Binocular Rivalry

This tutorial provides an introductory exploration of binocular rivalry with a review of some theoretical concepts and important research relevant to the field.

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When faced with ambiguous visual information you normally don't experience a combination of the different interpretations. Instead, you will see only one interpretation. After time, your perception will begin to switch between each of the competing ("rivalling") alternatives.

The images that cause this Perceptual Rivalry have a few names:

- Ambiguous
- Bistable/multistable
- Rivalrous

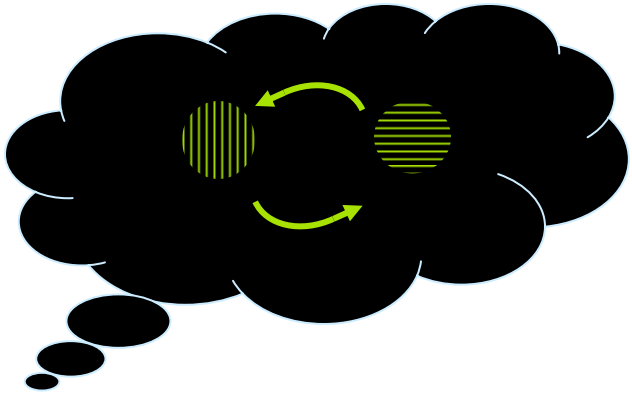
old / young
woman

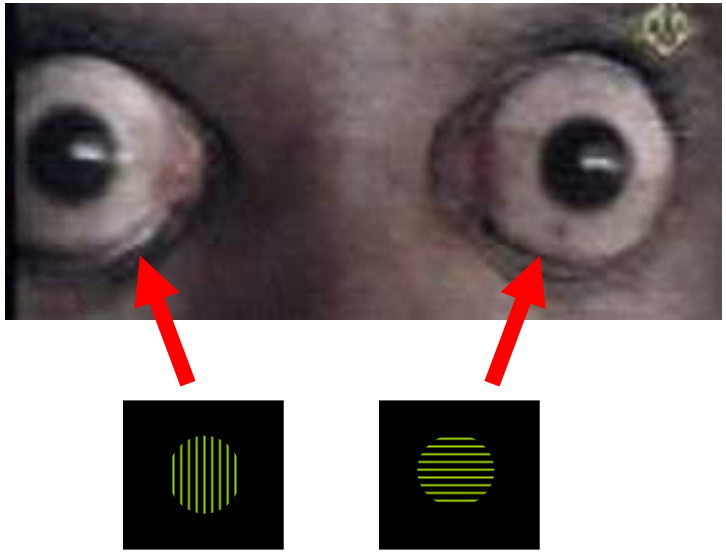
2 faces /
1 face behind candle

Blue face of cube
Front / back

Binocular Rivalry is a type of perceptual rivalry. When two different images are presented to the two eyes simultaneously, you are only conscious of one of the two images at a time.

- one is dominant, the other is suppressed
- every few seconds the perceptual dominance will switch





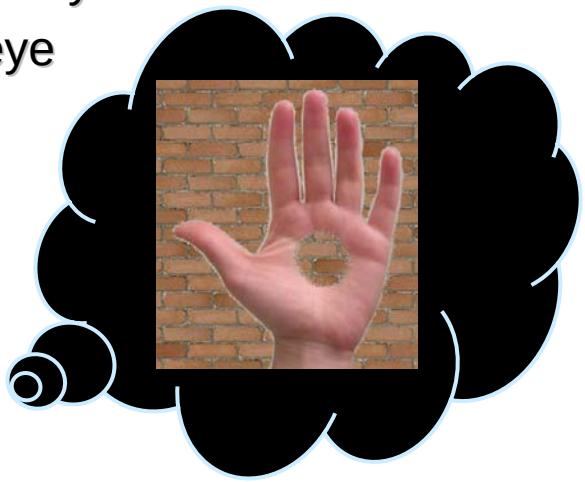
right eye image

left eye image

During Binocular rivalry all/part of one image appears totally suppressed from consciousness.

