



# How Meditation impacts the Brain

Mindfulness in Biz 2020

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## Learning goals

- What is mindfulness and meditation, and how does it improve health?
- Functional MRI and overview of neural systems
- **Direct experience:** Learn meditation exercises
  - Attention – focused attention to the breath
  - Emotions – mindful awareness of emotions
  - Social functioning – lovingkindness/compassion
- **Scientific findings:**
  - Brain functioning
  - Behavioral outcomes
  - Have a more nuanced understanding of the brain

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# How Meditation Changes the Brain

- We've all heard that meditation leads to greater mental clarity, lower levels of stress and reduced anxiety. But how does meditation benefits the brain.
- In recent decades, meditation has become more conventional. People are spending time working with their minds, following their breath and learning to appreciate the power of the power of the present moment.
- Recent scientific evidence confirms that meditation nurtures the parts of to brain that contribute to well-being. Furthermore, it seems that a regular practice deprives the stress and anxiety-related parts of the brain of their nourishment.

# What is Mindfulness and Meditation?

- **Mindfulness** is a proven method of **training attention** and **improving emotion regulation**. A distinctive feature of Mindfulness is that it specially relies on **introspective awareness of thoughts, emotions and bodily sensations**. This practice can help us not be distracted and carried away by the emotional thoughts and feelings, and enable the development of effective **self-regulation attention/emotion**, which will bring beneficial outcomes and evidence on **improving mental and physical health and well-being**.
- The practitioner in applying the principles of mindfulness in daily activity, for example, would be being **present** with the activity rather than lost in rumination about what happened or in planning in future activities, instead anchor **attention** on the sensations in the present moment with **attitudes of non-reactivity and non-judgment**.
- The available evidence suggests that **meditation** can lead to both temporary changes in mind and brain **states** and to longer-term shifts in personality **traits, cognitive functioning and brain structure**.

## What is mindfulness and meditation?

- Mindfulness – a kind of attention that is present-centered, intentional, and nonjudgmental (Kabat-Zinn)
- Meditation – practices from Buddhist traditions to cultivate qualities of attention
- Can be applied to many internal and external experiences
  - Sensory, body, emotions, thoughts, actions

# What is Mindfulness

- An awareness arising by purposefully paying attention in the present moment with an attitude of non-reactivity, non-judgment and openness (Kabat-Zinn, 2003; Kabat-Zinn, 2013)
- The attention component describes the ability to notice thoughts, emotions and sensations, sustain attention on them and shift attention away from distractions;
- The attitude component relates to the quality of attention in mindfulness which can be characterized by non-reactivity, curiosity and openness.

# Mindfulness Attitudes

According to Kabatt-Zine, there are *Seven attitudinal factors* constitute the major pillars of mindfulness practice. They are:

- non-judging,
- patience,
- a beginner's mind,
- trust,
- non-striving,
- acceptance, and
- letting go.

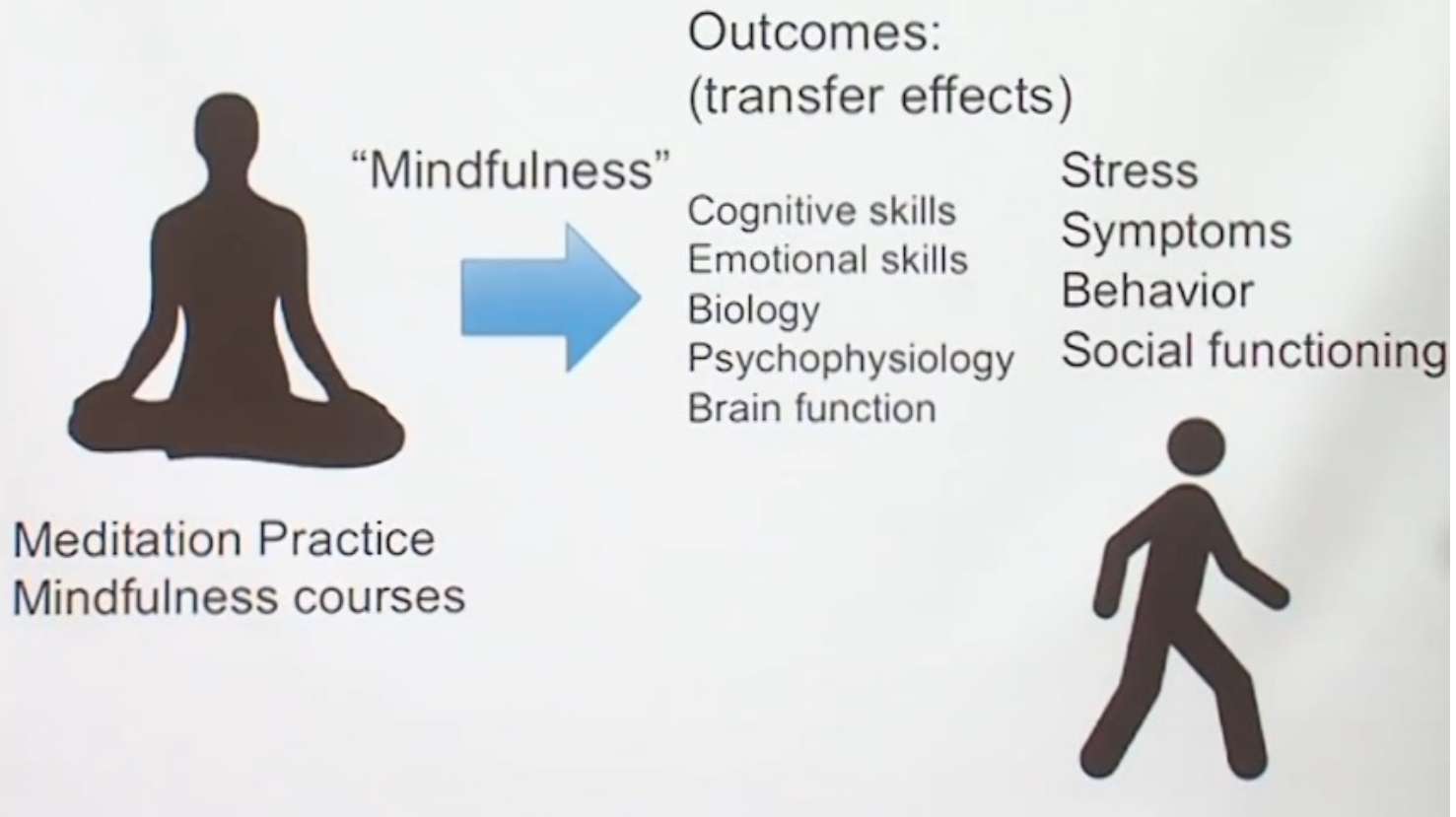
These attitudes are to be cultivated consciously when you practice. They are not independent of each other. Each one relies on and influences the degree to which you are able to cultivate the others. Working on any one will rapidly lead you to the others. Since together they constitute the foundation upon which you will be able to build a strong meditation practice of your own, we are introducing them before you encounter the techniques themselves so that you can become familiar with these attitudes from the very beginning. Once you are engaged in the ways you might continue to fertilize this attitudinal soil so that your mindfulness practice will flourish.



## How does mindfulness and meditation improve health?

- Attentional skills to recognize internal patterns (habits, “automatic pilot”)
- Increasing awareness of internal events to slow down the habits (increasing resolution) and choose new ways of responding (“cycle breakers”)
- Can decrease stress (thereby improving the immune system), help people choose healthier behaviors, improve relationships

# Model: from internal change to external change



# Effects of meditation on the brain

Harvard neuroscientist Sara Lazar explains how four regions of meditators' brains associated with healthy brain function become more substantial, while one of the areas associated with undesirable behavior actually shrinks. Let's take a look at these areas:

- Left Hippocampus

This is the area in the brain that helps us learn. The tools that we use for cognitive ability and memory are found here, as are emotional regulators associated with self-awareness and empathy. Research confirms that as the cortical thickness of the hippocampus grows in volume through meditation, gray-matter density increases and all of these important functions are nurtured.

- Posterior Cingulate

This is connected with wandering thoughts and self-relevance – that is, the degree of subjectivity and referral to oneself when processing information. It seems that the larger and stronger the posterior cingulate, the less the mind wanders and the more realistic the sense of self can be.

Two of the vitally important effects that meditation has on the mind are the ability to remain attuned to the present moment without judgment, regret or anticipation; and the ability to observe sensations and emotions that arise in the mindstream without necessarily identifying with them. Meditation seems to increase the density of the posterior cingulate.

# Effects of meditation on the brain

- Pons

This is a very busy and important part of the brain where many of the neurotransmitters that help regulate brain activity are produced. Located in the middle of the brain stem, its name, pons, comes from the Latin for “bridge.” The pons is involved in a great number of essential functions, including sleep, facial expressions, processing sensory input, and basic physical functioning. Meditation strengthens the pons.

- The Temporo Parietal Junction (TPJ)

We like to think that we’re good people – empathetic, humane and just. Empathy and compassion are associated with the temporo parietal junction of the brain, or TPJ, as is our sense of perspective. We might say that the posterior cingulate focuses on “me” while the TPL shines a light on everything else. The TPJ – combined with other benefits of meditation like lower stress and present moment awareness – can help us be the good people we aspire to become.

- Amygdala

There is another area of the brain that is changed through meditation: the amygdala. But it doesn’t get larger; it shrinks. The amygdala – that pesky corner of the brain that produces feelings of anxiety, fear and general stress – is physically smaller in the brains of expert meditators. For the rest of us, even an eight-week crash course in MBSR leads to a measurable decrease in the size of the amygdala. The smaller it is, the less apt it is to dictate our emotional responses, especially those of the “fight-or-flight” genre.

# The main mechanisms underlying changes in the mind and brain resulting from long-term meditation and associated factors

Principles of **neural plasticity of the brain** – changes in brain structure and function resulting from repeated practice, and their modulation by meditation resulting beneficial outcomes in health and well-being

- **Temporary** (state changes) and **lasting effects** (trait changes)
- **Quantity** (more hours of meditation) and **quality** (relaxation – release of tension in the body and mind, **stability** – maintaining attention on an object continuously, and **clarity** – vividness or attention to detail as the opposite of dullness)
- **Formal** and **informal practice** (embedding meditation in everyday life, such as taking a shower, brushing teeth, washing dishes, walking the dog, engaging in a conversation or answering emails)
- **Possible adverse effects on long-term meditation practice**, such as sensory hallucinations, paranoid thoughts, anxiety, dissociative experience, visions etc. Physical experience of pain in different parts of the body and respiratory problems, somatic discomfort and pain

# Behavioral and neuroplasticity

- Inherent to the philosophy of meditation
  - We have the ability to change the way our minds work and how we act
- **Neuroplasticity**
  - Our brains are one of the most responsive organs to the environment
  - Our brains (and biology) are not fixed
  - Adults are able to generate new neurons in the hippocampus (Eriksson et al., 1998)
  - Brain changes seen due to motor training (juggling), musical training, cognitive training, now we are seeing with meditation training
- As scientists, how do we study and measure these changes?

