Using music in audiovisual contexts to study human emotion processing

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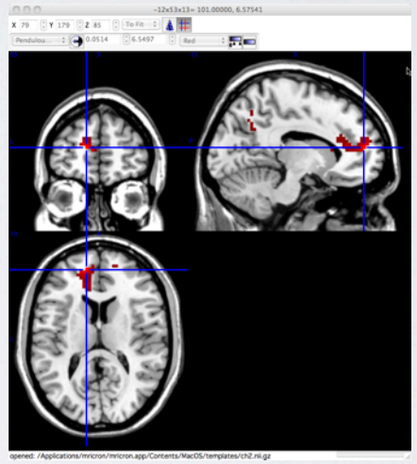
Purpose (focus):
Analyse how specific aspects within the musical structure influence the emotional interpretation of visual information

Experiments (controlled dissonance)

1) Behavioural Experiment (Audiovisual)

2) Neuroscientific Experiment (Music alone)



3) Proposed Neuroscientific Experiment (audiovisual)

Film Music Experiment

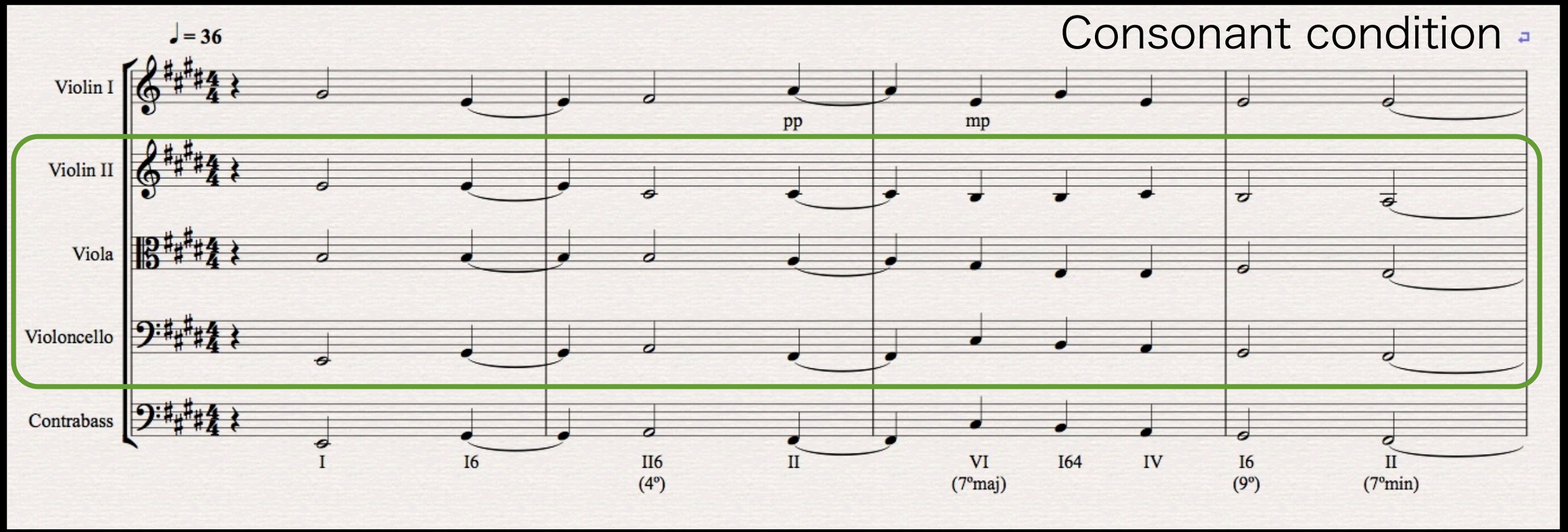
Tonal dissonance

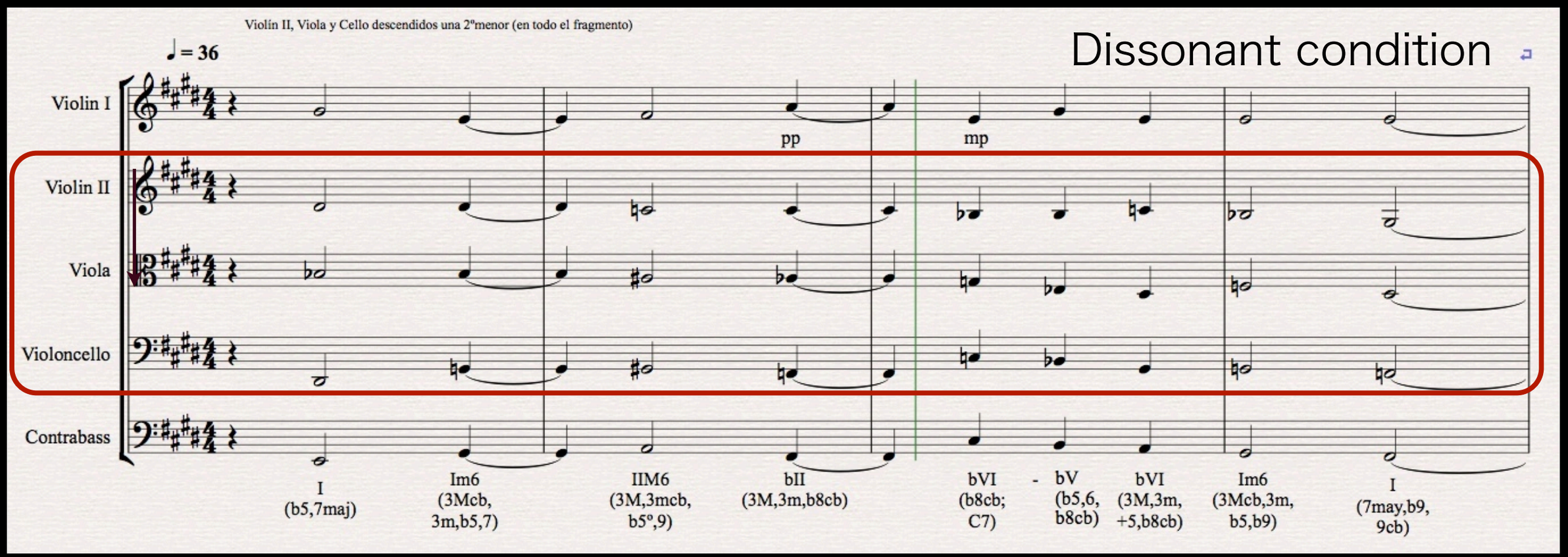
Tension created by melodic and harmonic motion

Effects on the emotional interpretation of visual information

Background Music

http://cmmr2012.eecs.qmul.ac.uk/sites/cmmr2012.eecs.qmul.ac.uk/files/pdf/papers/cmmr2012_submission_13.pdf