- To experience this suppression yourself

1) roll up some paper like a telescope.
2) look through it with your right eye & put your left hand next to the paper roll a few inches in front of your left eye



The image seen through the paper roll will suppress a section of the hand.

Note: The hand will generally stay suppressed because it is the “weaker stimulus” (the images need to be “equal strength” for rivalry – if you hold still and face a blank wall you might get rivalry between the wall and hand in the central patch).

Turn your flesh into beer …. If you are very bored you can even experience rivalry at the pub!!

All you need is  &

Why is binocular rivalry interesting?

Each image is constantly presented but every few seconds we switch from being conscious to unconscious of the image

… if we can identify what is different about the brain when someone is conscious vs unconscious of the image, we may have solved one of the biggest questions left in science….

*** The **BIG** question ***

How does the brain generate conscious experience?

- the search for a neural correlate of consciousness (NCC).

The Answer …??

…Lots of ideas from philosophy, but no evidence from science yet!!

A few smaller questions…

1) At what level of processing is the “competition” between the images resolved? … Early or Late?

2) Which stimulus factors influence perceptual dominance?

3) How much information can be processed “unconsciously”?

4) What is driving the switches in perception?

The Answer …. some ideas discussed in next few slides….

At what level of processing is the "competition" between the images resolved?

It has been proposed that binocular rivalry is resolved EARLY in the visual pathway, resulting from mutual inhibition between monocular neurons in primary visual cortex (V1) (Blake, 1989)

- In other words, each EYE's image is alternately suppressed.

Supporting evidence

-Using fMRI, neural activity was found to change in time with perception in monocular regions of V1 (Tong & Engle, 2001; Polonsky et al, 2000)

- When the images being presented to the dominant and suppressed eye are interchanged, observers will continue seeing with the dominant eye - causing the previously suppressed image to become dominant (Lee & Blake, 2004; Blake et al, 1980)

Continued….

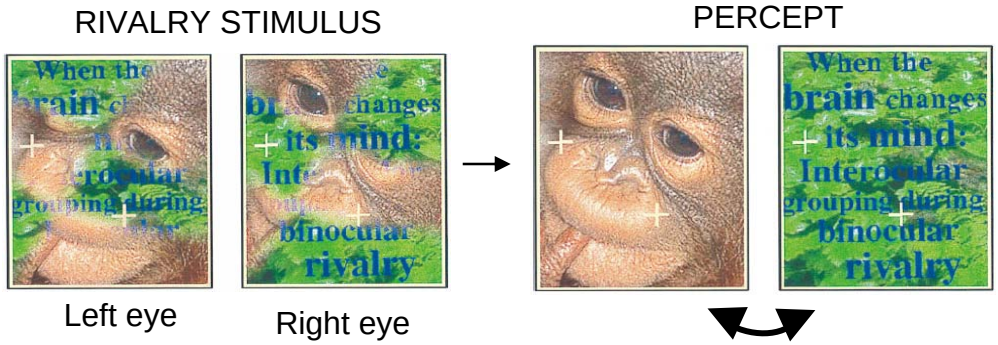
HOWEVER evidence also suggest that rivalry is resolved LATE (in higher cortical) areas after information from the two eyes has been integrated. – rivalry between images

<u>For example</u>

Normal, coherent rivalry dominance (2sec) will be seen if…

- the eye of presentation is swapped quickly (200ms) (Logothetis et al., 1996)

- you present corresponding patchwork images to each eye (see figure) (Kovaks et al, 1996)



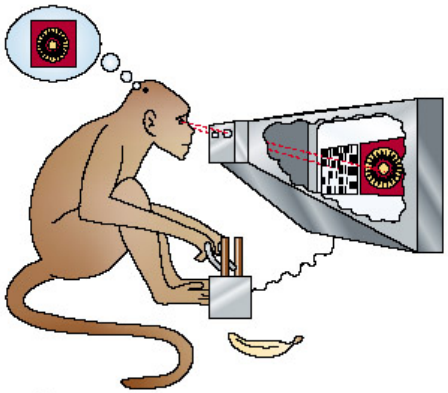
Colour and motion cues from two competing rivalry stimulus can be decoupled &/or integrated independently (Carney et al, 1987; Carson & He, 2000)

At what level of processing is the "competition" between the images resolved?