# Meditation skills and outcomes are difficult to measure



# What is functional MRI?

- Uses magnetic energy to measure brain function (hemoglobin/iron in blood)
- Assumption: greater blood flow to a region means more neuronal activity



## Measurement properties

Objective

Good spatial resolution (brain structure, where in the brain)

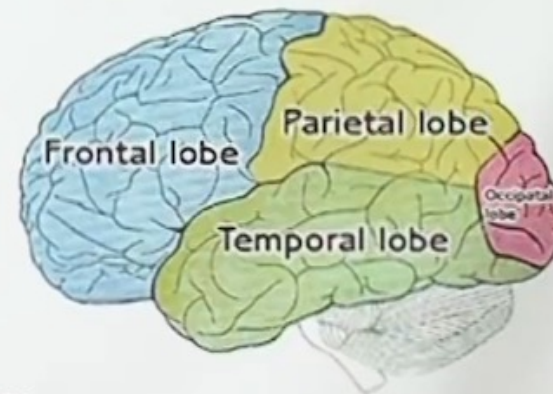
Moderate temporal resolution (1-2s)

Data quality depends on head motion and ability to lay still

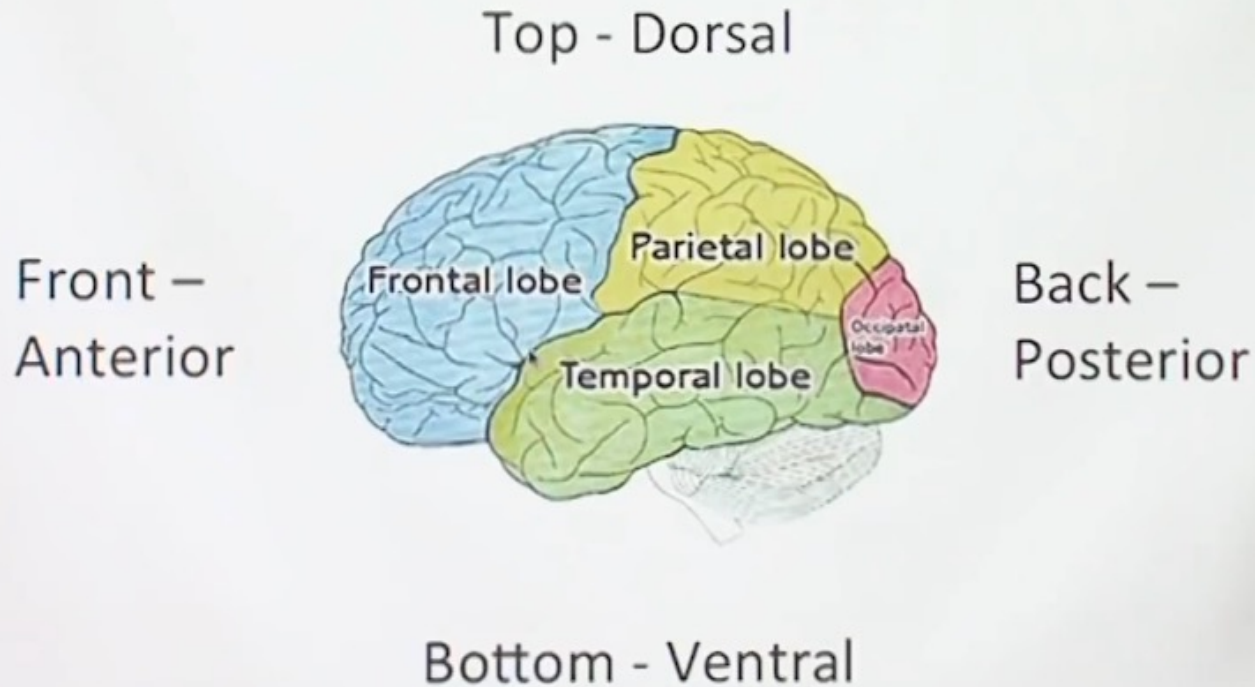


# Basic neuroscience systems relevant for the neuroscience of meditation

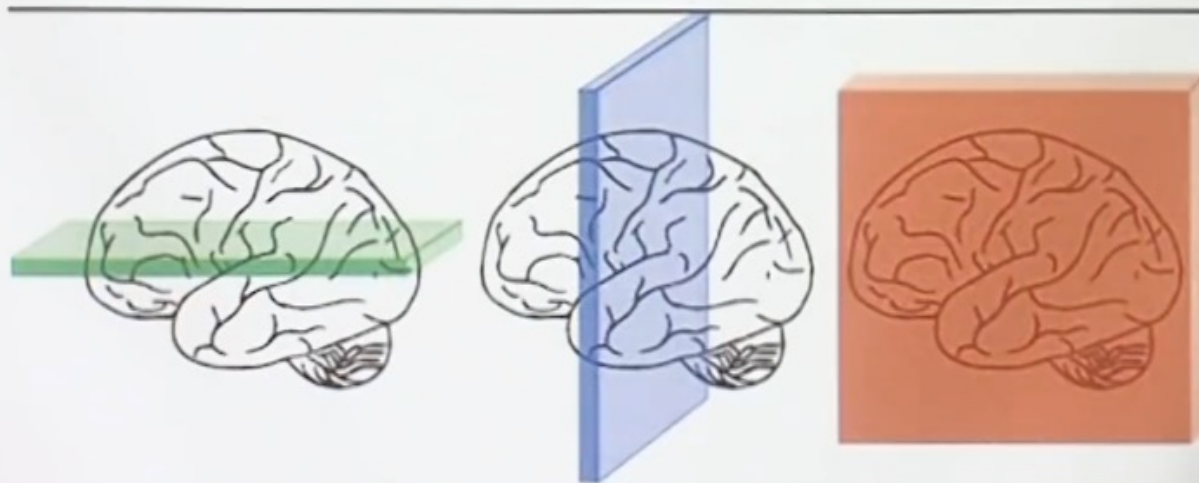
- **Executive functioning** (planning, thinking, attention)
- **Emotions**
- **Bodily Awareness**
- **Self-related thought** (“Default Mode”)
- **Emotions**
- **Empathy**
- Will talk about certain regions, but the brain uses many regions for many functions in networks (avoid “one region-one function” understanding)



# Location Language



# Views of the brain



Axial

Coronal

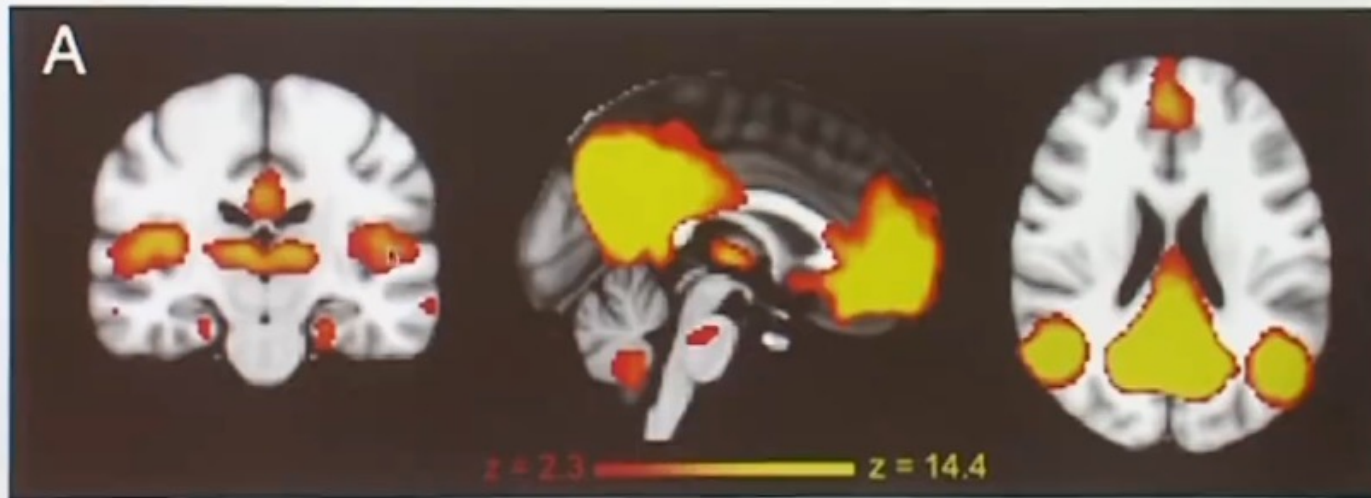
Sagittal

Top-Bottom

Front-Back

Side

# Functional images overlaid on Structural Images (voxels = 3D cubes)

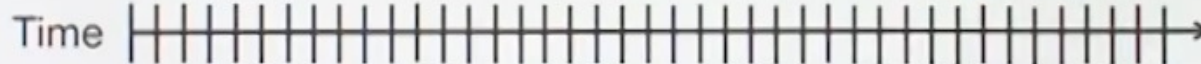


Coronal

Sagittal

Axial

# What is within a brain image?

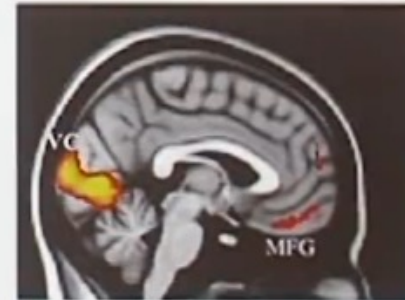


fMRI: picture every 2s



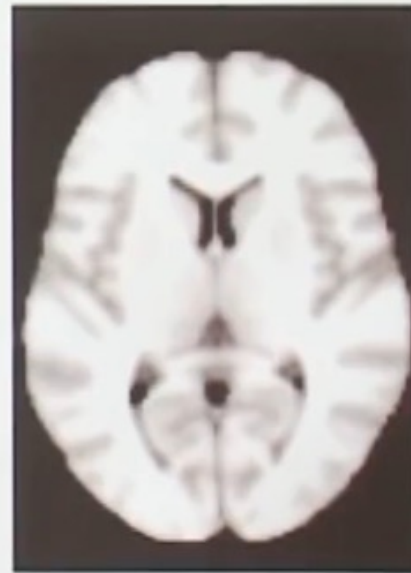
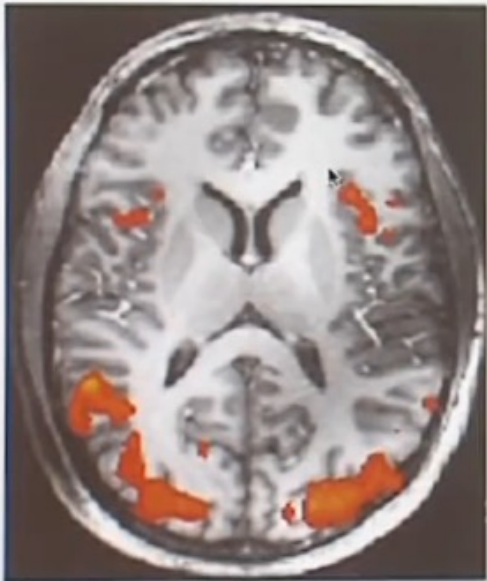
Brain activity is averaged within each person and across people

Averaged group brain



2 conditions compared – Shows relative difference

Individual brain warped to fit a  
standardized brain



## Meditation Exercises and Neuroscience

- Focused attention to the breath
  - Stabilize attention
- Mindfulness of emotions
  - Awareness and understanding of emotions
- Lovingkindness and Compassion
  - Cultivating positive relationship with self and others

# Meditation Exercises and Neuroscience

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Meditation Exercise:  
Focused attention to the breath  
Open awareness



# Practice of breath-focus (practiced with an attitude of non-reactivity)

**FIVE STEPS TO MINDFULNESS MEDITATION**

*Basic meditation, the practice of doing nothing and being tuned in to your own mind at the same time, can be frustrating at first. But research shows it reduces stress and increases focus.*

- 

**1.**  
Sit cross-legged on a cushion on the floor or in a chair. Keep your back straight and let your shoulders drop. Take a deep breath and close your eyes if you wish.
- 

**2.**  
Notice your breath. Don't change your breathing, but focus on the sensation of air moving in and out of your lungs.
- 

**3.**  
As thoughts come into your mind and distract you from your breathing, acknowledge those thoughts and then return to focusing on your breathing each time.
- 

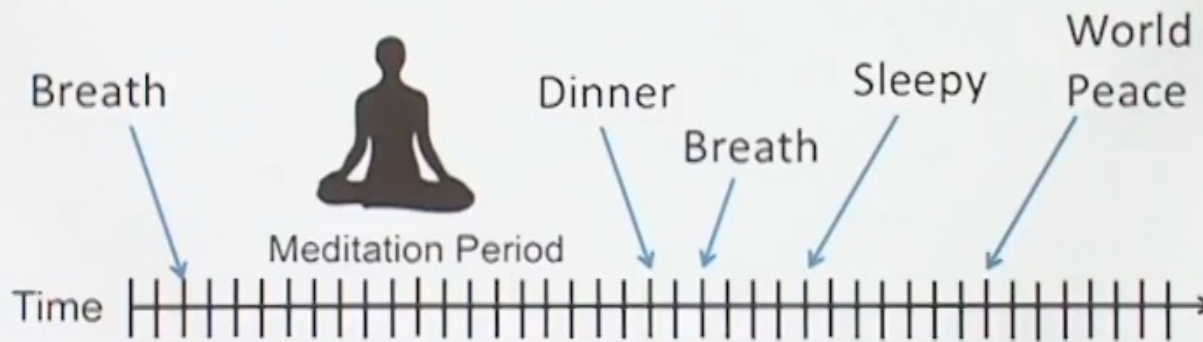
**4.**  
Don't judge yourself or try to ignore distractions. Your job is simply to notice that your mind has wandered and to bring your attention back to your breathing.
- 

**5.**  
Start by doing this 10 minutes a day for a week. The more you meditate regularly, the easier it will be to keep your attention where you want it.