1 semitone down

Film Music Experiment

"Man with pendulous arms" – 1997, directed by Laurent Gorgiard

Consonant condition

Dissonant condition

Independent samples: 60 participants in each group

Film Music Experiment

Dissonant

Film Music Experiment

Consonant

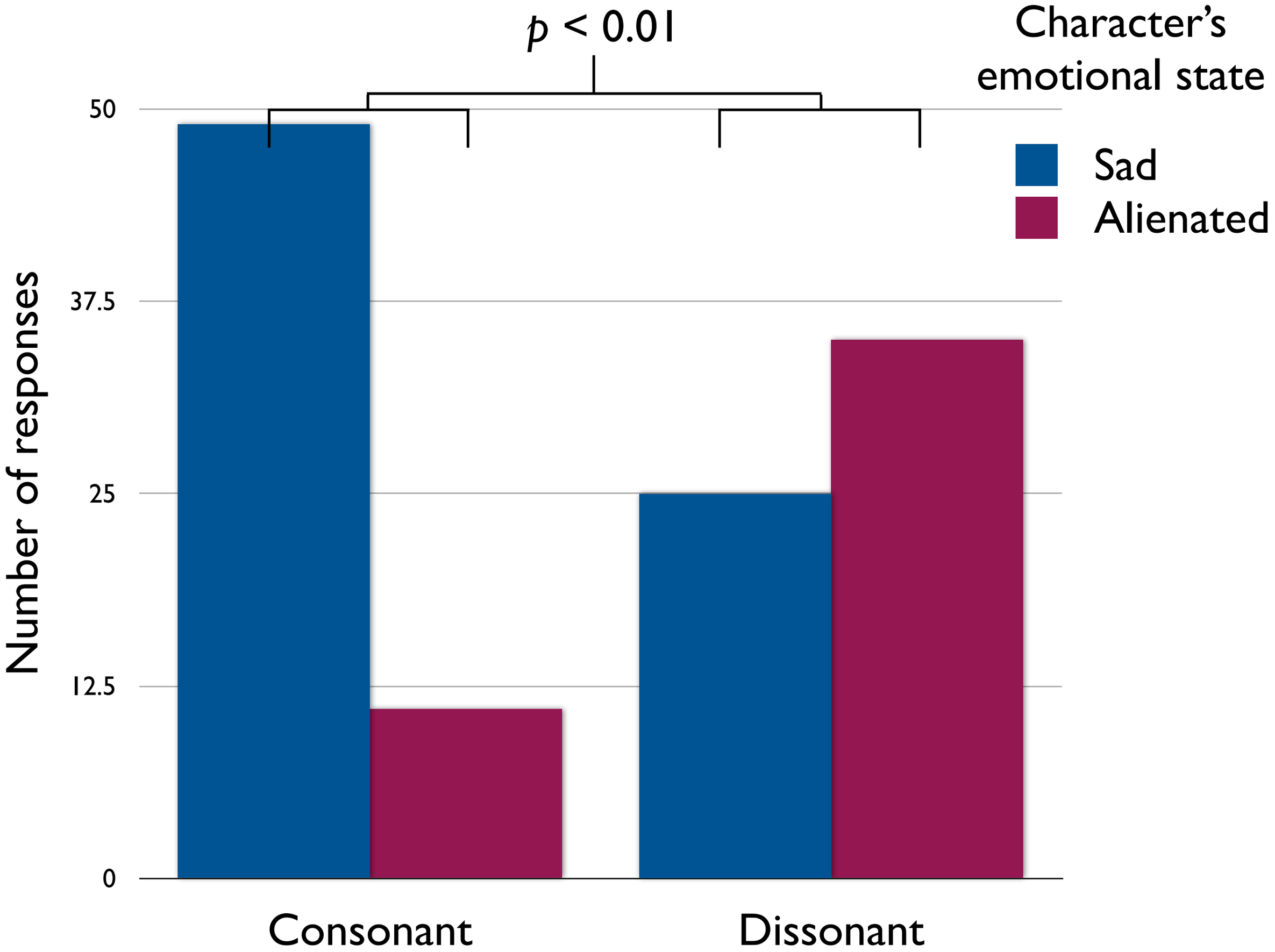
+

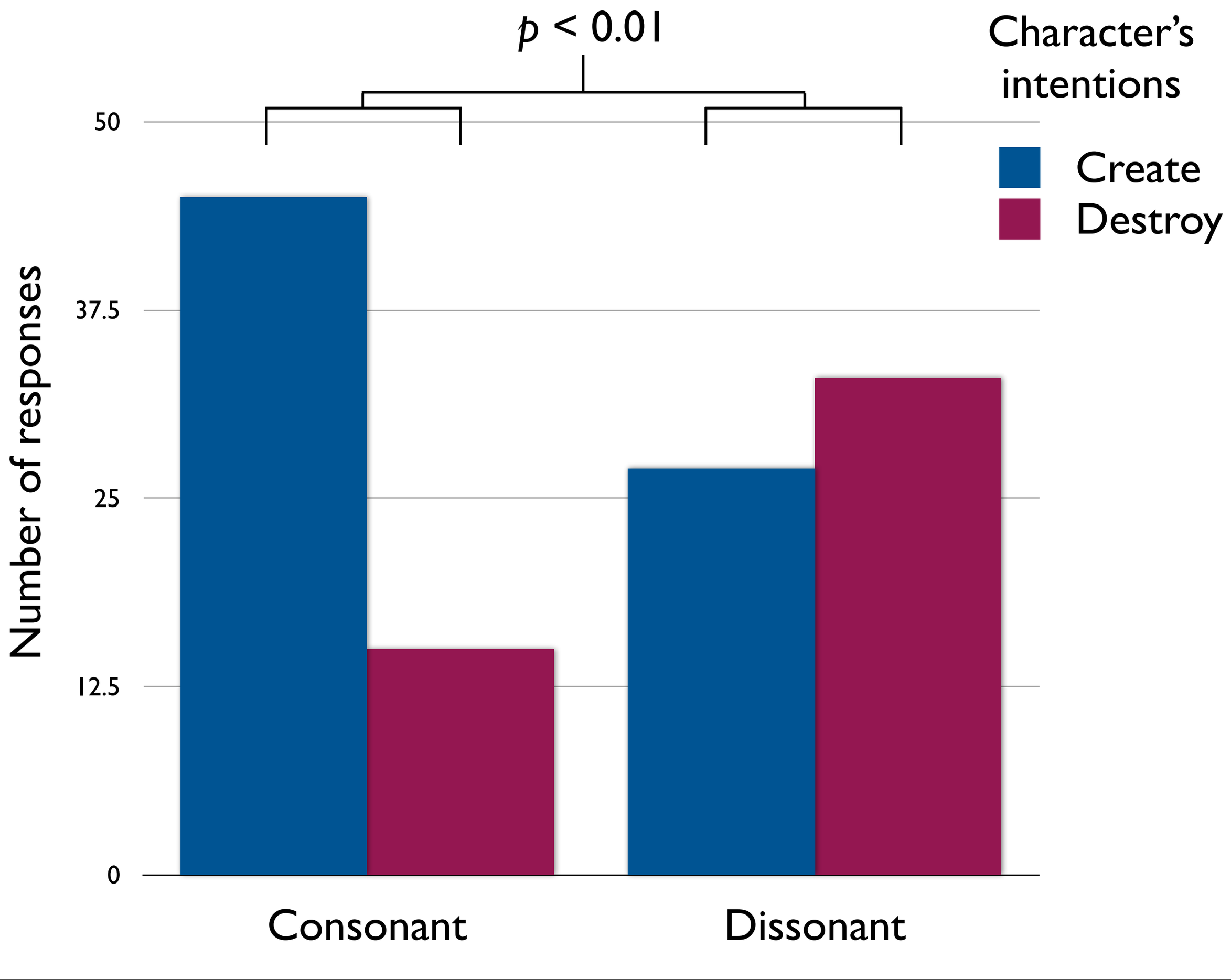
Results

Film Music Experiment

Dissonant condition

Character's intentions	→	destroy / create
Character's feeling	→	confident / scared
Interpreted mood in the story	→	nostalgic / sinister
Character's emotional state	→	alienated / sad
Source of character's actions	→	own will / external influence
Character's type	→	fantasy / monstrous
Genre of the short film	→	horror / drama
Ending (also writing)	→	hopeful / tragic