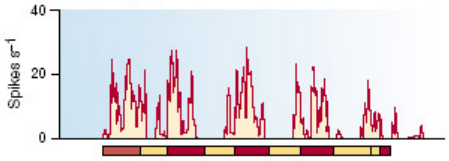
Continued….

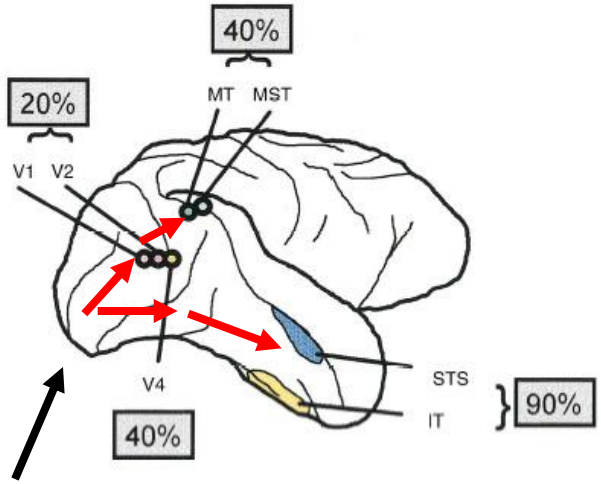
Electrophysiology experiments in monkeys show that the proportion of neurons firing in time with perception increases at higher levels of processing (Logothetis & Schall, 1989; Leopold et al., 1996)

Neural activity is recorded while, monkey reports what it sees. →



Neuron is active, only when it reports one of the two percepts. →





More neural activity correlates with perception at later stages of processing.

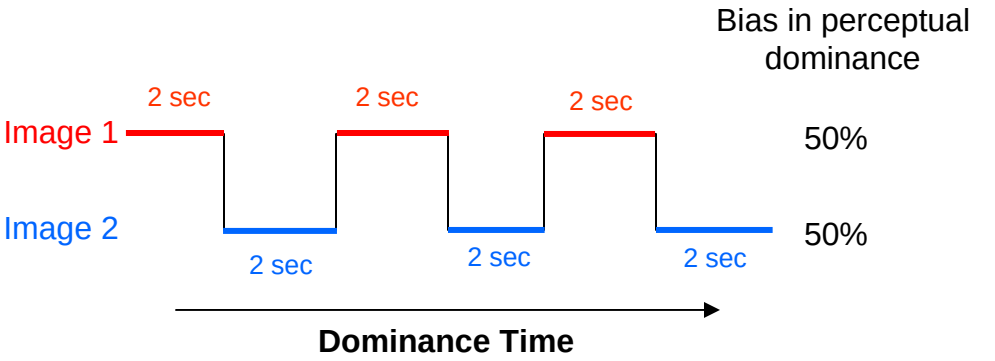
>> Together these results suggest a hierarchy of competition at multiple levels of processing.

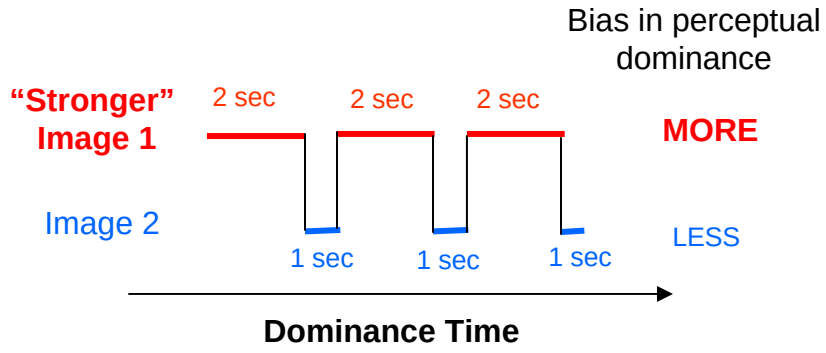
Which stimulus factors influence perceptual dominance?