Adapted from Full Catastrophe Living, 2nd edition, by Jon Kabat-Zinn

The attention mechanisms involved in mindfulness and meta-awareness training, one model described a cycle of attention processes including sustaining attention on a meditation object, distraction, noticing of distraction and shifting attention back to the meditation object (Hasenkamp et al., 2012)

# Mental states during meditation are dynamic and fluctuating

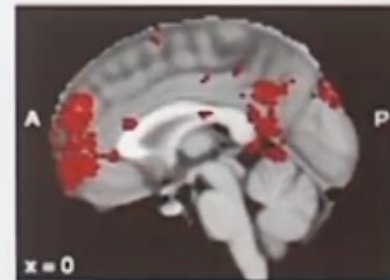


fMRI: picture every 2s

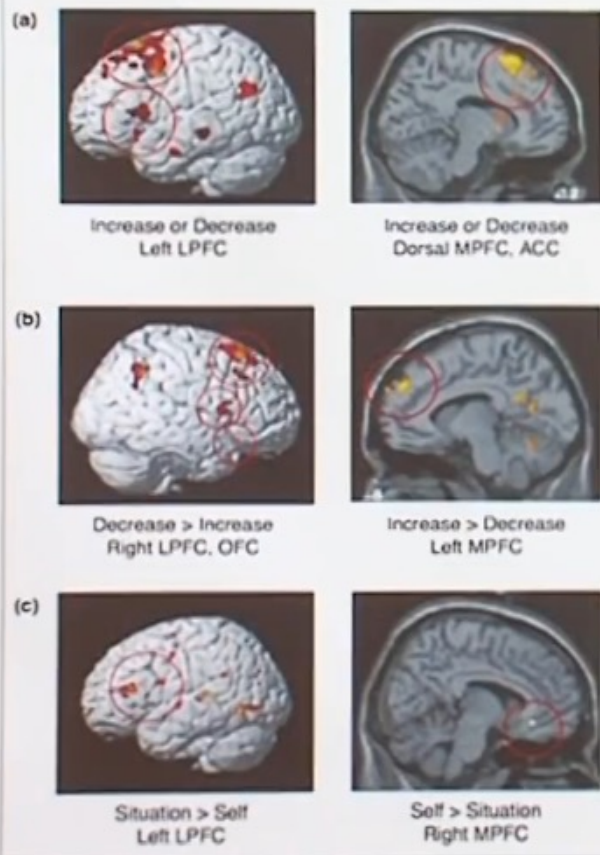


Brain activity is averaged within each person and across people

Averaged group brain



# Executive networks: Cognitive Control and Emotion Regulation (Ochsner & Gross, 2005)



**Prefrontal cortex (PFC)** – most evolutionarily advanced part of the brain

Planning, thinking, attention, working memory, working towards goals, regulating emotions

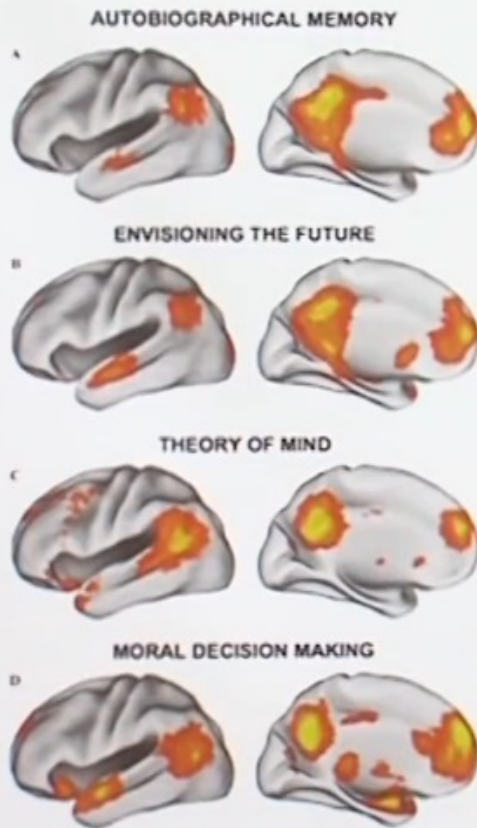
# Bodily Awareness or Interoception

(Craig, 2009)



- **Insula** – internal conditions of the body (“interoception”)
  - Pain, temperature, heartbeat, decision making, pleasant music, maternal affiliation, feeling of knowing
- **Anterior Insula** - involved in conscious awareness

# Default Network – Self-related thought, mind wandering (Buckner et al., 2008)

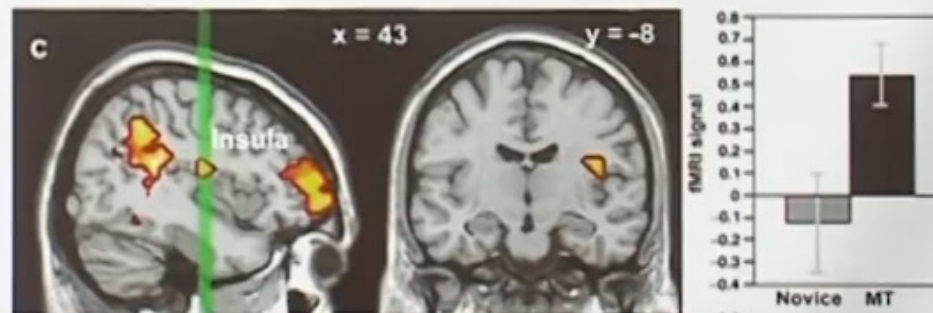


- What our minds do left to our own devices. The mind “at rest”
- Hub at the front of the brain – **medial PFC (mPFC)**
  - Hub at the back of the brain – **Posterior cingulate cortex (PCC)**

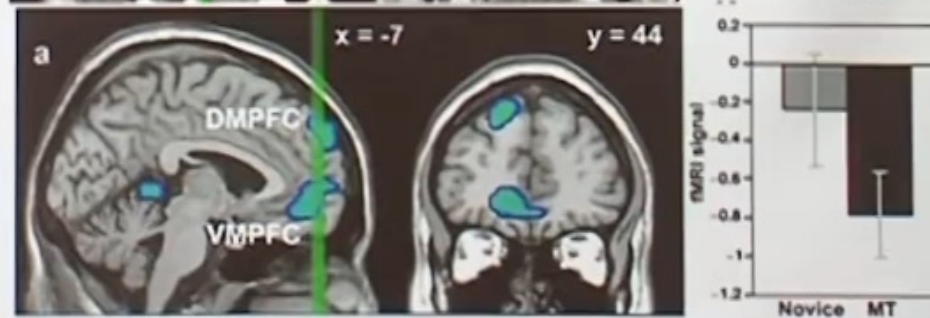
# Neural networks after Mindfulness-Based Stress Reduction (Farb et al., 2007)

- Meditation training enhances neural networks involved in “experiential focus” compared to “narrative focus” in response to trait words

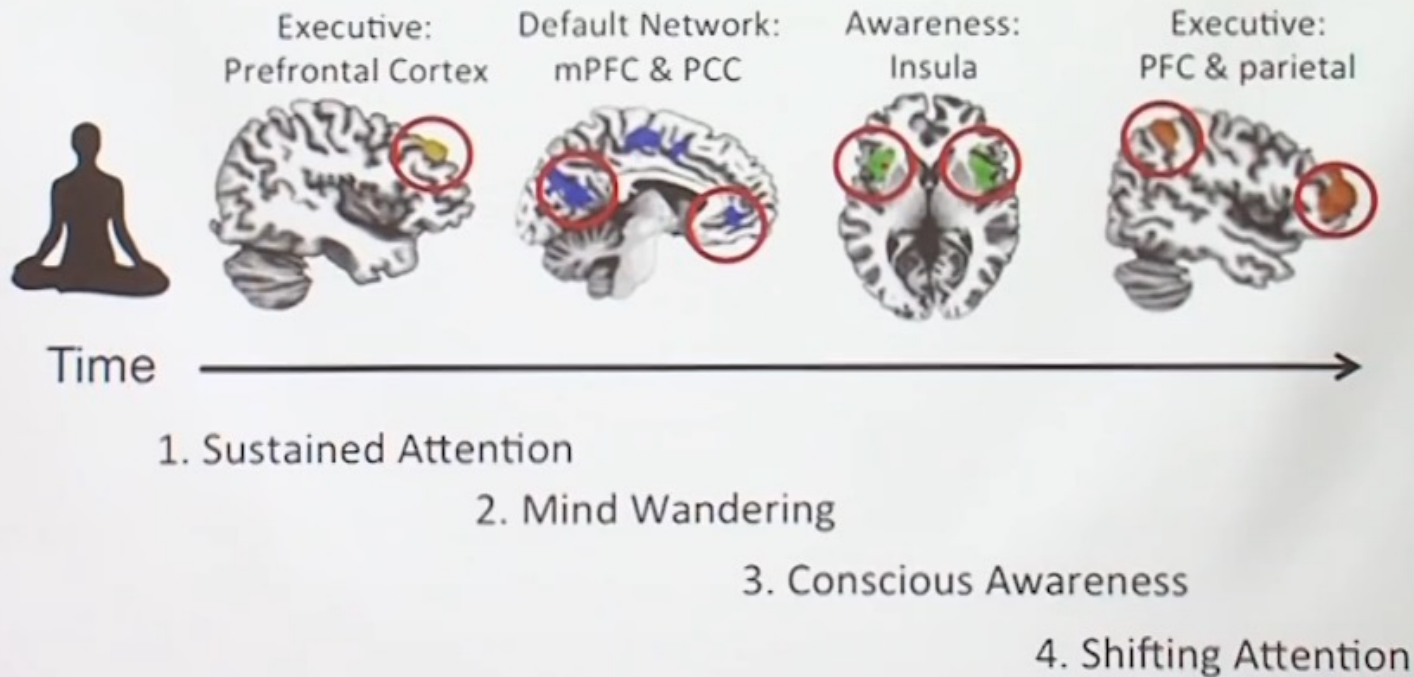
“Experiential Focus”  
Present-moment experience



“Narrative Focus”  
Lost in our thoughts –  
Default Network



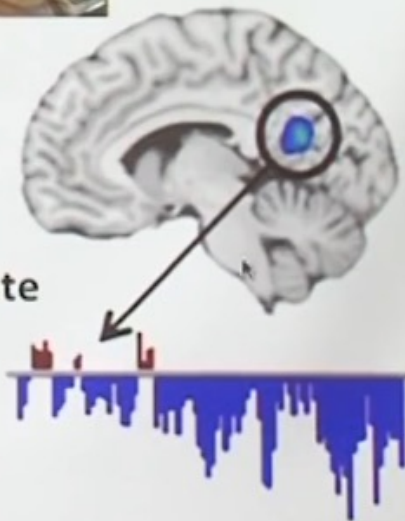
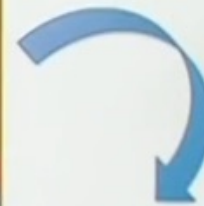
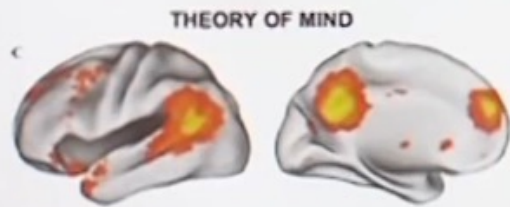
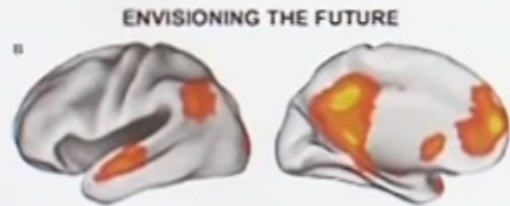
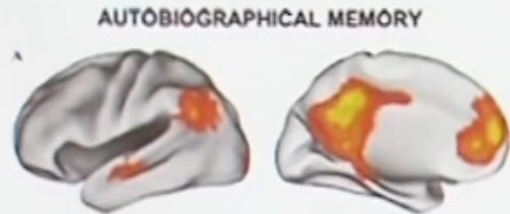
# Sustained attention to the breath: Training 4 mind states



Hasenkamp et al., *NeuroImage* (2012)