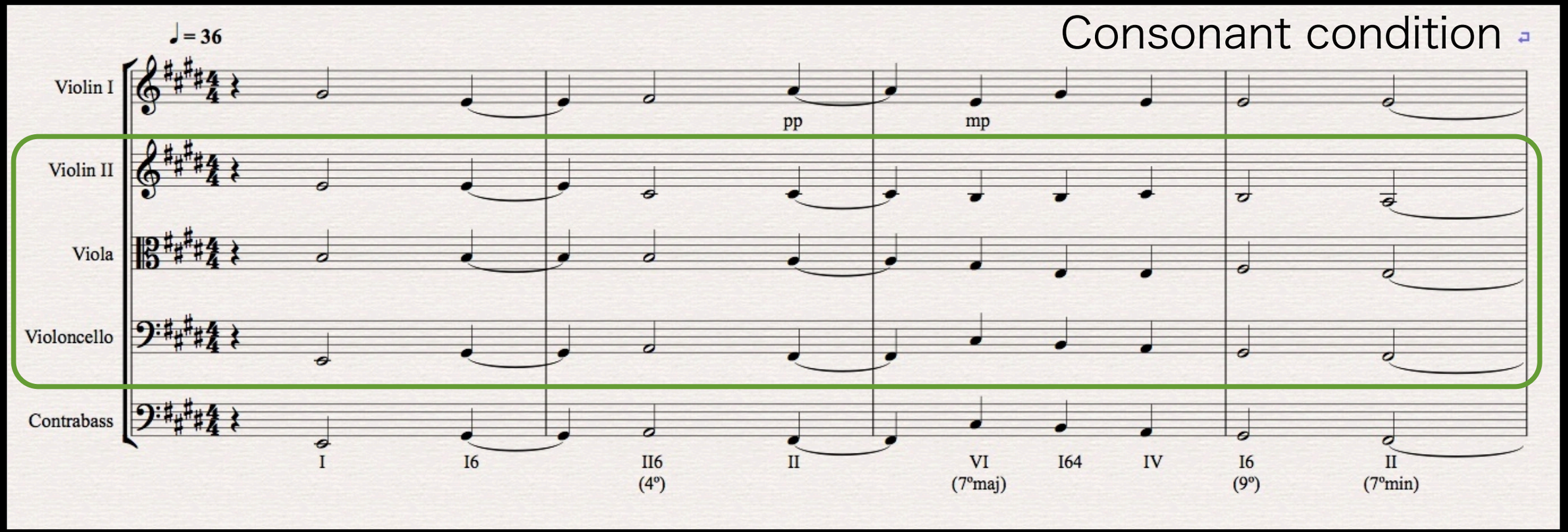

$p < 0.01$
Character's emotional state
Sad
Alienated
Number of responses
50
37.5
25
12.5
0
Consonant
Dissonant

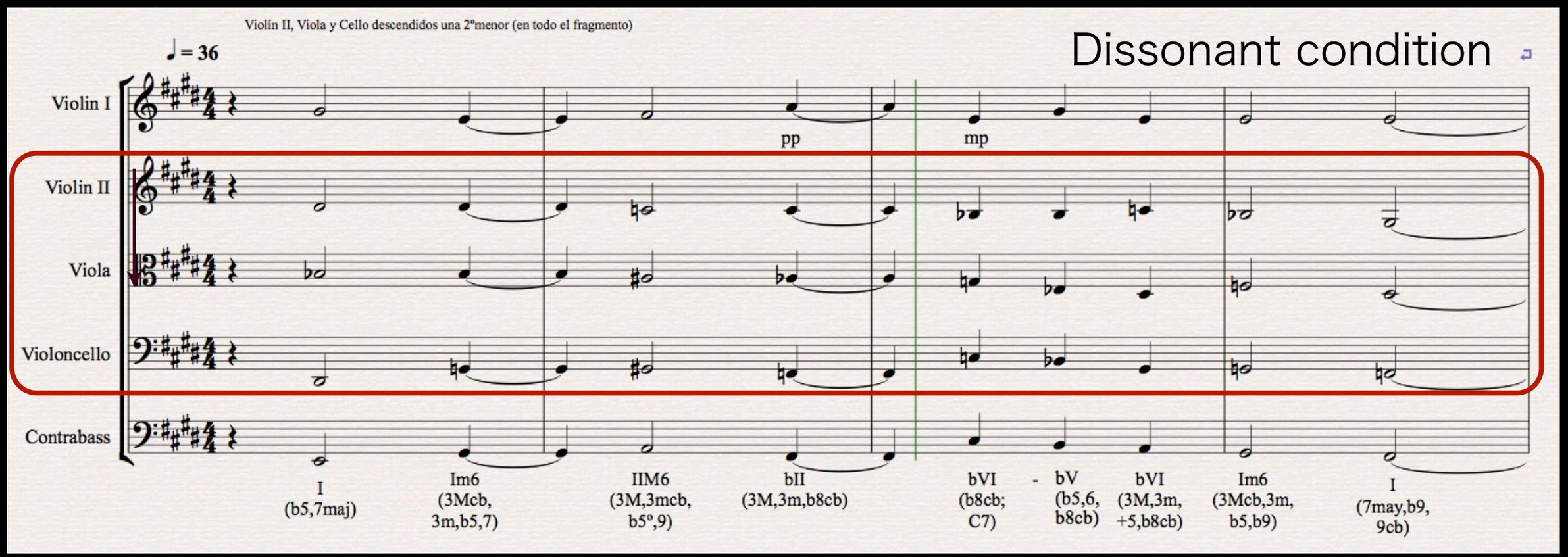

$p < 0.01$
Character's intentions
Create
Destroy
Number of responses
50
37.5
25
12.5
0
Consonant
Dissonant

Study the neural correlates underlying
our emotional responses to dissonance

Musical stimuli

http://cmmr2012.eecs.qmul.ac.uk/sites/cmmr2012.eecs.qmul.ac.uk/files/pdf/papers/cmmr2012_submission_13.pdf





