a function can be flexible/plastic (expanding or moving)
  - With slowly developing changes (e.g., tumor), the impacted function can sometimes migrate
- These phenomena suggest that the mind can adapt to work in different cortical regions
  - Especially if the structural change has been gradual or if the patient is still young
  - Neural "re-wiring" is needed and there are probably limits to how much adaptation is possible
- New methods of rehabilitation from brain injury/stroke may be possible
  - Suggested by this model of mind and brain
  - Redirect functional region of the mind to another brain region (e.g., the opposite hemisphere)
  - Devise new learning processes (e.g. involving movement)

6. Mind plays an active role in brain development

In postnatal brain development…

- Significant “regressive events” occur during infancy (many neurons die off)
- There is gradual “myelination” of neurons
  - Myelin covers the axon so the neuron can efficiently transfer neural impulses
  - The first brain areas to be myelinated are: motor, olfactory, somatosensory
  - Last areas (teen and adult years) are: complex visual functions, executive functions, working memory
- The mind’s activity, especially during infancy and childhood, influences which neurons are retained and myelinated, and are available for use
- Implications for child development and education:
  - Child development entails the child’s mind integrating with and re-forming the brain and body

7. Memory resides in the mind, not the brain

- Brain structures (hippocampus) are needed to form, consolidate and recall memories
  - Bilateral damage to hippocampus results in the inability to form new memories (anterograde amnesia) -- example, patient H.M.
- Memories formed during the NDE are accessible afterward
  - Are vivid, long-lasting and not subject to embellishment over time
  - Implies that memories can be formed and “stored” without the brain
- Memories prior to NDE are accessible during the NDE
  - Implies that memory content is accessible without the brain
  - Implies that memory formation and recall are functions of the mind and are only supported by brain functions while in the body
- Therefore, memory *content* is a function of the mind, not the brain
  - The brain supports formation and recall of memories while we are in the body
  - Suggests a different model for memory loss in Alzheimer’s disease: rather than *lose* the contents of memory, the patient gradually becomes *blind* to them

A new paradigm

A good scientific theory has *explanatory* and *predictive* power

- Explanation: essentially all neurological and consciousness phenomena ultimately need to be explainable in these new terms
  - Example: Libet's paradox of delayed awareness of willed action

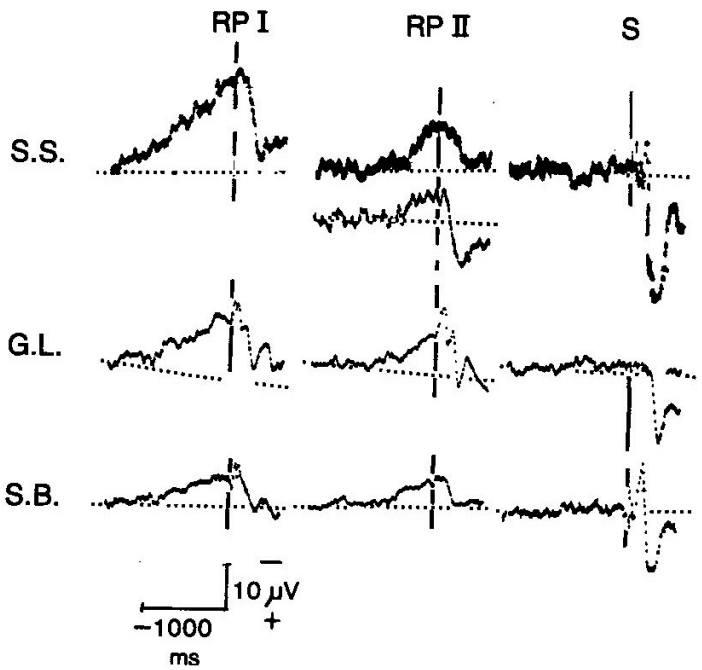
- Prediction: phantom limbs (as exposed "mind-limbs") should exhibit as yet unnoticed properties, similar to the NDE-OBE "body"