# Focused Attention and the Default Network

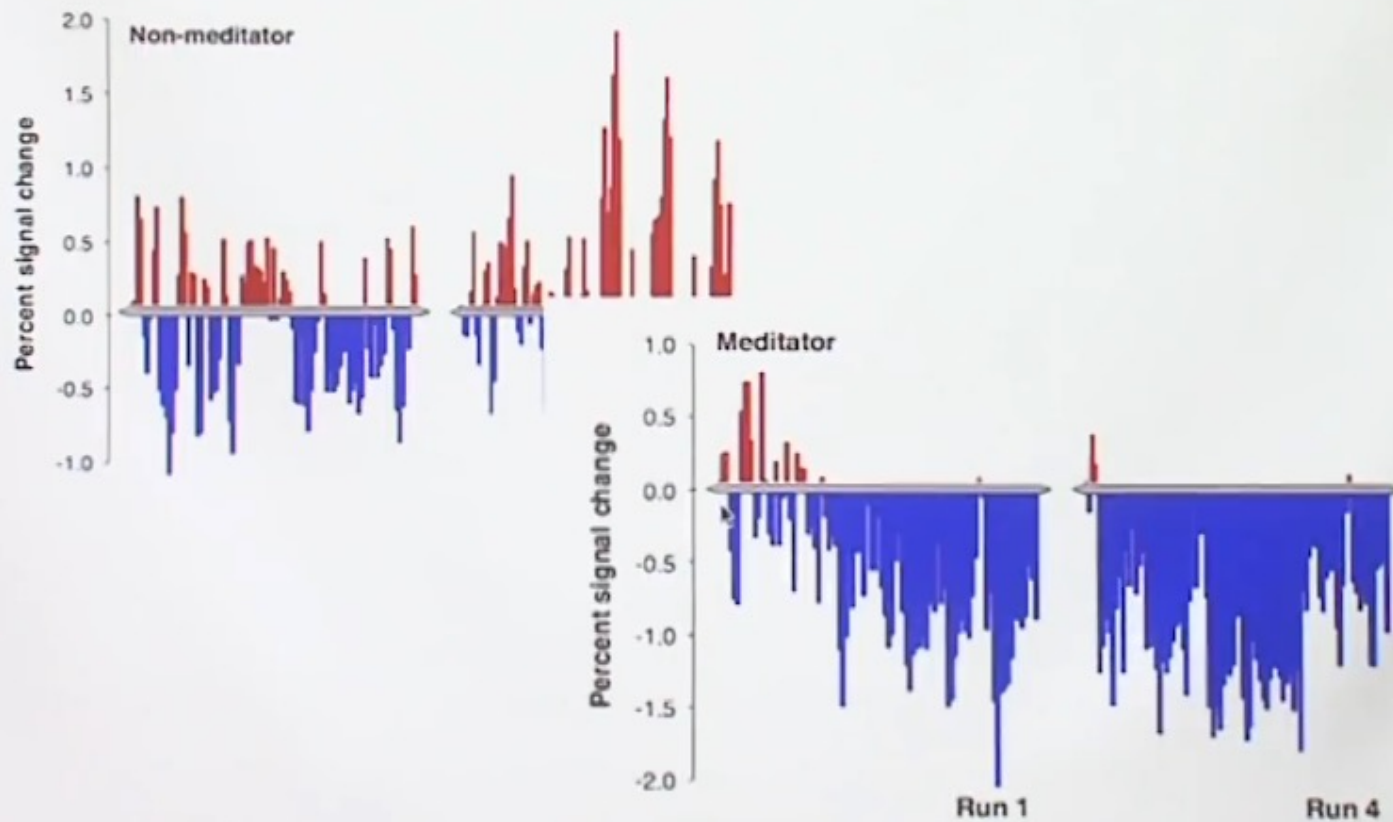


Posterior Cingulate Cortex (PCC)

Buckner & colleagues

Garrison, Brewer et al.

# Real-time feedback from the PCC



# Summary

- Focused attention to the breath
  - Enhances activation in networks
    - Attention
    - Bodily Awareness
  - Decreases activation in networks
    - Mind wandering / Default Network
- Most studies average data across many trials and across participants, or use only one region of a network
- At UCSF, we are taking this a step further

# Groundbreaking work at UCSF

UCSF University of California, San Francisco

Osher Center for Integrative Medicine



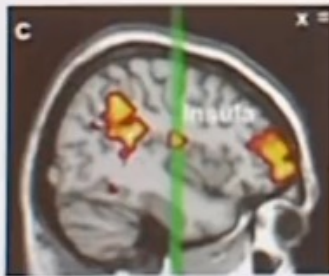
Dr. Adam Gazzaley



# Groundbreaking work at UCSF



Pattern Recognition



Attention



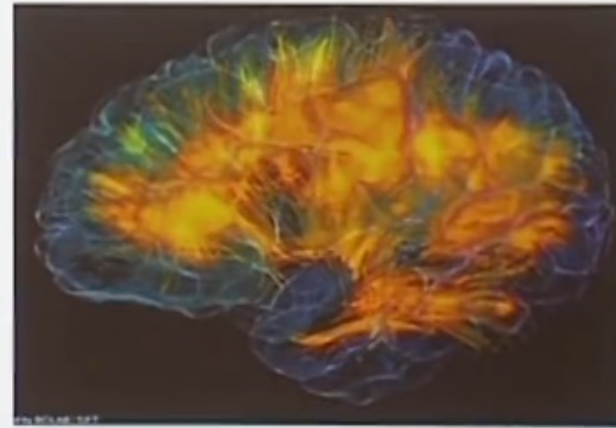
Mind Wandering



Individualized to each person

# We are currently recruiting!

- [www.embodystudy.com](http://www.embodystudy.com)
- Meditation experience: at least 5 years or very little experience



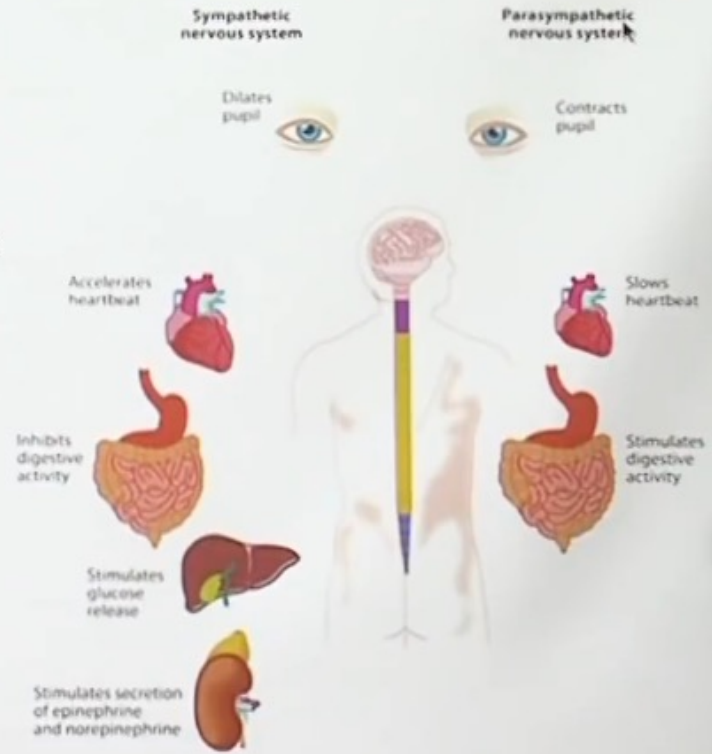
Meditation and emotions –  
balanced responses to all experiences  
accessing emotional knowledge



Emotions are signals about responses to the environment and are instantiated in the body



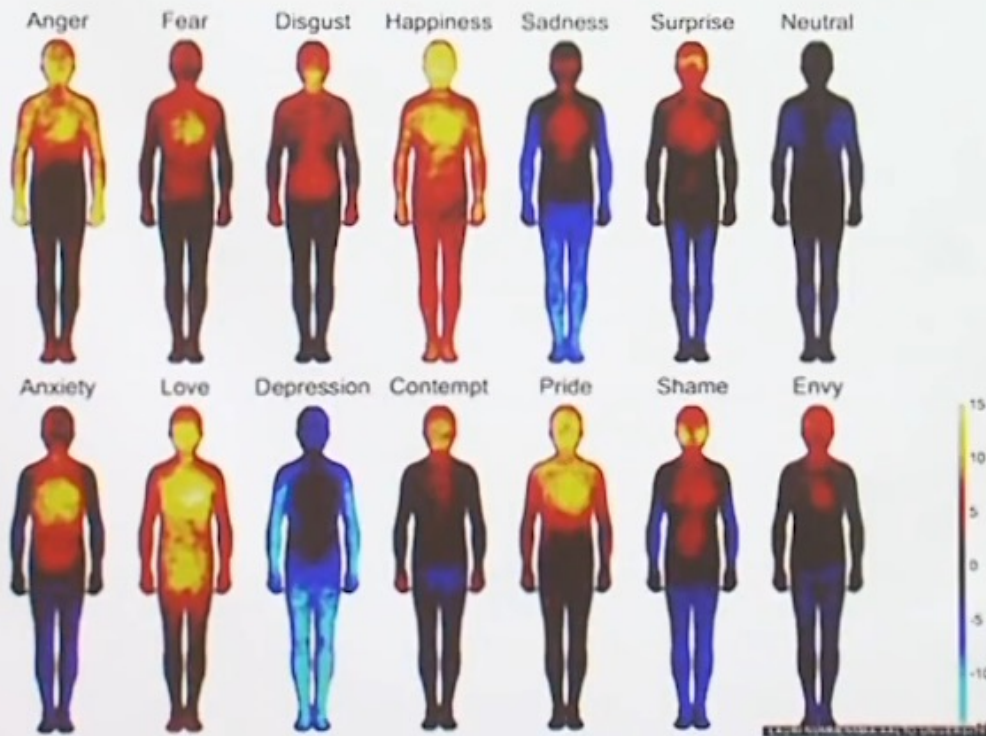
Interpretation



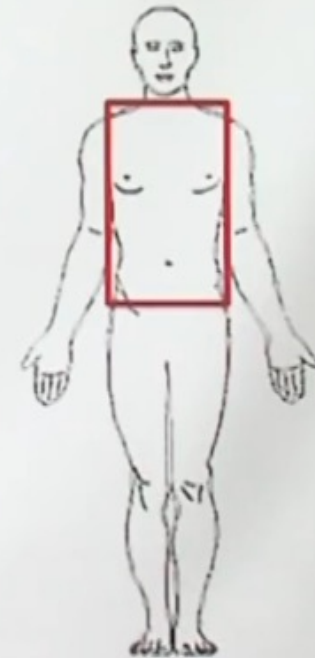


# Emotional awareness through body awareness

Emotions rated as colors in the body



Clinical Experience



Nummenmaa et al, *PNAS* 2014

# Meditation and emotions exercise

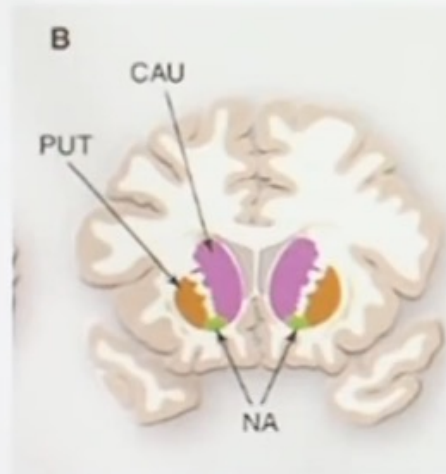


# Meditation and emotional health

- Clinical studies: Mindfulness-based interventions improve symptoms of depression, anxiety, chronic pain, stress, medical symptoms, general psychological symptoms
- Paul Gilbert conceptualization of emotion systems
  - Threat protection systems (negative)
  - The drive system (goals)
  - The contentment system (safety, connection)
- Mindfulness trains awareness and acceptance of all experiences
- What may be some of the neural mechanisms of these effects?

# Emotions (Sanfey, 2007) – limbic system, “reptilian brain”

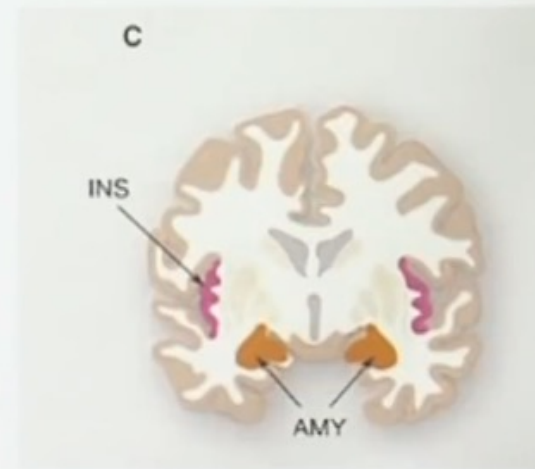
Move towards (“grasping”)



**Nucleus Accumbens (NA):** Reward

- social, monetary, drugs, food,
- habit formation
- Dopamine-based

Move away from (“aversion”)