1 semitone down

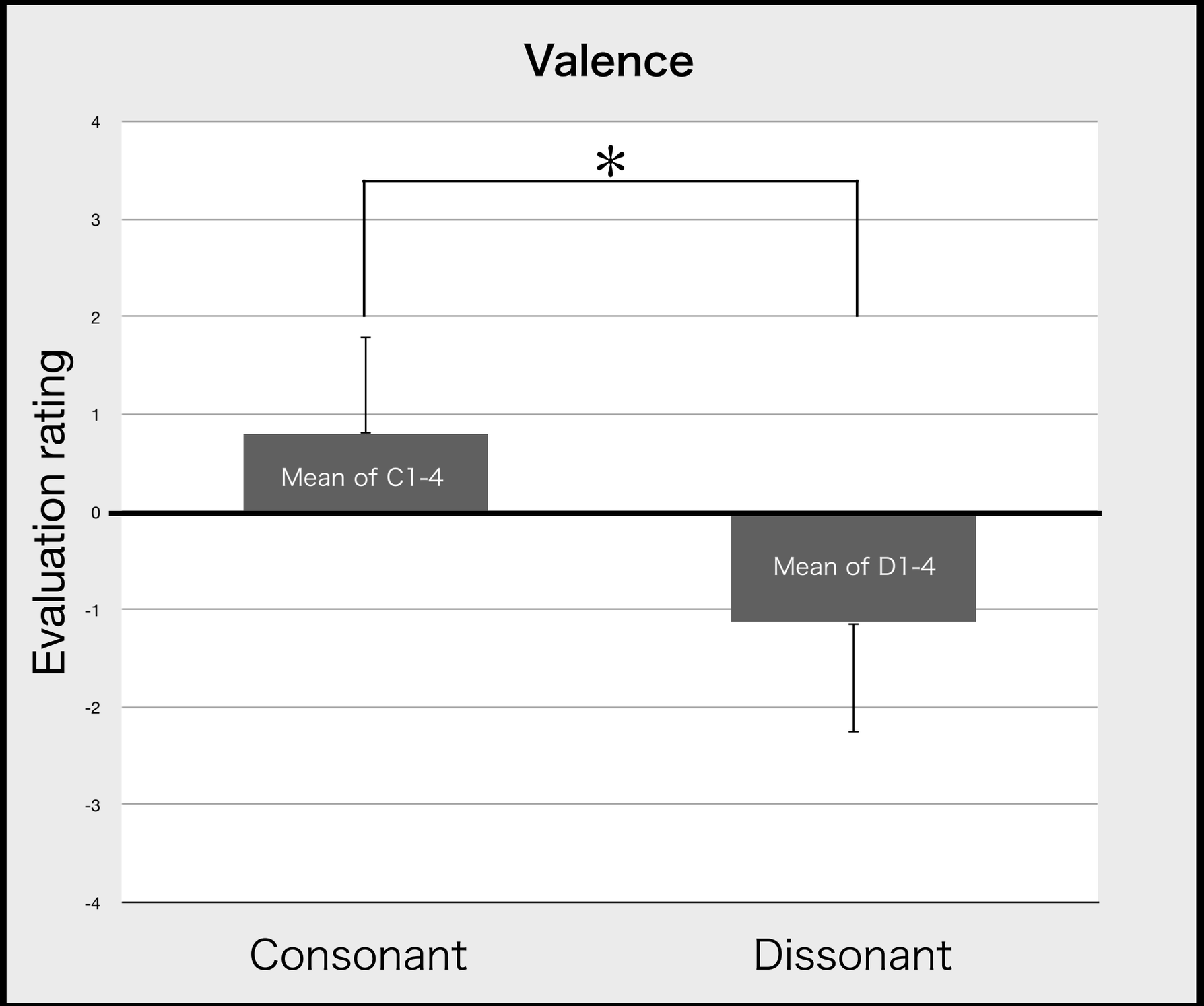
Behavioural test

Isolating Valence

Positive

Neutral

Negative



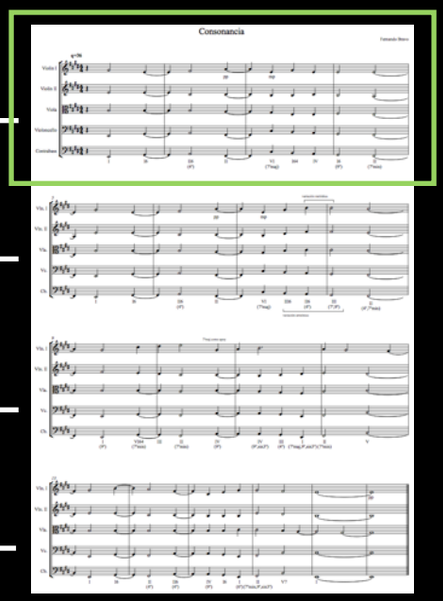
Variations

C1

C2

C3

C4



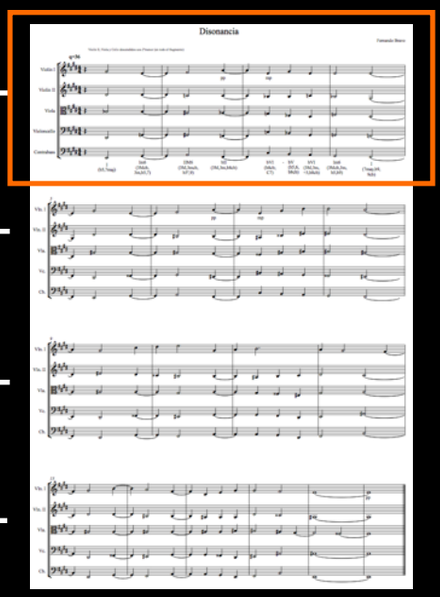
Consonant

D1

D2

D3

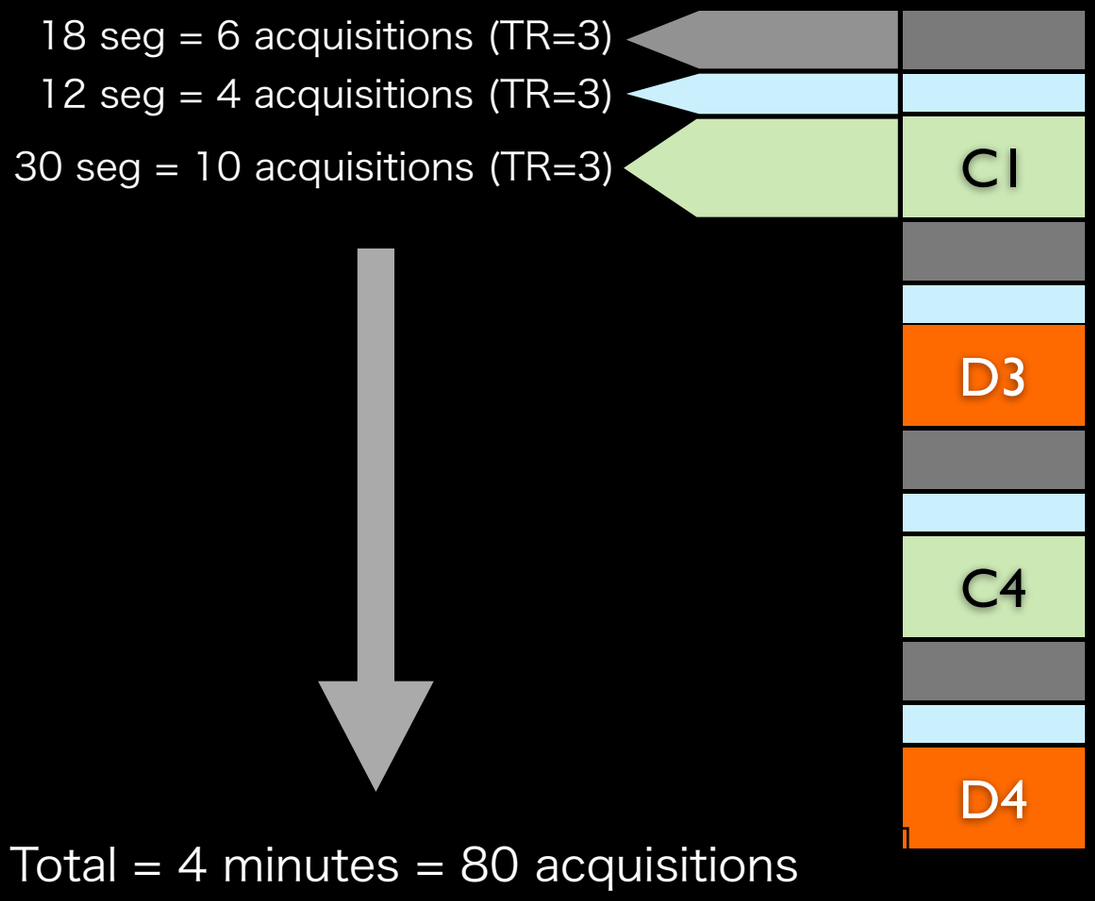
D4



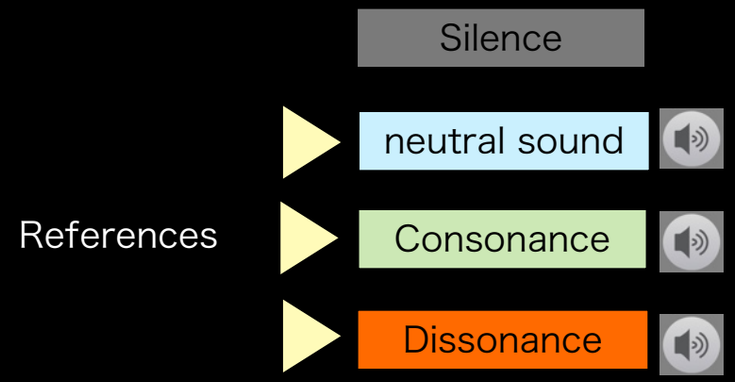
Dissonant

Dissonance Task - fMRI
(13 participants)

3T scanner
TR: 3 seconds

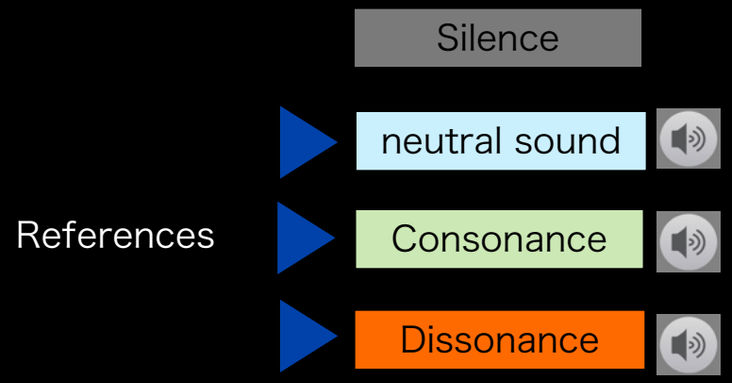


Total = 4 minutes = 80 acquisitions



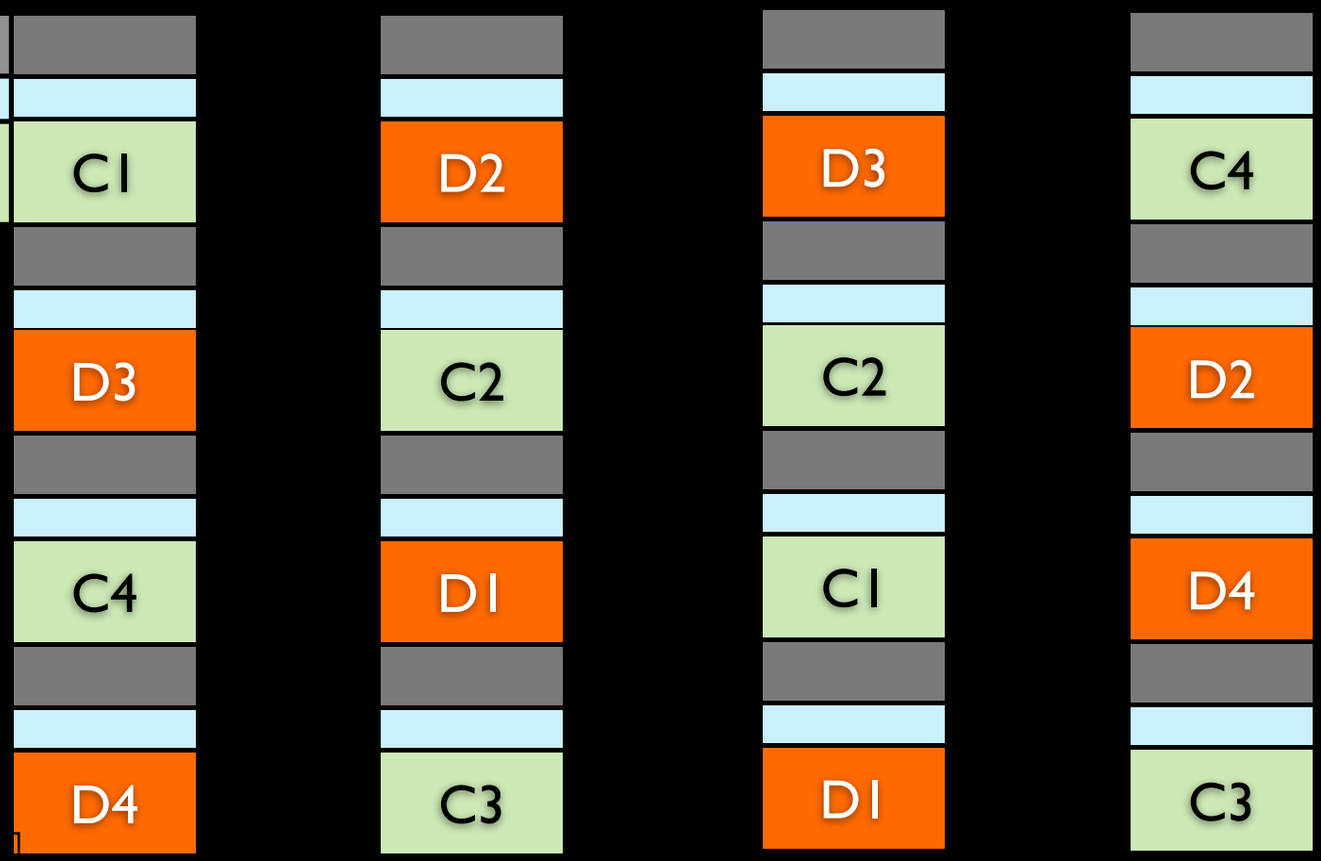
Dissonance Task - fMRI
(10 participants)

3T scanner
TR: 3 seconds



18 seg = 6 acquisitions (TR=3)
12 seg = 4 acquisitions (TR=3)
30 seg = 10 acquisitions (TR=3)

Total = 4 minutes = 80 acquisitions



4 pseudo-randomised orders

Experimental Questions

(i) whether different brain regions would be involved in the processing of musical stimuli with contrasting levels of dissonance;

(ii) whether increased musical dissonance would recruit certain areas that are known to be implicated in the appraisal/ evaluation of negative emotion (medial prefrontal cortex, anterior cingulate cortex and amygdala);

(iii) whether these evaluative regions would interact distinctively with other areas involved in processing negative emotions (withdrawal network: left insula, left fusiform and superior parietal and superior occipital cortices),

(iv) whether the auditory cortex plays a role in the emotional processing of negative valenced auditory information

FMRI results

We would like to determine the number of voxels which exceed a certain activation threshold.