Stimulus "strength"

Increasing the strength of one stimulus, by adding motion or contrast etc.., will increase its dominance by decreasing the duration of its suppression - This is sometimes termed Levelt's 2nd proposition.

(Breese, 1909; Mueller & Blake, 1989; Levelt, 1965)





Salience also makes a difference!

For example, an upright faces will dominate over an upside down or a garbled face (Engel, 1956; Yu & Blake, 1992)

Note: the image through the paper role (shown on previous slides) dominates most of the time because it generally has more motion and salience cues.

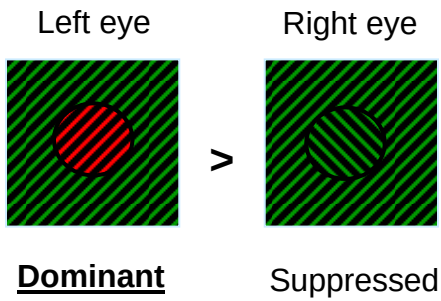
"stronger"

Which stimulus factors influence perceptual dominance?

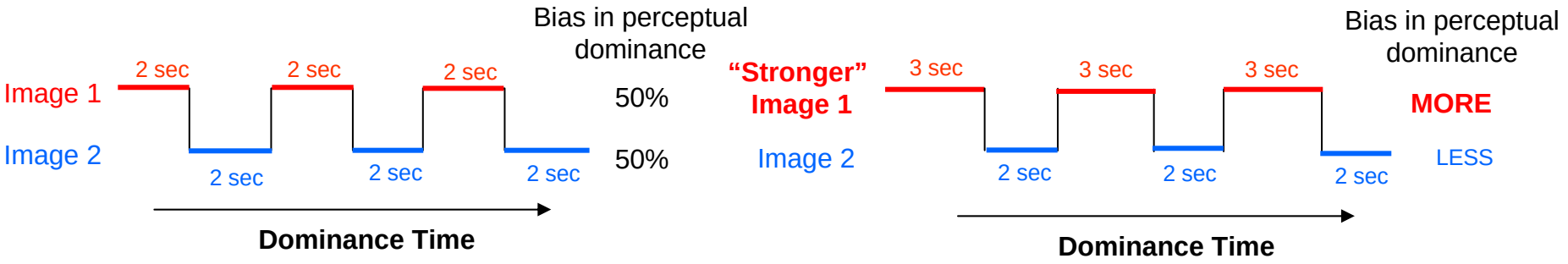
continued…

Context

Addition of a contextual background will increase predominance of the inconsistent target (Fukuda & Blake, 1992; Carter et al., 2004)



NOTE: In this context effect, dominance is increased due to increase in dominance phase duration ("anti-Levelt" effect).