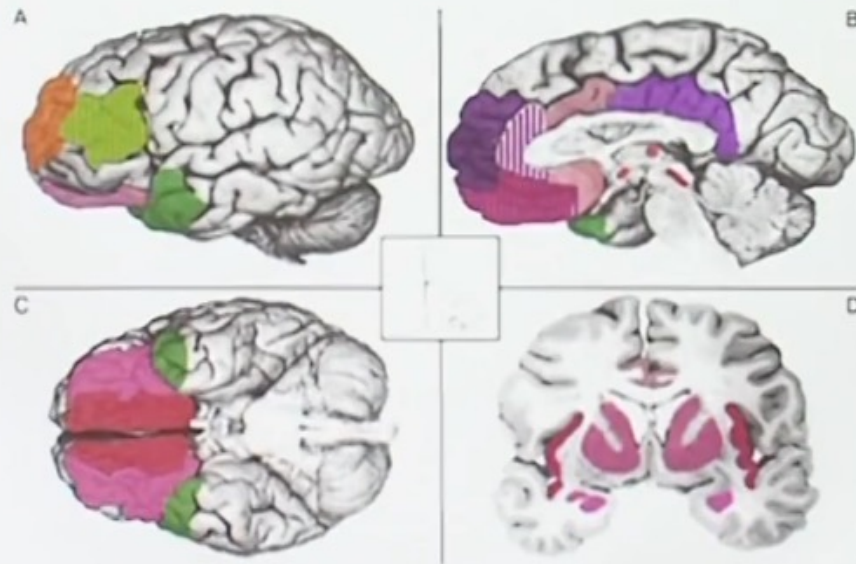


**Amygdala:** salience

- fear, anxiety, surprise
- Fight, flight, freeze

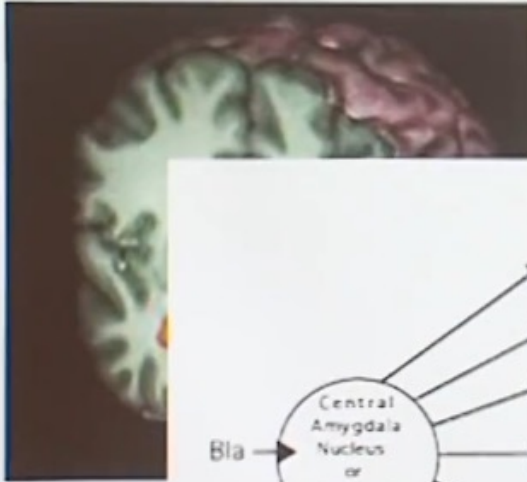
# Emotions - complex systems

(Lindquist et al., 2012)

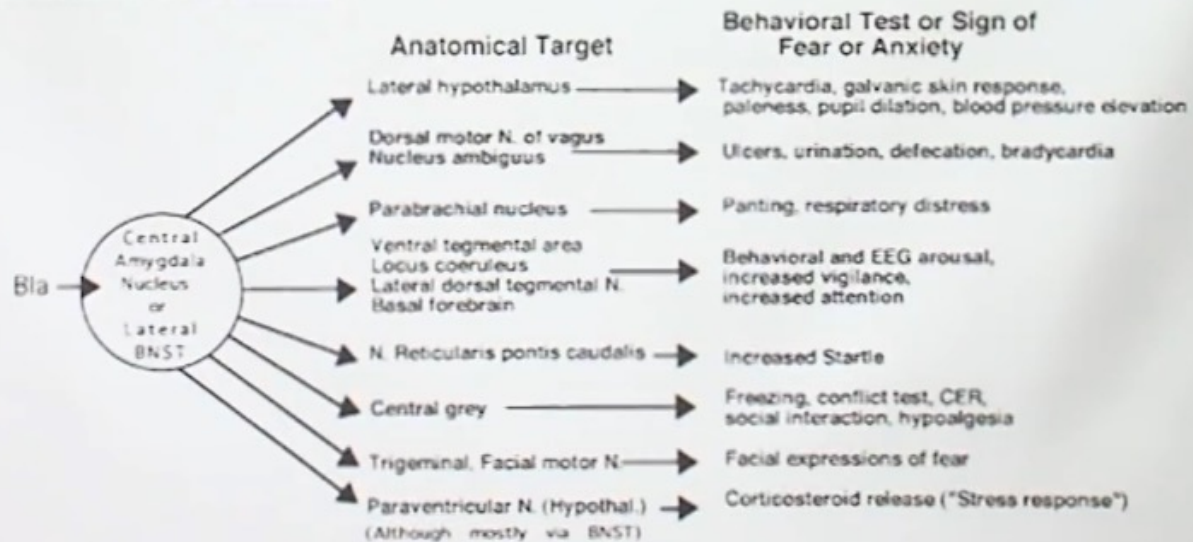


- **Core Affect** (pink) – amygdala, insula, mOFC, IOFC, ACC, thalamus
- **Conceptualization** (purple) – vmPFC, medial temporal lobe, PCC
- **Language** (green) – VLPFC, anterior temporal lobe
- **Executive attention** (orange) – DLPFC, VLPFC

# Saliience Detector: The Amygdala

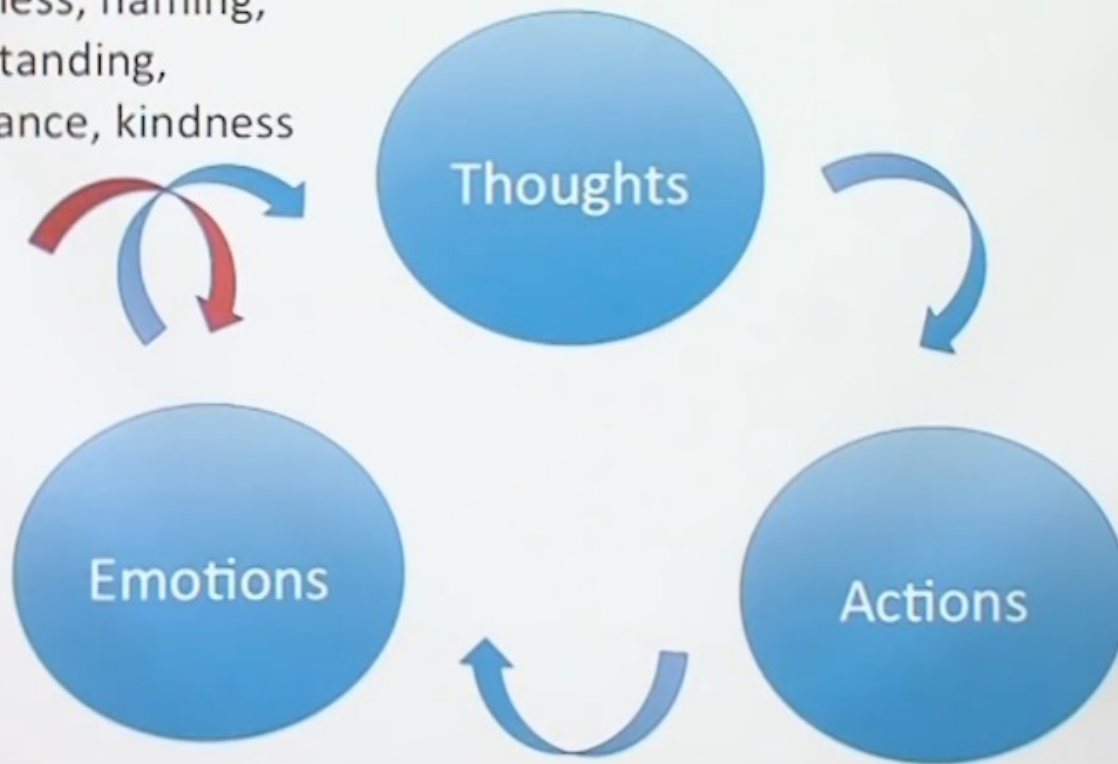


Threat:  
Fight, Flight, or Freeze



# Habits of suffering

**New habits:** sensing,  
awareness, naming,  
understanding,  
acceptance, kindness



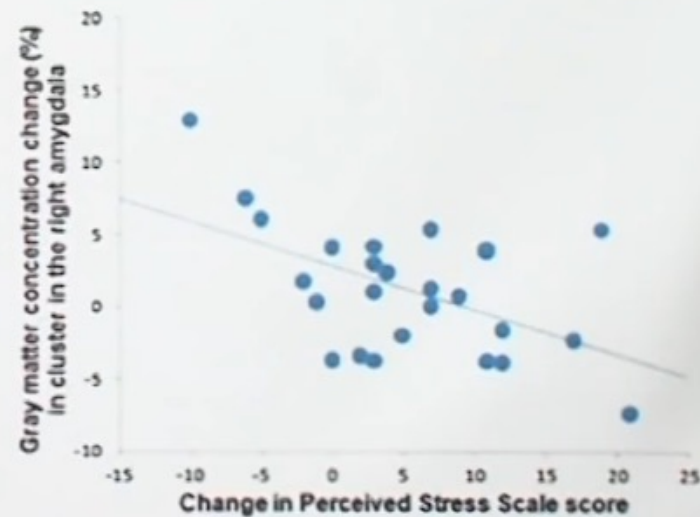
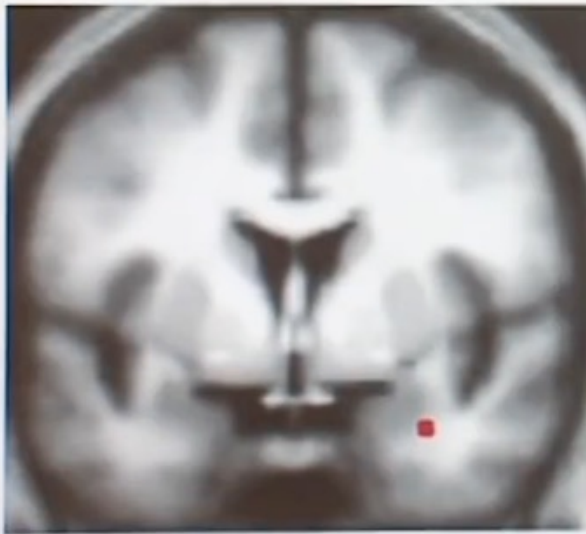
## Meditation can

- Lessen *additional* layers of suffering in response to emotions/pain
- Improve emotional understanding to recognize needs
- Inform adaptive “wise” action



# Mindfulness and Amygdala gray matter

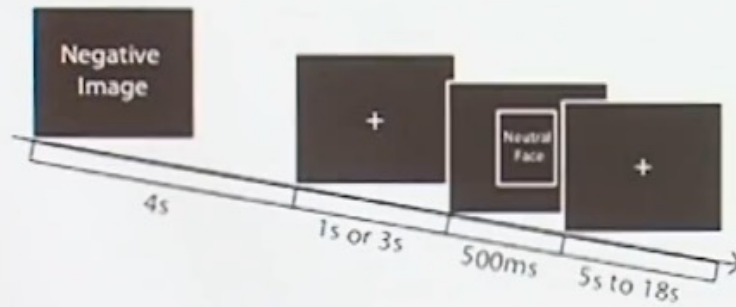
- 8 weeks of MBSR (no control)
- Measured gray matter density (neuronal cell bodies) with anatomical MRI before and after



Hoelzel et al., 2011

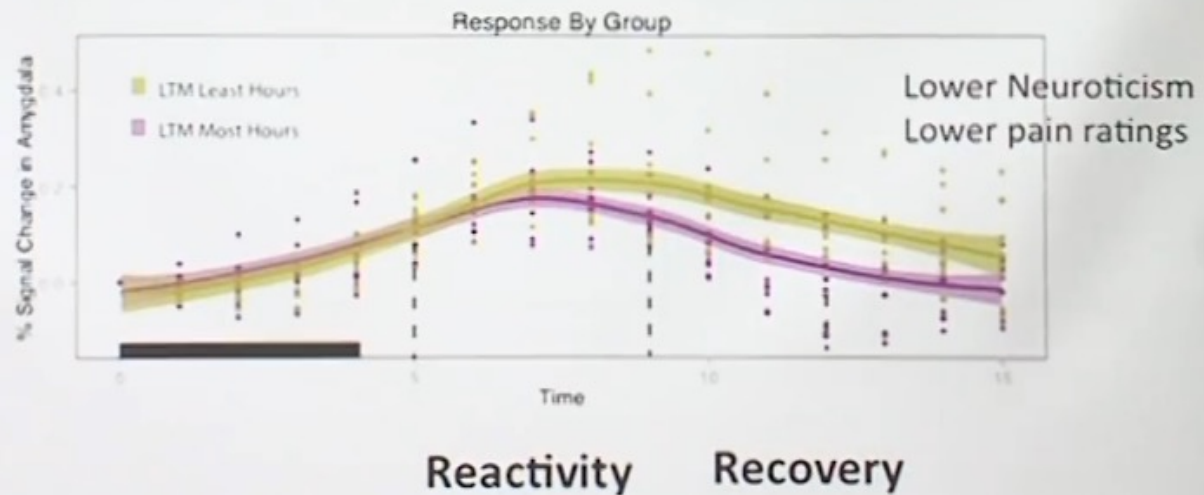
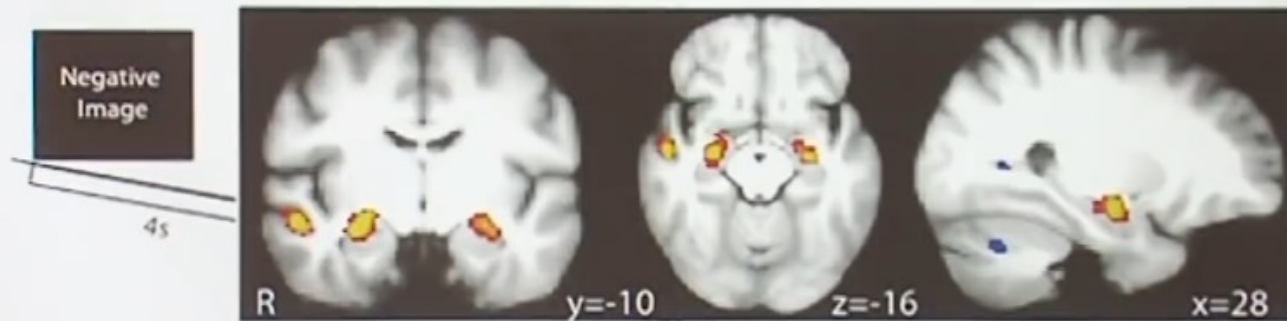
# Meditation practice increases amygdala recovery