Libet's paradox

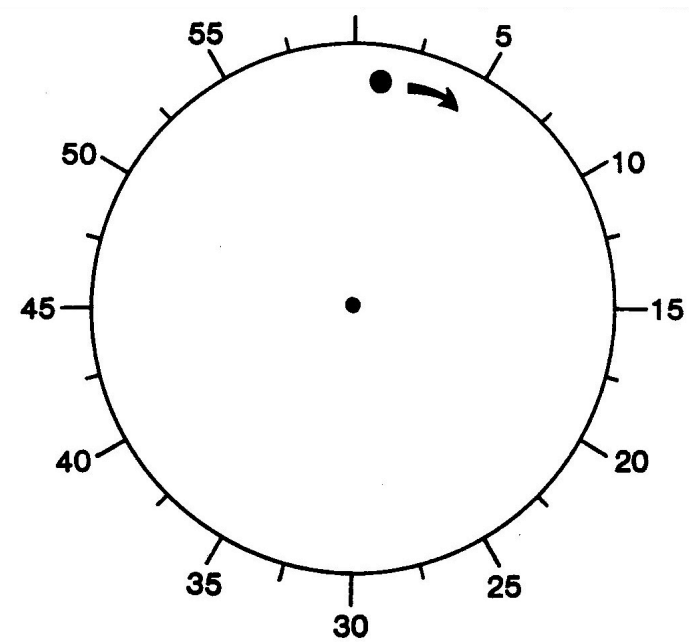
The brain appears to "decide" to move before we are conscious of deciding

- Prior to a muscle movement, an electrical "readiness potential" (RP) appears in our brain about 500 msec before the movement, indicating that the brain is "preparing to move"
- Task: after a signal, move your finger spontaneously at a time you choose (no "pre-plans"), and note the time (on the clock) when you first are aware of deciding or wishing to move

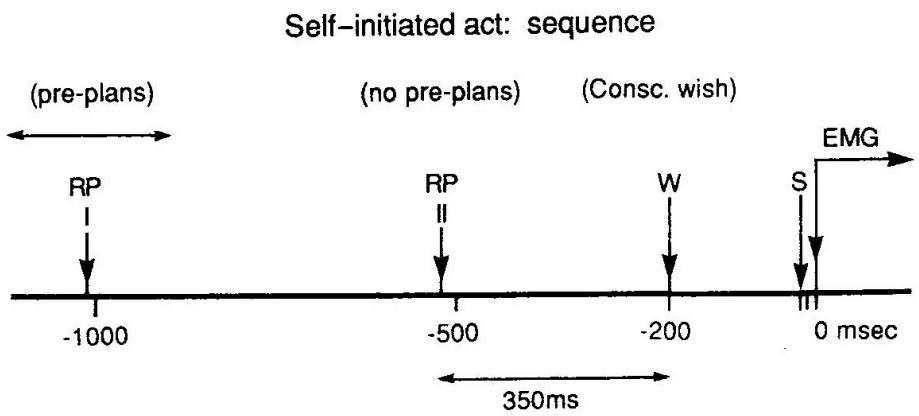
Readiness potential timings (RP II)