(corrected for multiple comparisons, FWE $p < .05$)

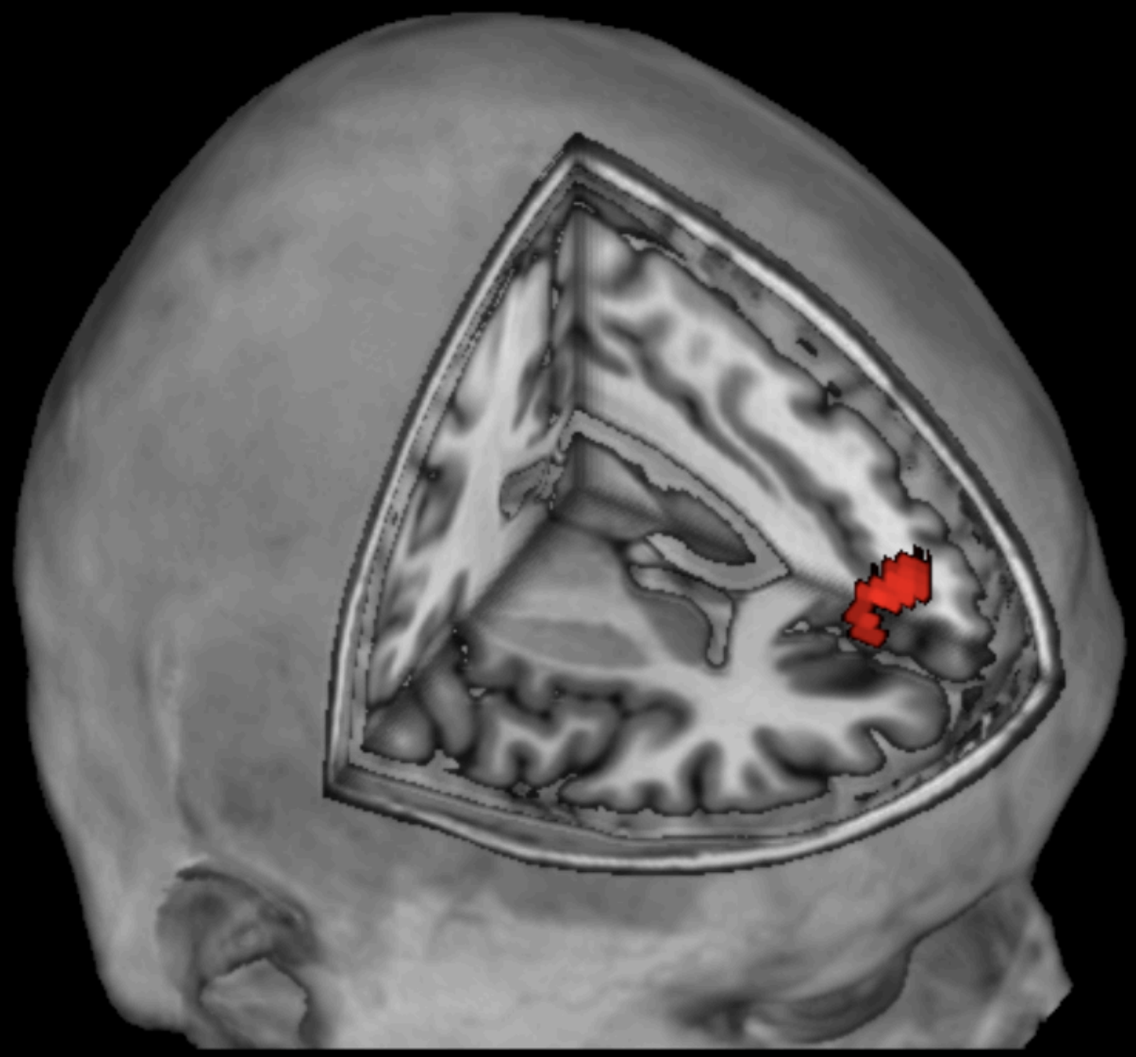
Neutral sound > Rest

Consonance > Dissonance

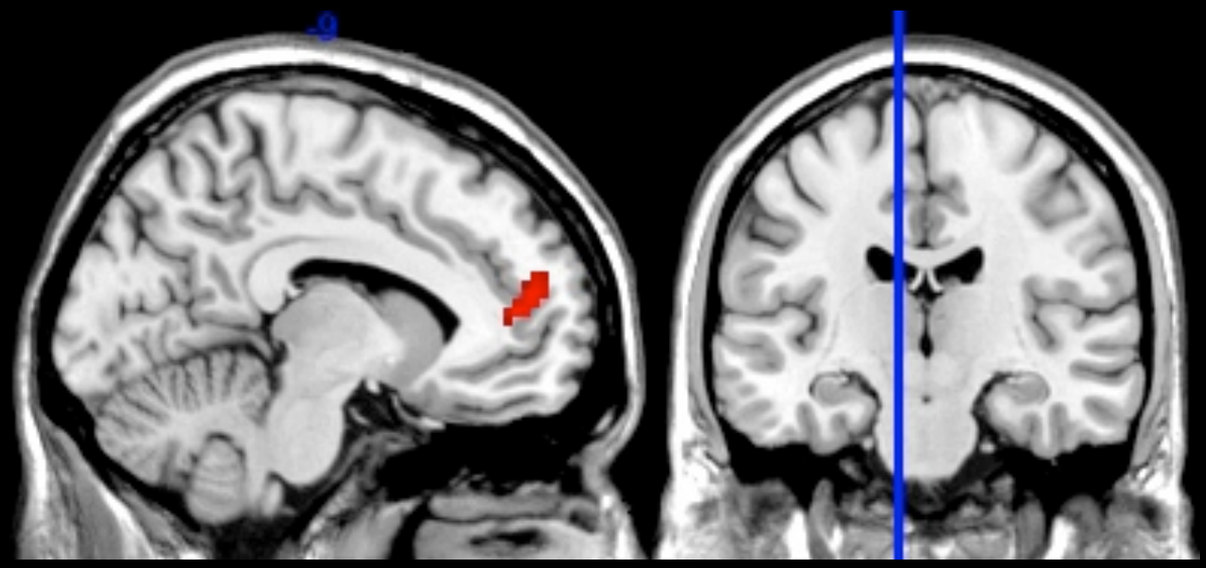
→ Dissonance > Consonance

FMRI results (corrected for multiple comparisons, FWE p < .05)