(Schuyler, Weng, Davidson et al., under review)



# Meditation practice increases amygdala recovery

(Schuyler, Weng, Davidson et al., under review)



# Amygdala recovery associated with meditation practice type



Amygdala recovery associated with total hours, **greater mindfulness and compassion practice**. No relationship with concentration

## Summary

- Meditation training may increase amygdala gray matter and decrease stress
- Meditation training may increase amygdala recovery to negative events
- This may represent changes in the way the brain responds to threatening stimuli

# Lovingkindness and Compassion Meditation

Improve relationship to self and others

Lovingkindness – wishing well-being

Compassion – caring for and wishing relief from suffering



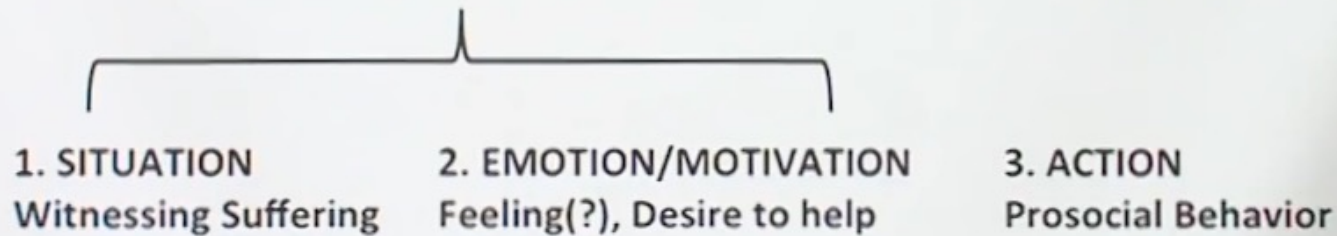
# Relationships and Health



House et al., 1988; Uchino, Cacioppo & Kiecolt-Glaser, 1996;  
Cohen & Wills, 1985; Holdt-Lunstad et al. 2010; Copeland et al. 2013; Alloy et al., 2001

# Compassion: A route to healthier relationships

Compassion is described as “the feeling that arises in witnessing another’s suffering and that motivates a subsequent desire to help” (Goetz et al., 2010)





# Strengthening the Compassion Muscle



Loved One

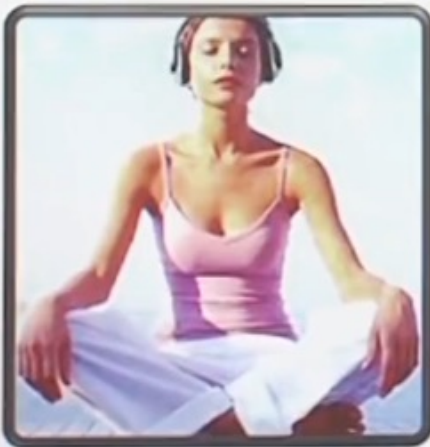


Difficult Person



# How does compassion meditation impact the brain and helping behavior?

Compassion Practice



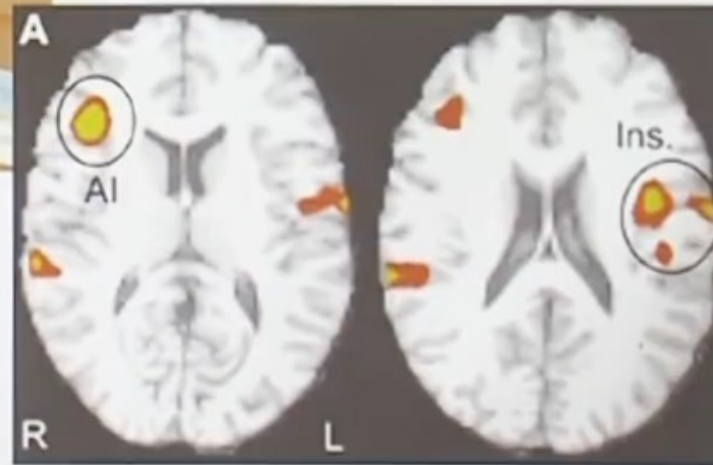
Real-world behavior



# Compassion experts



**Anterior Insula** – bodily awareness,  
Emotional responses, empathy



Lutz, Davidson et al., 2008; 2009

What about people like you and me?

Does compassion meditation change  
our brains and how we treat others?

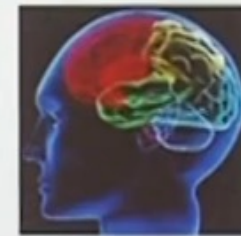


# How do we study Compassion Training?

Before



After



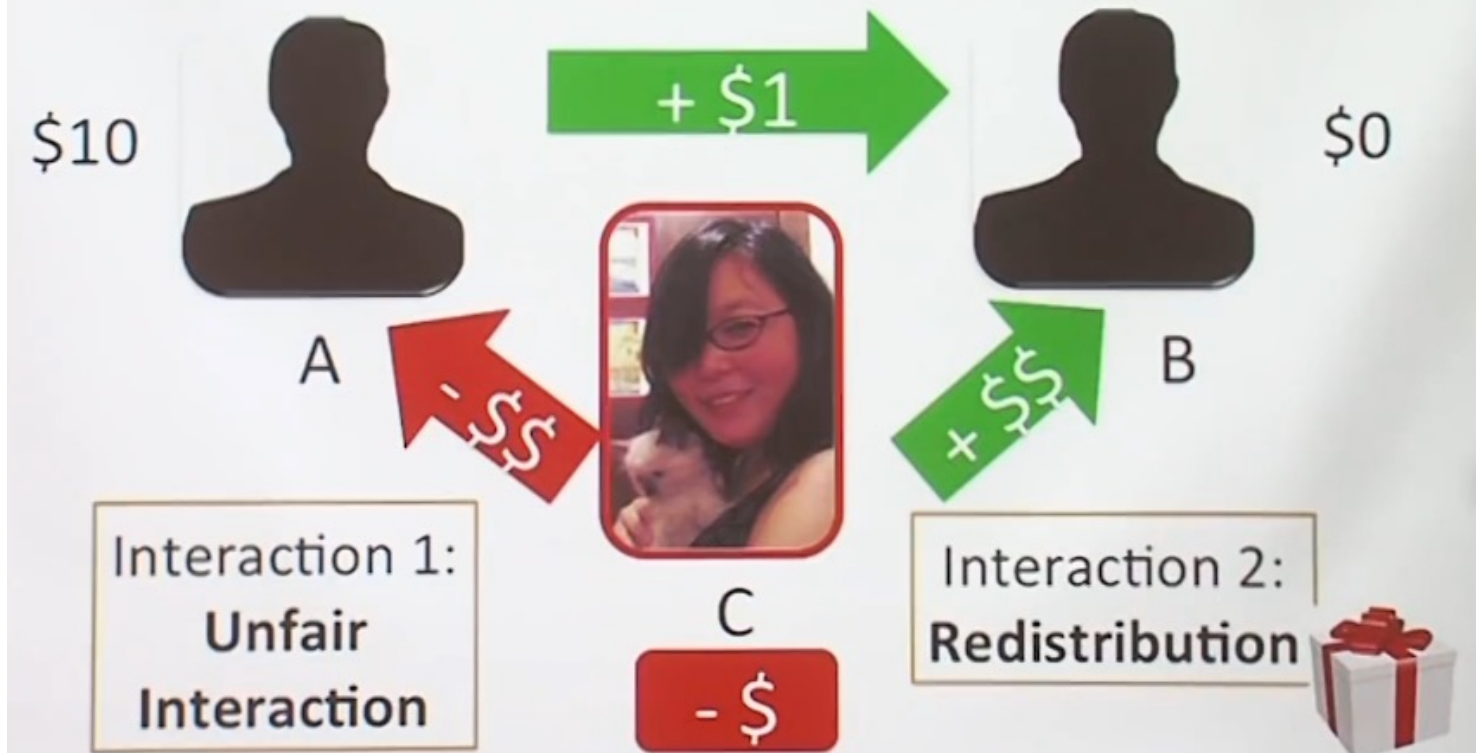
30/min day on the Internet  
for 2 weeks

Random  
Assignment

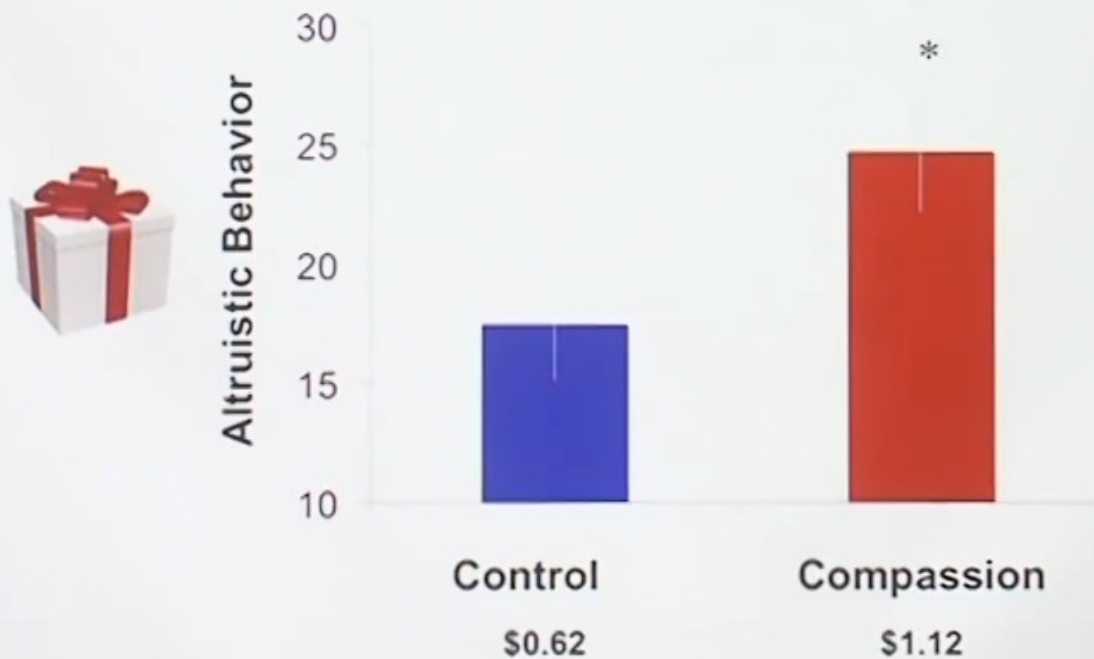
Compassion Training

Control Training

## Measuring compassionate behavior: Redistribution Game

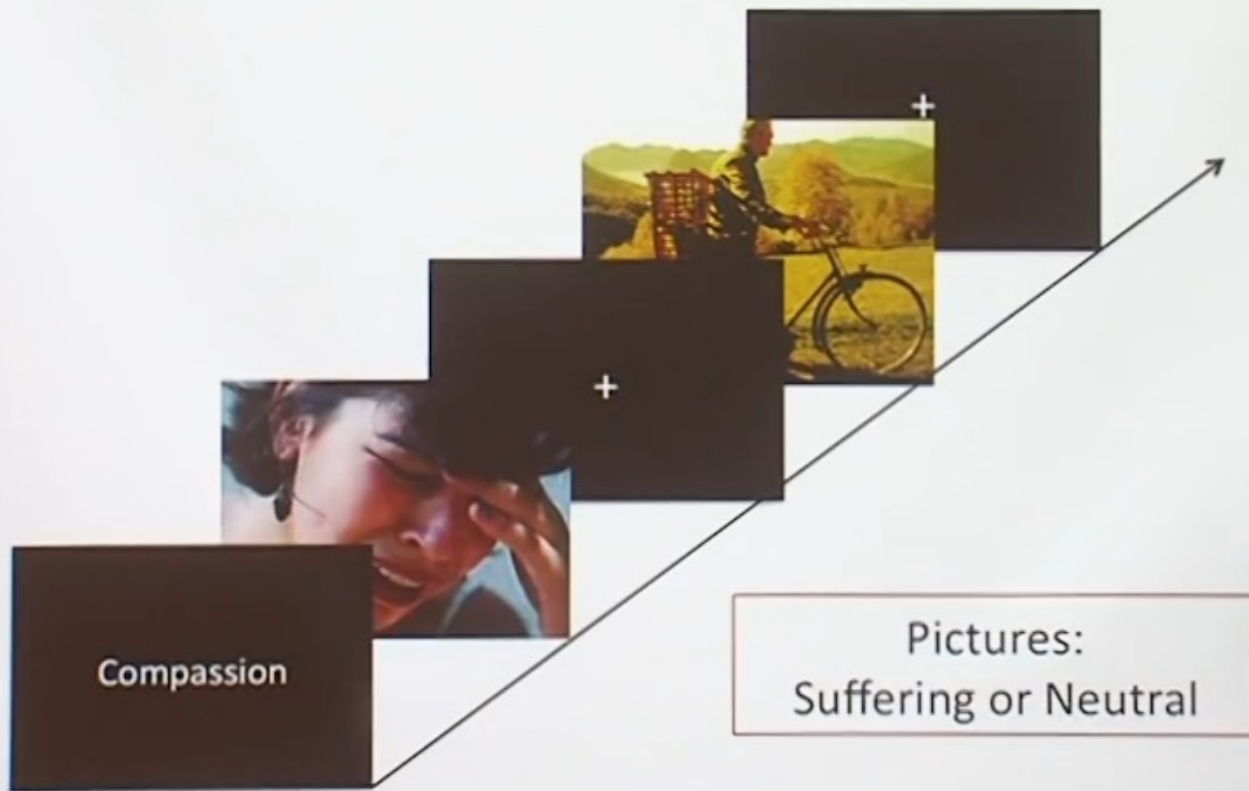


## Compassion training increases altruistic behavior after 2 weeks



Weng, Fox, Shackman, Stodola, Caldwell, Olson, Rogers & Davidson  
*Psychological Science* (2013)