Clock: 1 revolution = 2.56 sec



Libet's paradox 2



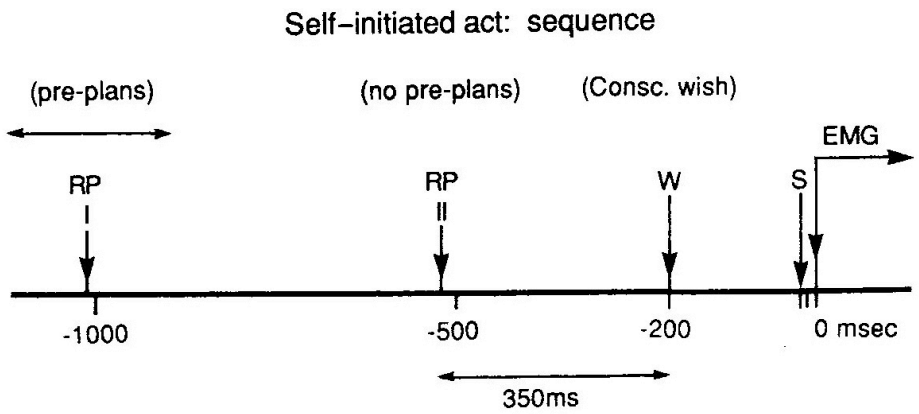
The results were:

- The readiness potential (RP) started 550 msec before movement (EMG) -- expected
- Awareness of the wish to move (W) occurred 350 msec *after* the start of the brain's preparation to move -- *not* expected
- Implies that the brain "decides" to move before we do (i.e., we have no free will)

Note: an average of 40 trials for each subject; cases of "pre-planning" the movement were omitted. "S" is a separate timing of tactile stimuli, to determine the accuracy of timing measurements

Libet, B., *Mind Time: the temporal factor in consciousness.* Cambridge, MA: Harvard University Press, 2004.

Libet's paradox 3



- Our explanation: the decision to move is *initially subliminal*, starting 500 msec prior to W
  - The decision occurs at -700 msec or 150 msec *prior to* start of RP
  - The *decision* initiates the movement, so we *do* have free will
- Our decisions are first made *subliminally*, but are made out of the conscious context we are in, by the conscious agency of the mind
  - This principle applies generally to all endogenous mental activities: they are initially subliminal and somewhat later we become aware of them