3D rendering



Sagittal view



Dissonance > Consonance

medial Prefrontal Cortex (left) / Peak MNI coordinates -6 53 13

rostral Anterior Cingulate Cortex (left) / Peak MNI coordinates -9 47 10

mPFC - ACC

Fear Conditioning

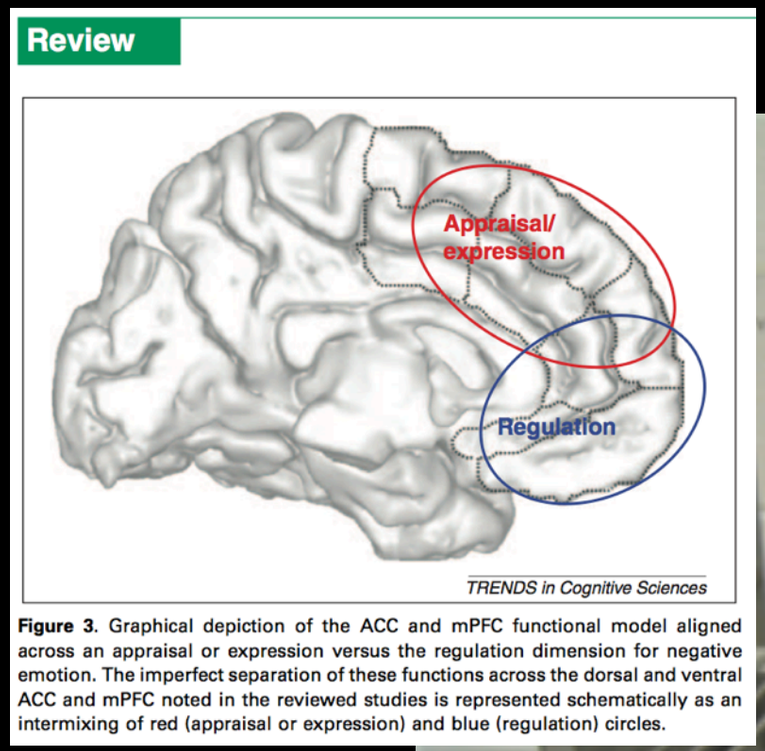
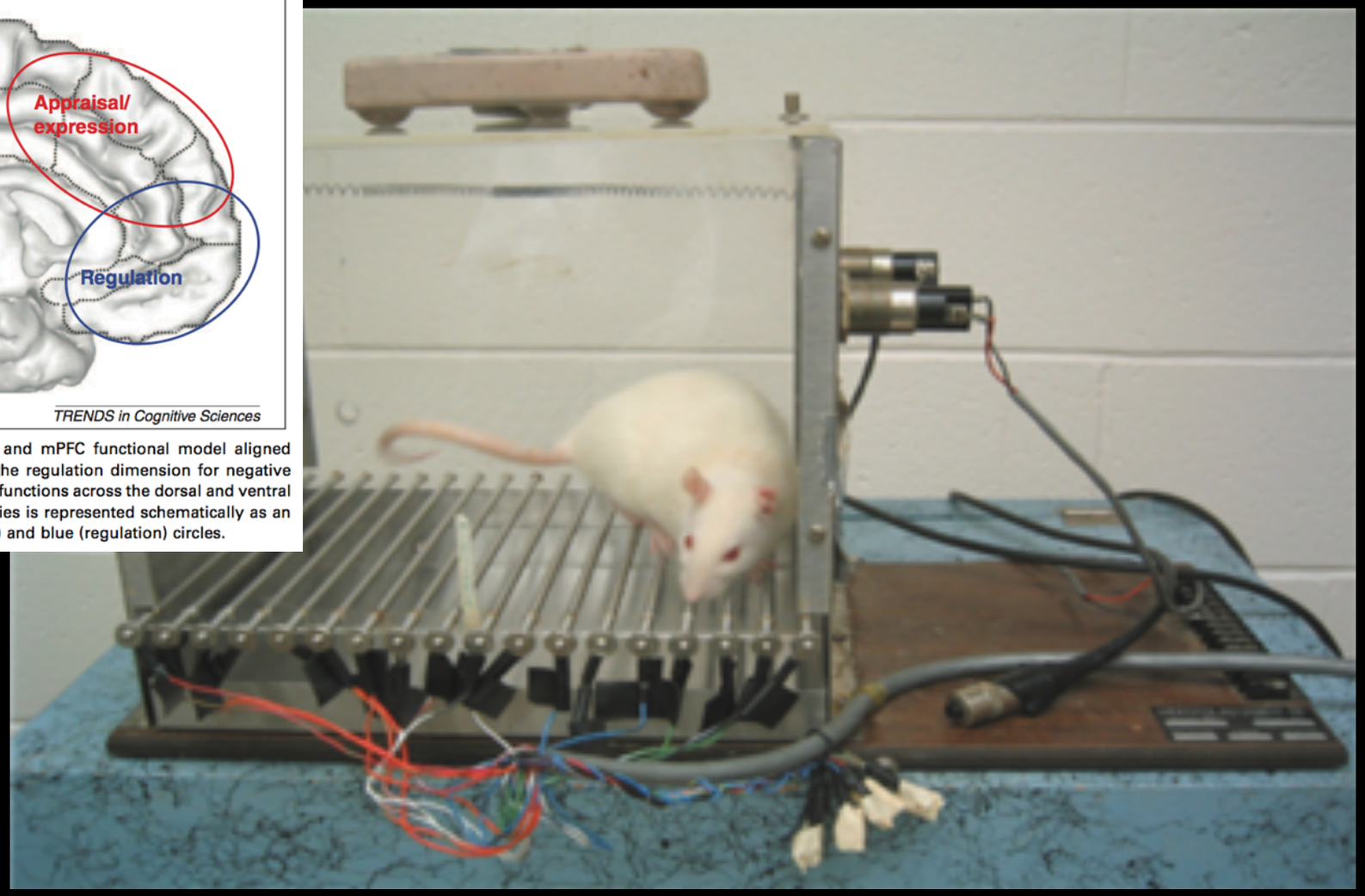


Figure 3. Graphical depiction of the ACC and mPFC functional model aligned across an appraisal or expression versus the regulation dimension for negative emotion. The imperfect separation of these functions across the dorsal and ventral ACC and mPFC noted in the reviewed studies is represented schematically as an intermixing of red (appraisal or expression) and blue (regulation) circles.



-Crucial involvement in the evaluation and expression of negative emotion

- Brain's major system used to integrate predictions of aversive stimuli

- Essential role in processing of anxiety and fear-related information

Etkin, A., et.: Emotional processing in anterior cingulate and medial prefrontal cortex. Trends in Cognitive Sciences, February, Vol. 15, No. 2 (2011)

Steenland, H.W., Li X.Y., Zhuo, M.: Predicting aversive events and terminating fear in the mouse anterior cingulate cortex during trace fear conditioning. J Neurosci 32, 1082--95 (2012)

fMRI

Potential design for the proposed experiment

Study neural processes underlying emotion recognition in sound

Levels of consonance/dissonance

Interval content

fourths, fifths and octaves

Consonant

Interval content

minor thirds

Intermediate dissonance

Interval content

minor/major seconds and tritones

Dissonant

126

3

5712

A radio-telescope located in Cambridge captured a series of radio signals from outer space. You will listen to these sounds and your task is to think and decide if they were produced by good or bad aliens. You will hear 24 different sounds in total.

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SETi

*Participants can not consciously discriminate the difference in the stimuli.

*They report that they are randomly rating the sounds.