# fMRI Paradigm: Before and After Training





## Neural Hypotheses based on Psychological Theory

- Compassion training will increase
  - **Empathy** – awareness and shared experience of suffering (Singer; Klimecki; Zaki)
  - **Emotion regulation** – ability to regulate both positive and negative emotions to increase prosocial responses (Batson; Eisenberg; Decety)
    - Increase empathic concern
    - Decrease personal distress

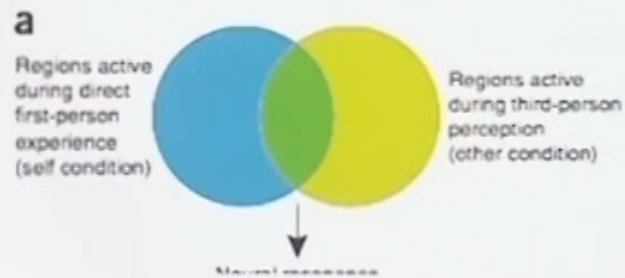
## Mind & Life 2012: “Effortful Compassion”



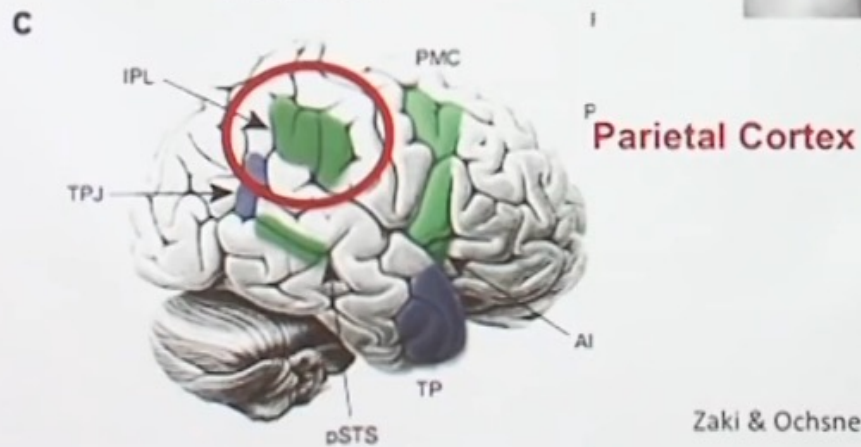
Richard Davidson, PhD, David Vago, PhD, Willoughby Britton, PhD,  
His Holiness the Dalai Lama, Helen Weng, MS, Baljinder Sahdra, PhD,  
Norman Farb, PhD

# COMPASSIONATE BRAIN CHANGES – EMPATHY LITERATURE

## Experience Sharing “Mirror Neurons”



Rizzolatti & colleagues



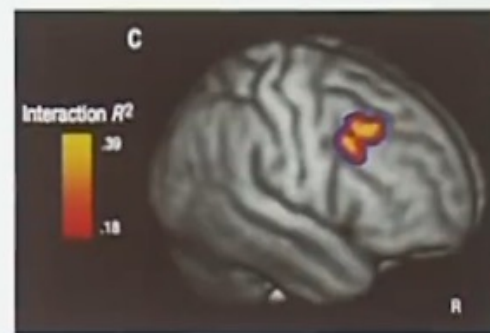
Zaki & Ochsner, 2012

# Compassionate brain changes result in more altruistic behavior

↑ Parietal Cortex

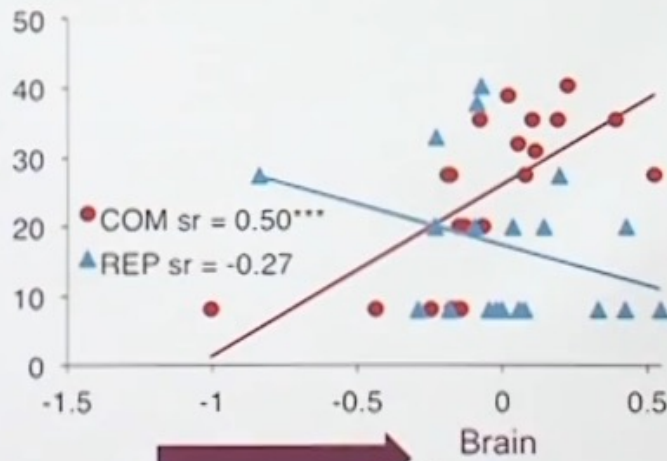


↑ Prefrontal Cortex



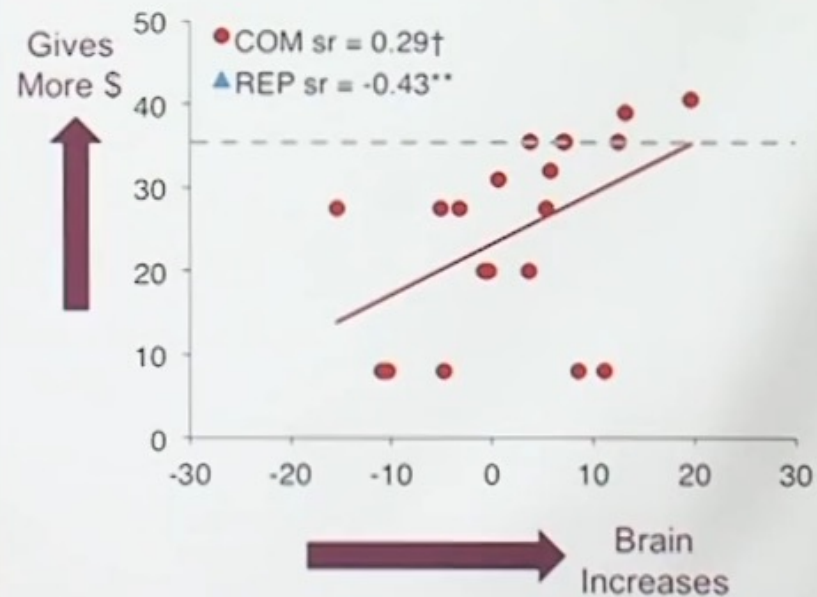
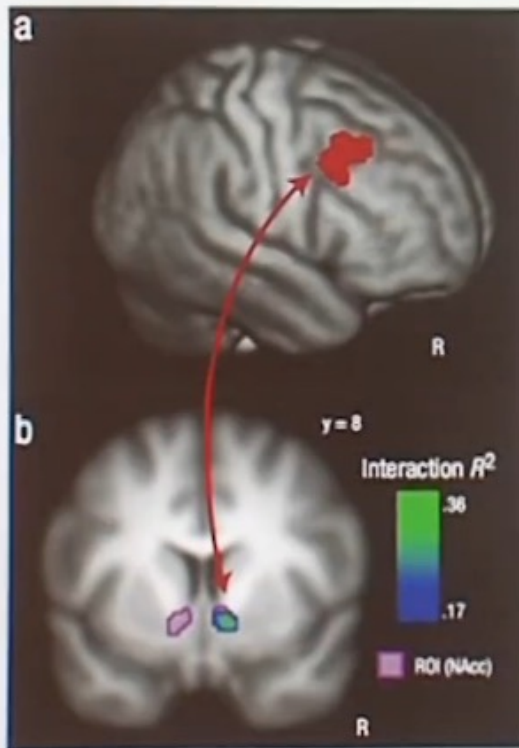
Empathy /  
Mirror Neuron  
Network

Gives  
More \$



Weng et al., 2013

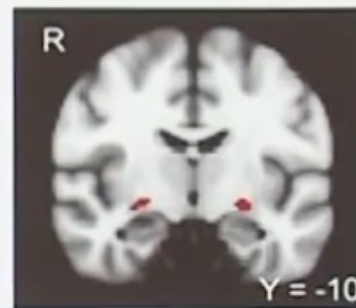
# Greater communication between the PFC and reward system from compassion training



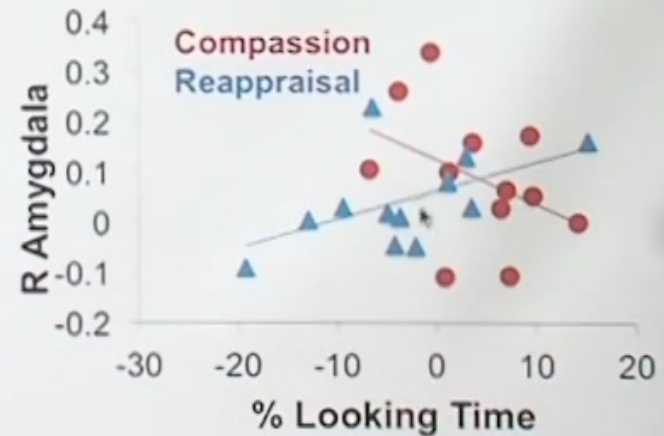
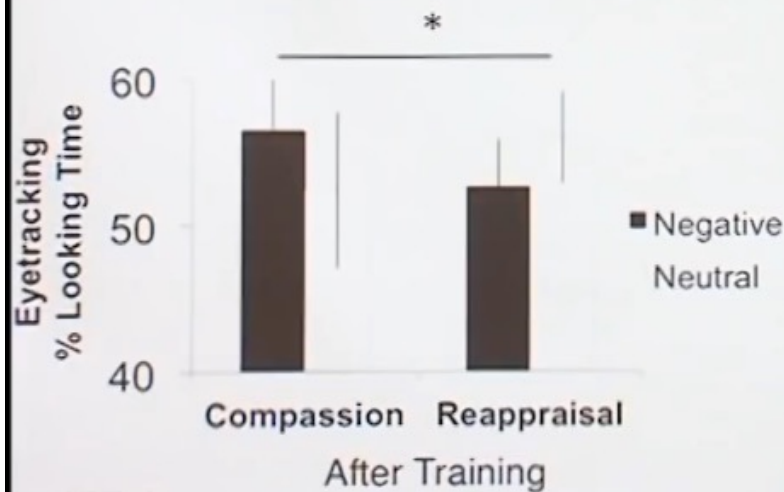
R Nucleus Accumbens – reward system

Weng et al., 2013

# Compassion training increases visual attention to suffering and decreases amygdala responses



Centromedial Amygdala



CAN  
COMPASSION  
BE LEARNED?