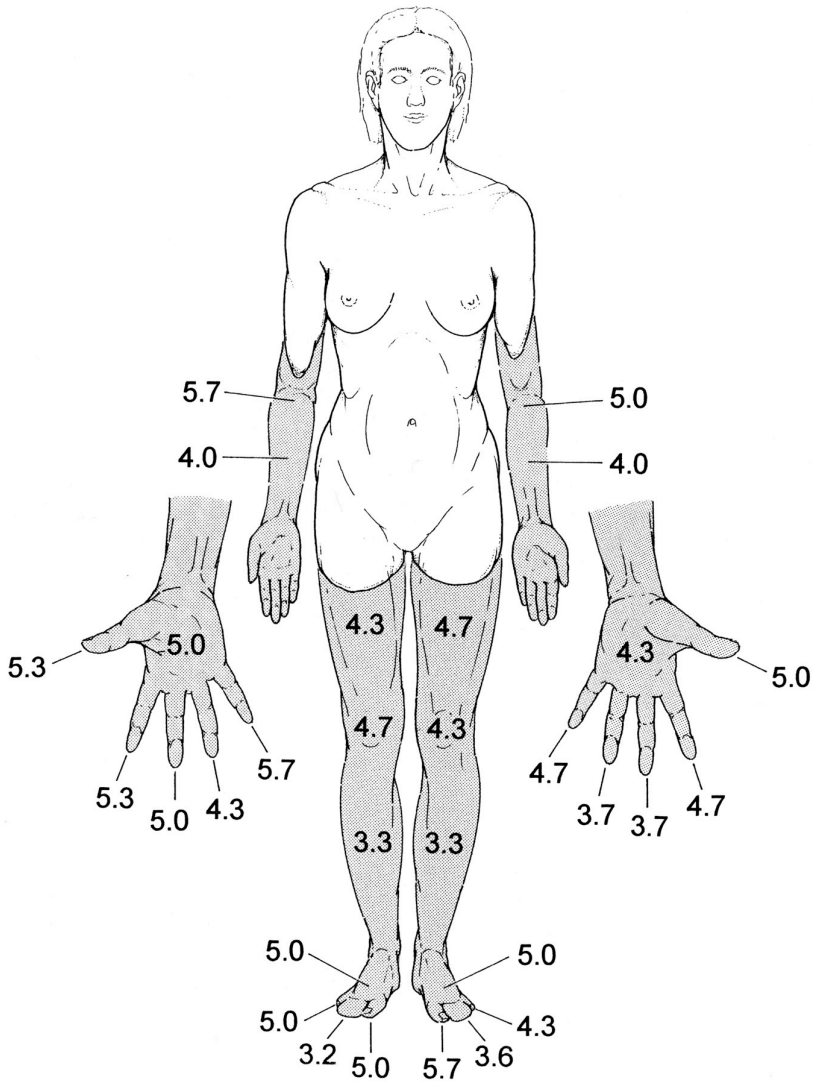
Phantom limb phenomena

- A *phantom limb* is a distinctive subjective experience of a physical limb which is absent.
- Prediction: phantom limbs are exposed “mind-limbs” extending beyond the physical body and should exhibit as yet unnoticed properties, similar to the NDE-OBE “body”:
  1. There should be subtle interactions with objects, causing sensations
     - the NDE-OBE body interacts with objects/walls, causing a subtle feeling of resistance
  2. There should be subtle interactions with another person’s body
     - the NDEr can touch another person and cause sneezing, can “merge” with another person’s brain and experience what they are sensing and thinking
  3. There may possibly be a faint glowing of the phantom in the dark
     - the NDEr can be “seen” by dogs, can see fellow NDErs and can see their own “body” with luminous limbs

Phantom limbs

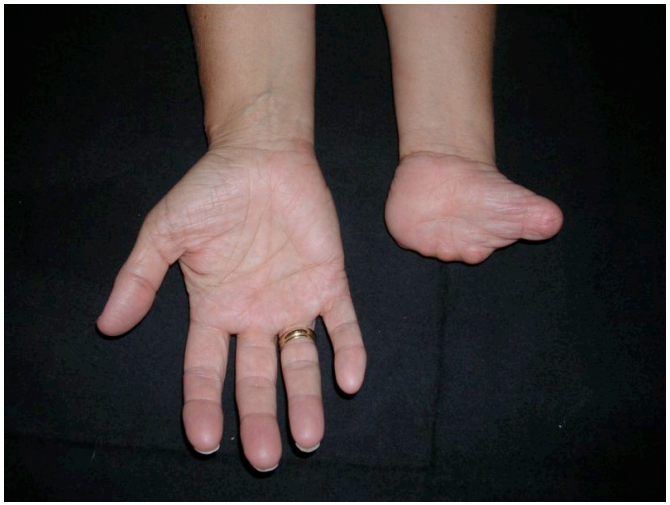
Subject A.Z. was born missing all four limbs (congenital tetramelia)

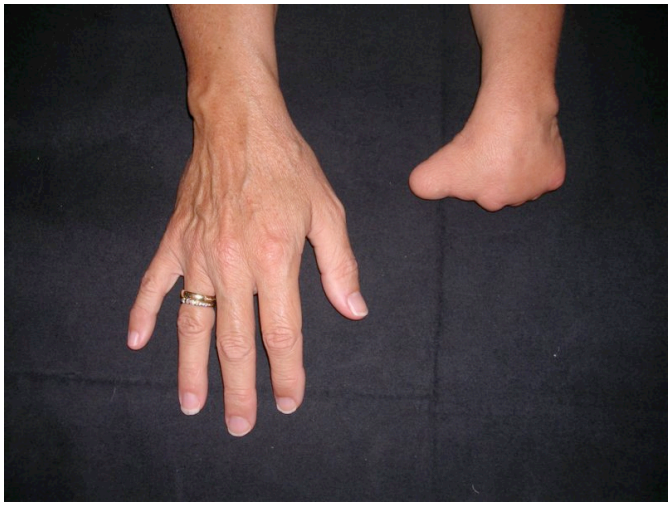
- She has significant “proprioceptive” sensations of her phantom limbs, in all details.
  - The numbers indicate how strongly each part of the phantom is subjectively felt (scale of 0 to 6)
- She has the ability to move the phantom limbs subjectively
- She told the researchers, ‘‘In darkness, I have noted a faint glowing of my phantom body parts’’