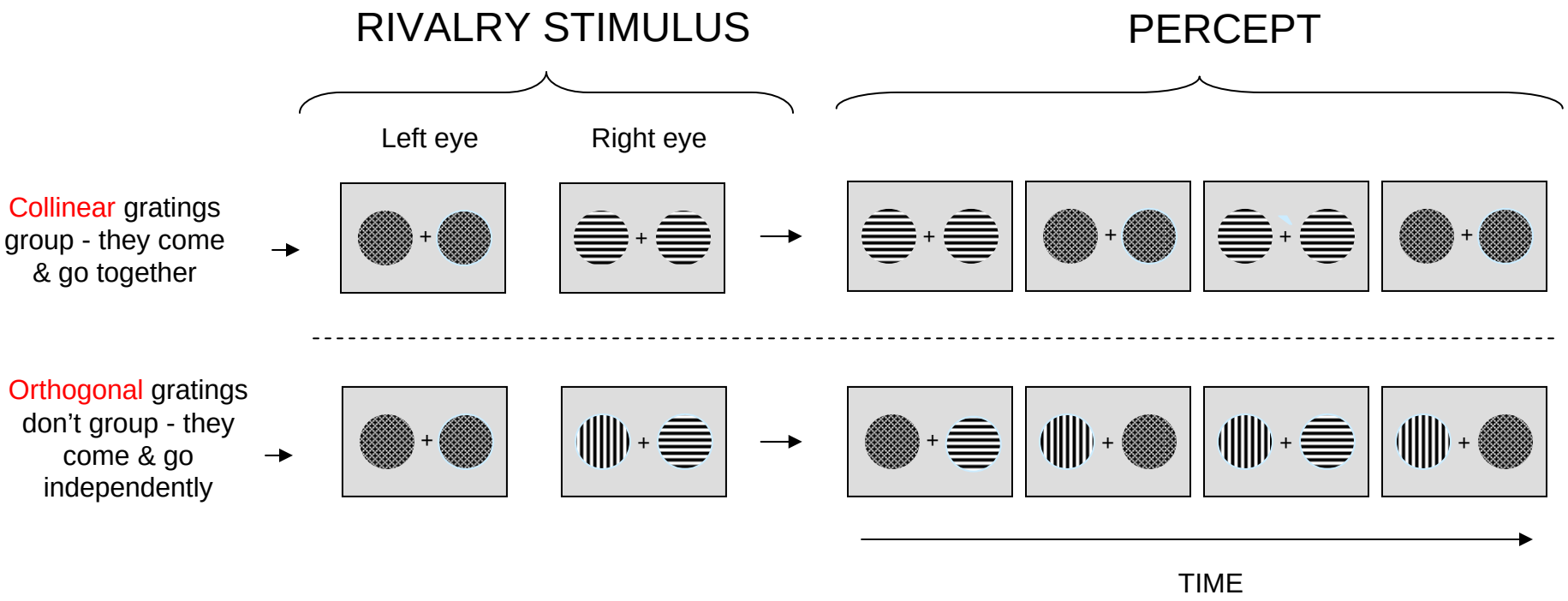
Which stimulus factors influence perceptual dominance?

continued…

Grouping

Motion, orientation and other gestalt cues can promote synchronised dominance of multiple "grouped" targets.

(Alais & Blake, 1999; Sobel & Blake, 2002)



What information can be processed “unconsciously”?

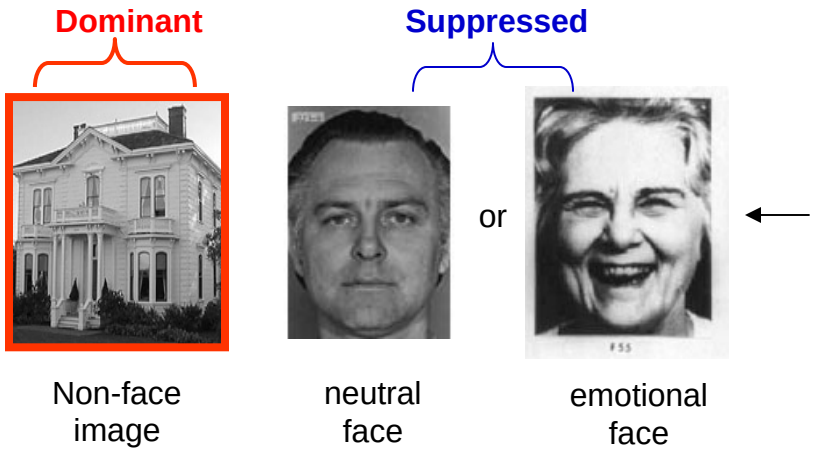
Adaptation after-images..

Aftereffects from adaptation to orientation, spatial frequency and motion cues, can be generated by suppressed stimulus.

(Wade & Wenderoth, 1978; Lehmkuhle & Fox, 1976; Blake & Fox, 1974)

Emotional cues

The amygdala shows greater fMRI response to fearful and happy faces relative to neutral faces, even during periods of suppression. (Williams et al., 2004)



Information about emotion can be processed “unconsciously.”