# Free Download

## Try It and Share It!



<http://centerhealthyminds.org/well-being-tools/compassion-training/>

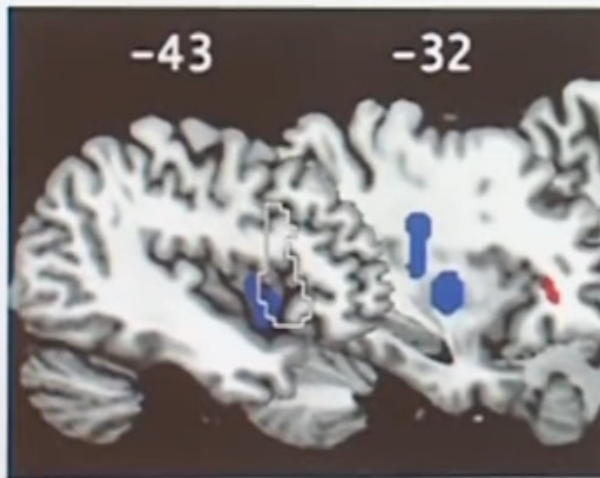
# Empathy vs. Compassion training

(Klimecki, Singer et al., 2013)

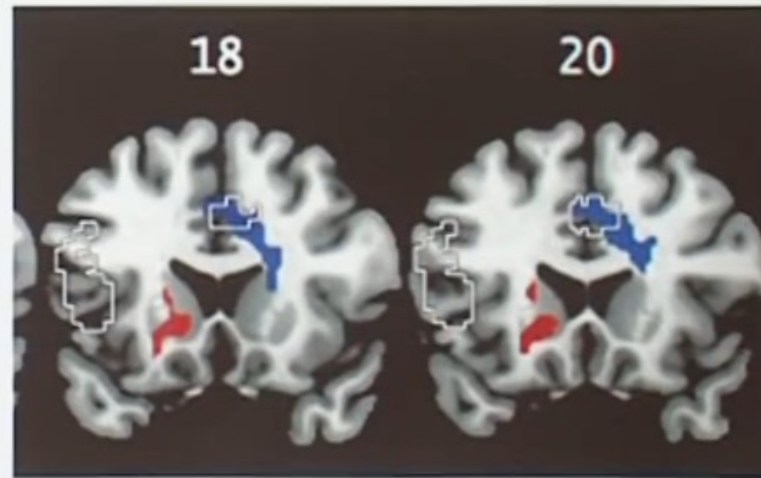
- 4-week training within same participants
  - Empathy training – resonating with suffering
  - Compassion training – friendliness and caring
- “Compassion fatigue” in health care (Figley) = “empathy fatigue”
- **Empathy training increases negative emotions** in response to videos of suffering
- **Compassion training increases positive emotions** and decreases negative emotions caused by empathy training



## Empathy and Compassion training activate different networks



Empathy training  
Increases insula



Compassion training  
Increases ventral striatum

Klimecki, Singer et al., 2013

# Take home message



University of California  
San Francisco

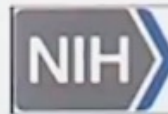
*advancing health worldwide™*

Training our internal mental lives can have positive effects on our minds, health, and relationships



# Thank you!

- **UCSF Osher Center for Integrative Medicine**
  - Rick Hecht, MD and Shelley Adler, PhD
  - Maria Chao, DrPH, MPA
  - Vierka Goldman
- **UCSF Neuroscience Imaging Center**
  - Adam Gazzaley, MD, PhD
  - David Ziegler, PhD
  - Melina Uncapher, PhD
  - Sasha Skinner, AJ Simon, Faye McKenna, Ryan Lopalito
- **UCSF Psychiatry**
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  - Tiffany Ho, PhD
  - Colm Connolly, PhD
  - Eva Henje Blom, MD, PhD
- **UW-Madison Center for Healthy Minds**
  - Richard Davidson, PhD
  - Larissa Duncan, PhD
- **UT-Austin**
  - Jarrod Lewis-Peacock, PhD




National Center for  
Complementary and  
Integrative Health



Development of mindfulness is integral to the myriad of different meditation practices and is often considered one of the first steps in meditation training.


Accordingly, mindfulness can be developed in many different ways, breath-focus being a common approach in secular meditation-based program and Theravada Buddhist schools. Other approaches include visualizations-based practices and mantra recitation, focusing on a visual object (either sacred object or any neural object such as a point on the ground or a pebble), focusing on sounds etc. Mindfulness can also be developed in more discursive meditation practices, for example, in focused contemplation on a certain topic (e.g., preciousness of human life or nature of suffering) as long as the contemplations involve elements of sustained attention on the topic, monitoring of distraction and non-reactive control of attention which helps return attention back to the topic of meditation. However, discursive mindfulness meditation of this type is unlikely to lead to high levels of stability described in the Shamatha training due to elaborative verbal (even if silent speech) nature of these practices.

Mindfulness practice can be embedded into our everyday activities to support the connection between the effects of our formal practice and everyday functioning and to increase the quantity and quality of our mindfulness practice. Exploring ways to spend a usual day mindfully, we can start in the morning right after we wake up by remembering the motivation/intention for the day. This is particularly important in the Buddhist context where motivation/intention gives direction to all meditation practice. After setting the motivation for the day, we can do a brief mindfulness practice which can take on different forms depending on the context, the practice might simply involve attending to the sensations in our body, for instance by doing a brief body scan as we are still lying in the bed or as we sit up. In the Tibetan Buddhist context, the mindfulness practice might be a set of visualization and mantra practices, often those focusing on taking refuge and cultivating compassion for all beings. The meditations can also include brief contemplations on topics such as impermanence, opportunities of the day to develop our meditation practice and reminders about different forms of suffering and a path towards liberation from suffering. Some practitioners may prefer, and be able to engage in, a longer and more formal meditation session on the cushion. Whatever the duration of this initial morning practice, whether 5 minutes or 1 hour, developing a regular routine of waking up in a more settled meditative way may contribute to our well-being.



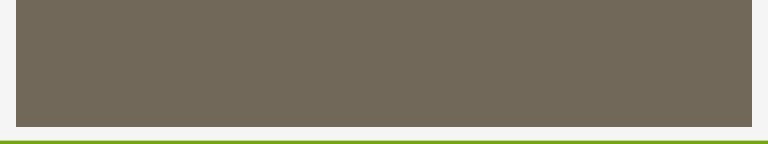
The initial more formal mindfulness practice right after we wake up may be followed by informal practices while we are engaging in the morning routines. Almost any of these activities can be turned into a mindfulness practice if we stay in the present moment focusing on the activity at hand while regularly monitoring sensations, emotions and thoughts in our mind and body. This would involve noticing when we are getting tense and feel pressed for time and pausing for a moment, or noticing moments of contentment and savoring those. It might be helpful to select a couple of activities from the morning routines during which we engage in mindfulness – it might be tooth brushing, making a tea or coffee, having breakfast or getting dressed. Meditators practicing in the Buddhist context may apply a slightly different approach, where, for example, they use everyday routines as reminders of contemplative topics such as impermanence or motivation for the day, or they can recite silently a mantra or do visualizations during some of the morning activities. They may also mindfully engage in loving kindness and compassion practices.

These practices can continue while commuting to work and can become a useful way to turn a dull everyday activity into a refreshing mental practice. At work, mindfulness can be practiced while working by staying present with the task at hand and reducing distractions if possible. Some of the distractions may be inevitable, other distractions are self-initiated – for example, many of us repetitively check e-mails while engaging in a task even when it is not necessary. We can also practice meta-awareness by noticing when we start to ruminate about past or future activities which are not relevant to the task at hand, and then gently return our attention back to task. A Buddhist practitioner can also use moments of distraction as a reminder of some aspect of their practice, whether it is a contemplative topic such as loving kindness or impermanence or devotional practice. It can also be particularly helpful to build in a brief break every hour, or at any other regular interval that is possible, and use these breaks for short 205 minute meditation practices. These could involve mindful stretching, mindful attention to the breath or the body, listening mindfully to sounds or, in the Buddhist context, doing a brief visualization or compassion practice. The key element of mindfulness practice here is to remember these little meditation breaks, staying present while doing the meditations and monitoring for distractions.



Lunch break can be another opportunity to practice mindfulness, from walking mindfully while getting the meal, to eating the meal mindfully instead of multitasking while eating or eating the food while planning the tasks for the afternoon. Depending on what is possible, lunchtime might be also an opportunity to engage in a short practice of 3-10 minutes which might be refreshing and help us engage our attention during the afternoon in a more balanced and less tense and exhausting way. During the afternoon, we can apply the same principles as in the morning: staying present on tasks, reducing distractions and introducing short mindfulness practice breaks. For example, we can use a coffee break for a brief mindfulness practice –start by walking down the corridor while noticing the movement of our body and placement of our feet, staying present while making the tea, noticing the smell and taste of the tea while drinking etc. We can also try to include brief afternoon breaks to check for tension in our body and relax or stretch if needed. A meditator practicing in a traditional meditation context can use the tea break for gratitude practice or to do focused practice on a sacred object, mantra or visualization.

The commute from work can again be used to settle the mind and body, perhaps returning to the mind and body, perhaps returning to the mind and body in the present moment after a busy afternoon. Or it can be an opportunity to do other calm abiding practices on the go, by focusing on sounds or any neutral visual object in the environment. Buddhist practitioners can use the time to refocus on contemplative topics of their practice, do devotional practices or visualizations. After returning home, preparation of an evening meal and talking with family can also be opportunities to stay in the moment and practice mindfulness without the need to ruminate about what happened at work or plan for the next day. Engaging with a family in a mindful way may simply mean giving them full attention and being aware of our responses and their feelings, thoughts, expressions etc. Meal time can again be an opportunity to practice focus on the senses and also being fully present with others. In the Buddhist context the meal time can be also an opportunity for practicing generosity, gratitude, loving kindness and compassion together with a brief visualization meditation.



In the evening, mindful approach can enable us to be more aware of our choices of spending the time. We may notice that we have a habit of watching TV programs or doing some activities which are not necessary or helpful to our well-being. We may change our choices instead. We can also choose to do further formal meditation practice, a brief one or longer one, according to what is possible and how we want to engage with our meditation practice. It might be that mindfulness help us to get to sleep in the evening or it might be that we practice for spiritual reasons and the formal practice in the evening is an opportunity to reflect and to do a deeper meditation practice. A Buddhist practitioner would typically end the day by reflecting on her practice during the day and dedicating virtue accumulated during the day for further progress on the path and for liberation of all beings from suffering.

# Neuroscience of mindfulness

- Attention training in mindfulness-based approaches
  - Mindfulness
  - Metacognitive awareness
  - Acceptance
  - Self-compassion
  - Decentering (MBCT)
  - Visualization (Shamatha)
  - Loving kindness and compassion (Shamatha)
- Study to investigate neurocognitive changes in attention resulting from MBSR training specially focused on **three attention networks**:
  - **Alerting network** is linked to the ability to sustain a state of vigilance and detect changes in that state; and
  - **Default mode network**, usually activated during moments of distraction (off-task activity)
  - **Saliency network**, supports monitoring for and noticing distraction
  - **Executive network (conflict-monitoring)** prioritizes amongst competing information and tasks
  - **Orienting network** relates to the ability to direct attention and selectively attend to relevant information in the environment;

None of the networks work in complete separation from the other networks and there is also certain neural overlap between them.
- Longer meditation training may further enhance both sustained attention and the ability to notice distractions while focusing on a meditative object
- Other types of meditation training which include mindfulness for different outcomes, for instance, neural mechanisms of mindfulness included factors such as exposure, memory mechanisms (extinction and reconsolidation of memories), reappraisal (changes in ways we think about experience) and perspective on the self (Holzel et al., 2011).



# Secular mindfulness training

- The retreat participants were able to perform better on a **sustained attention** task which required subtle perceptual discrimination, possibly due to enhanced abilities of vigilance and clarity in perceptual discrimination. These findings suggest that the retreat training may have particularly improved the metacognitive element of attention cultivated in Shamatha which would be expected in the more advanced stages of Shamatha training.
- Motivation to perform better might be a significant contributing factor to results reporting improvements in attention after meditation training.

# Meditation practice modifies the metacognitive self-regulatory capacity (MSRC) of the mind and modes of existential awareness (MEA)

- Mindfulness as a practice targeting the development of MSRC, particularly attention and meta-awareness skills together with an attitude of non-reactivity (Dorjee, 2016). Such characterization of mindfulness is more narrow than the conceptualization of mindfulness in MBSR or MBCT because it does not equate mindfulness with intention of meditation practice, a mode of awareness or a range of emotion qualities such as acceptance, kindness etc.
- The definition of **mindfulness** in terms of changes in **non-reactive attention and metacognition/meta-awareness** as the core processes of MSRCs at the same time broader than some Buddhist accounts of mindfulness which single out **meta-awareness** as a separate faculty.
- The definition points to the central role of mindfulness in the development of **self regulation** as one of the two core pillars of **well-being**.
- Mindfulness is indispensable in both Shamatha practices, which aim to develop **attention stability and control**, and in Vipassana practices, which apply refined **non-reactive attention and metacognition** abilities in examining the nature of self, mind and reality.

- Training to produce strong health conducive changes in emotion regulation and well-being
  - Mindfulness in terms of non-reactive attention and meta-awareness
  - Practice of acceptance (MBSR and MBCT)
  - Adaptive emotion regulation strategies
  - Emotion qualities of loving kindness, compassion, rejoicing and equanimity
  - Inquiry into mental habits (MBSR and MBCT)
  - Education about stress or cultivation of decentring (MBSR and MBCT)