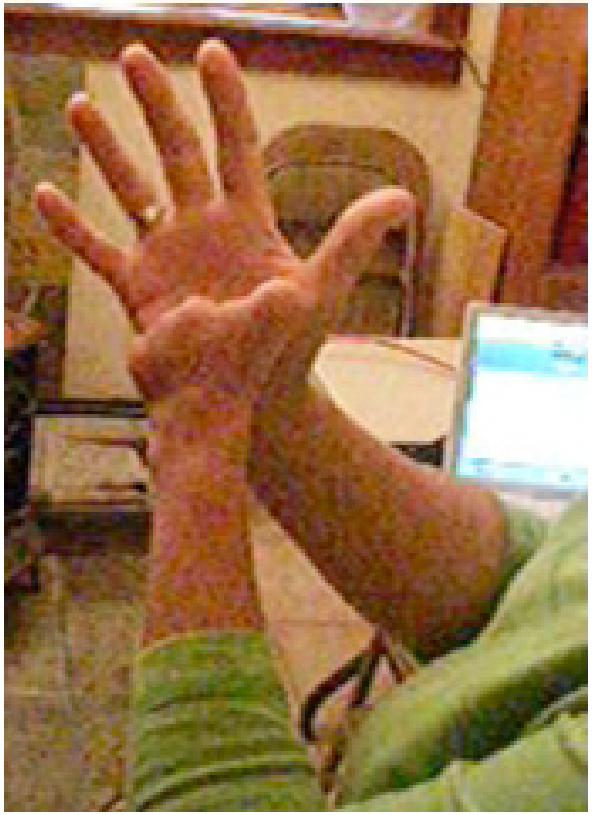


Brugger, P., Kollias, S. S., Müri, R. M., Crelier, G., Hepp-Reymond, M.-C., and Regard, M. (2000). Beyond re-membering: Phantom sensations of congenitally absent limbs. *Proceedings of the National Academy of Sciences of the United States of America, 97*, 6167–6172.

Subject M.G.







Missing the fingers of left hand (congenital digital agenesis with arrested metacarpal development, origin unknown). M.G. is a college educated woman, born in 1952.

Subject M.G. 2

- M.G.'s phantom fingers in many respects are typical of phantom limbs in other subjects:
  - Subjectively they have a normal shape but are "frozen"
  - They appear (they "light up") when they are thought about
  - M.G. experiences proprioceptive sensations of them
  - They disappear when M.G. is not paying attention or is using her physical left hand
  - They sometimes feel "telescoped" into the upper arm near the shoulder
- What's different about M.G.'s phantom fingers: next five slides