Factors determining switch rate

Stimulus & Attention

Aside from changing stimulus strength, a number of other factors can influence rivalry switch rate. For example, rivalry switching will become slower if:

1) The rivalry stimulus is moved relative to the eye (Blake et al, 2003)

2) The rivalry stimulus is presented intermittently – on for a few seconds, off for a few seconds (Leopold et al., 2002)

3) The observer attends to some feature of the dominant target (Lack, 1978)

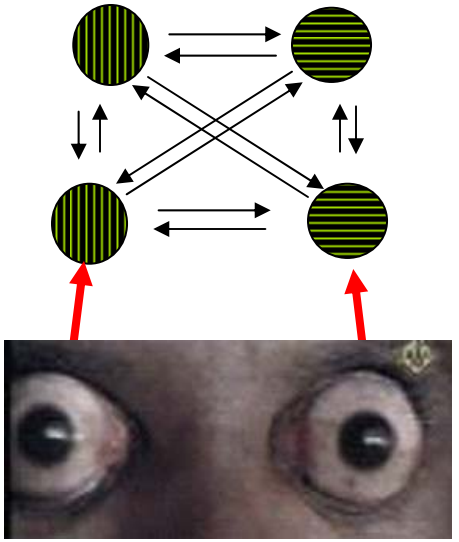
Differences between people

1) There is a huge degree of variability in switch rate across the population. However, within an individual the switch rate is quite stable and correlated across different types of perceptual rivalries (Carter & Pettigrew, 2003)

2) People with bipolar disorder show slower than normal switching (Pettigrew & Miller, 1998).

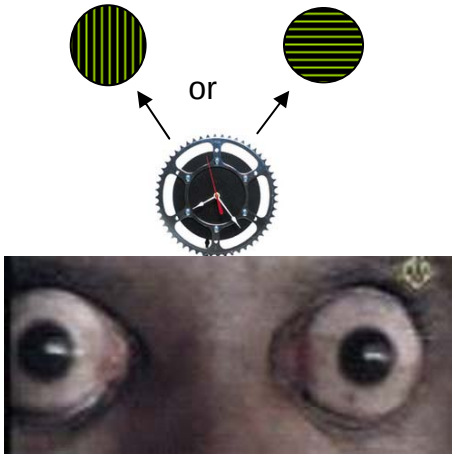
What is driving the switch in perception?

Multiple stages of mutual inhibition between neural populations coding for the competing images features. The neurons generating the dominant image inhibit the neurons corresponding to the suppressed image, but over time the system fatigues and the strength of inhibition reduces allowing the suppressed image to become dominant... This processes continues indefinitely. (Blake, 1989; Wilson et al, 2001)



OR

The perceptual switches are generated by an oscillator external to the level of visual representation. It has been proposed that oscillatory activity in the brainstem may generate rhythmic fluctuations in activity throughout the brain. The perceptual switches may be driven by these oscillations (Pettigrew, 2001)

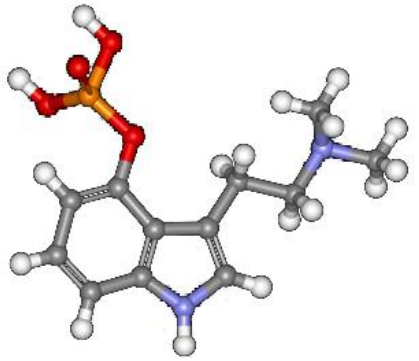


Some unusual facts about rivalry

Meditation - Tibetan Buddhist monks can slow and even stop the binocular rivalry switching during a focused style of meditation called “one-point.” (Carter et al, 2005c)

Hallucinogenic drugs – A study using psilocybin (the active compound in “magic mushrooms) found that the speed of binocular rivalry switching can be reliably slowed, in proportion to the drug’s affects on attention & arousal (Carter et al, 2005a&b)

Psilocybe mushrooms



Psilocybin

Further Reading - References

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