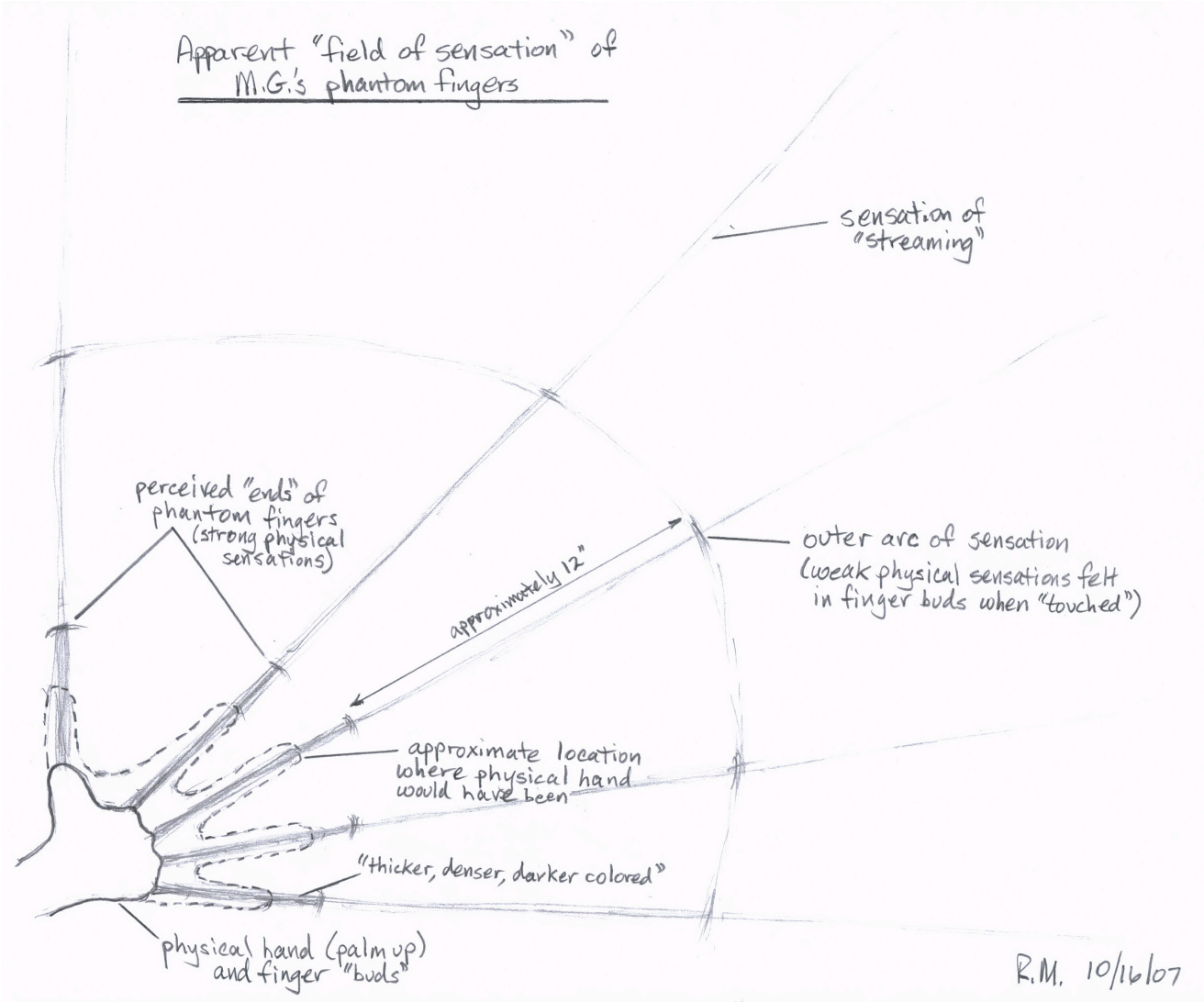
“Structure” of phantom fingers

Video clip: 1’43

- **What’s different**: M.G. can locate her phantom fingers by pulsing with her right fingers. The pulsing causes physiological sensations in her left finger buds, left palm and up her left arm, ending is a specific spot in outer upper arm. There is also a feeling of warmth and resistance in the right finger tip during the pulsing.
- M.G. can “feel” objects with the phantom fingers, also causing sensations in the left hand and up the left arm.

“Structure” of phantom fingers 2

M.G. initially feels a sense of “streaming” out of her phantom fingers. By pulsing with her right fingers, she can find where the touch first starts (about 18” away from her finger buds). Then she follows that sensation down to the “finger ends” where she senses a warmth and resistance in her right finger and a tingling in her finger buds.



Phantom limb interaction

Video clip: 1’46

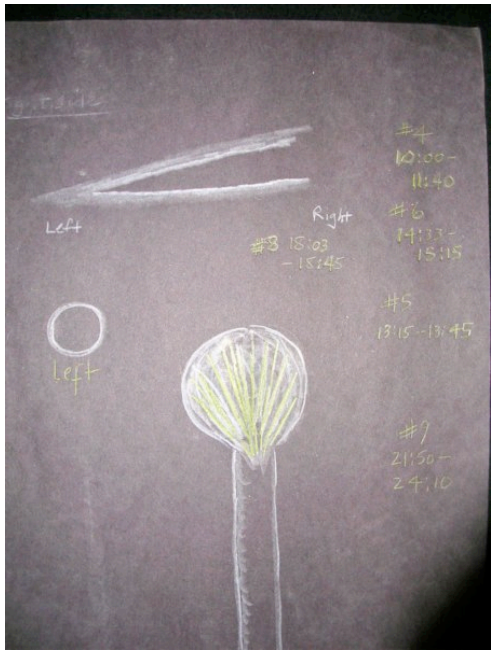
M.G. can also “touch” another person and the “touch” is felt, especially when the other person’s head is “touched”. Here, a point in the occipital area is “touched” and a visual image is perceived, similar to the images perceived with electrical brain stimulation. The image is perceived almost immediately when M.G. moves her hand in closer (a “charge” going right to left, a stream of light like a sword).

Phantom limb interaction 2

Video clip: 1’49

Another area is “touched”. Note the immediate reaction in subject S.M. when M.G. moves her hand closer in: the shoulders raise and there is an immediate response (perceiving a “beam” of dark, rich black, later superimposed with a black disc with a white rim or corona around it)

Phantom limb interaction 3



A total of 9 points were “touched” (two points on the sides are not shown). The images perceived were drawn and described in detail:

- Black circles with a white ring, black swords with a white outline (several instances each)
- Point 9 (blue) was a very strong experience: a black column rising through the body followed by a brilliant white light filling the head, also felt physically in the body and head. “It's dynamic, it has a movement, like I am moving (upward) through it, with a light streaming out. My whole head, my whole skull is just white, just filled with light, with my whole skull feels like it's being energized, with a pulsing of the skull.”

Phantom limbs - conclusions

- The phantom limb phenomena from A.Z. and M.G. suggest:
  - It is possible to have a visual perception of phantom limbs
  - The phantom limbs can interact with other parts of the subject's body, causing definite sensations
  - They can interact with physical objects, causing sensations (subtle)
  - They can interact with another person's body and brain, producing visual and tactile sensations (generally subtle, but sometimes intense)
- These phenomena suggest that phantom limbs have an objective reality and are a field extending beyond the physical body
- Phantom limbs fit the present theory:
  - The mind has a spatial structure, a "body" that is co-extensive with the physical body
  - In the phantom limb, the "mind-limb" is present without the physical limb and extends beyond the body
  - Phantom limbs are sensed in part through existing neural pathways, probably with "cross-wiring" in the thalamus or spine to other body neurons

Self-conscious mind

The self-conscious mind is a new, fundamental *objective* element of reality:

- The mind is a non-material “field of consciousness”
- The mind interacts with physical processes, especially neurons
- A new “force” must be involved in the physical interaction between the mind and neurons
- In ordinary consciousness, the mind is united with and extensively interacts with the brain and body neurons

The self-conscious mind is the seat of the consciousness and essential selfhood of the person.

We are conscious because we *are* a self-conscious mind.

Future work

1. Conduct further phantom limb experiments with M.G., summer of 2009
    - Repeat key “touching” experiments from earlier sessions
    - Double-blinded “touching” experiments with additional subjects
    - Test possible interactions with a Michelson interferometer
    - Present findings to other phantom limb researchers for comments
    - Submit abstract to 2010 Tucson Consciousness Conference
2. Monitor the progress and findings of the AWARE study
3. Refine the present model with additional neurological phenomena
4. Write our next major paper