Positive
Good aliens

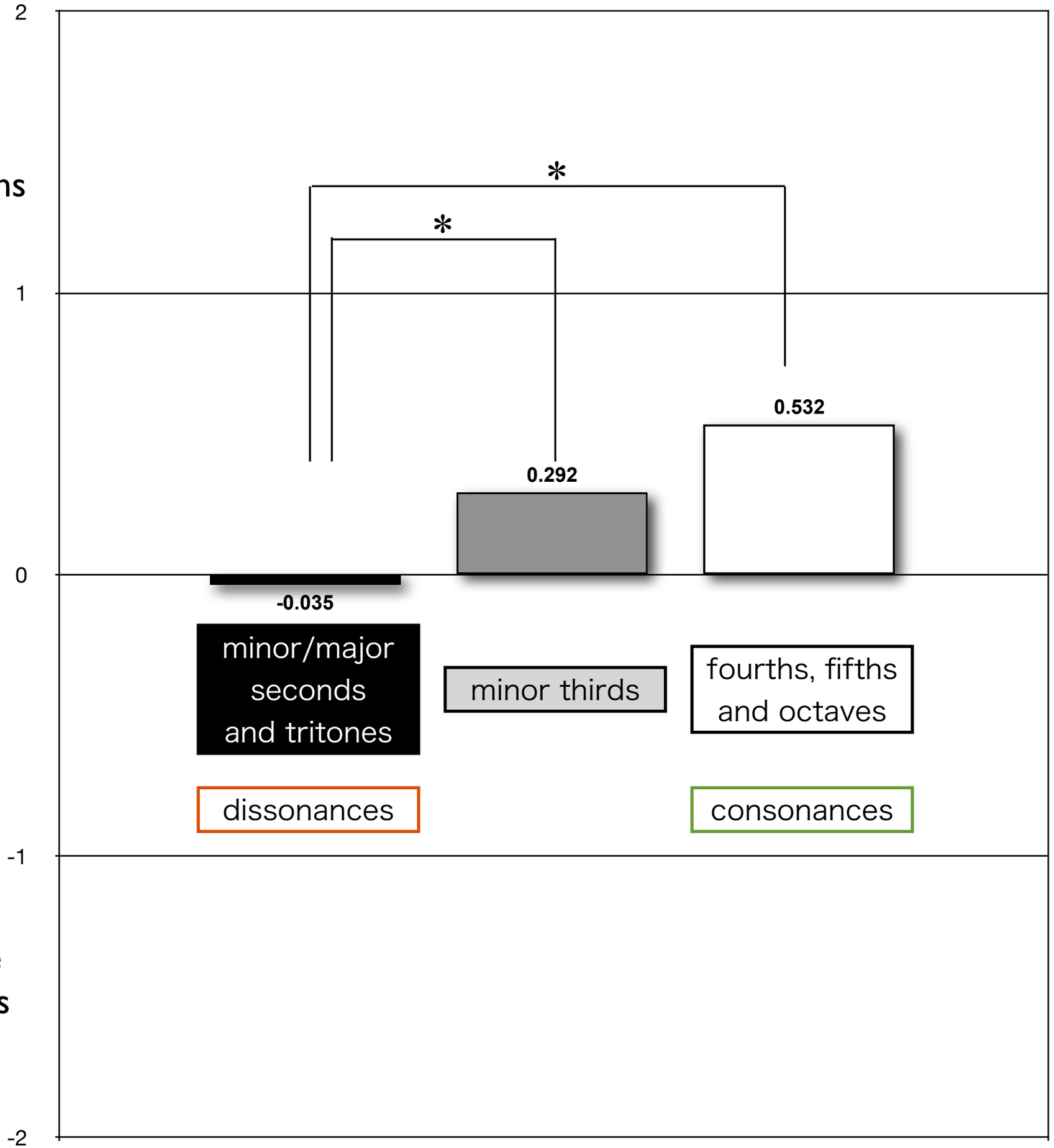
ONLINE
SETi

http://setiexperiment.blogspot.co.uk/

39 participants

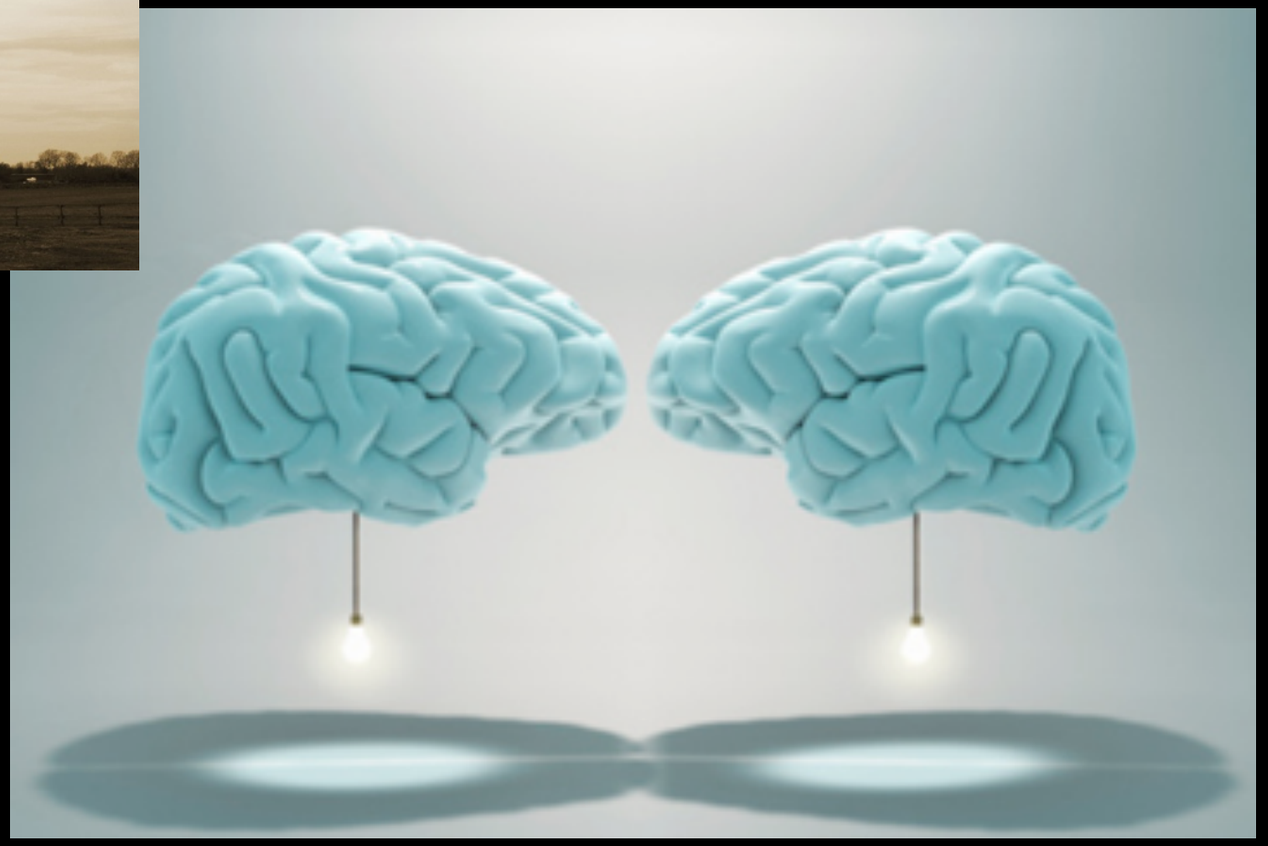
Neutral

Negative
Bad aliens



Neuroscientific experiment - Region of Interest

The mechanism we use to attribute thoughts, emotions and intentions to other individuals



Theory of Mind

Right Temporo-Parietal Junction (RTPJ)

Non-social

Physical descriptions
Nine planets and their moons, plus various lumps of debris called asteroids and comets, make up the sun's solar system. The earth is one of four rocky planets in the inner solar system.

Physical causal inferences
The night was warm and dry. There had not been a cloud anywhere for days. The moisture was certainly not from rain. And yet, in the early morning, the long grasses were dripping with cool water.

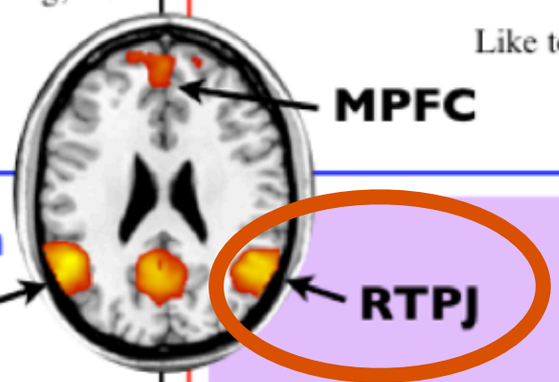
Social

Visible facts that convey social information
Joe was a heavy-set man, with a gut that fell over his belt. He was balding and combed his blonde hair over the top of his head. His face was pleasant, with large brown eyes.

Social background about a person
Your friend Carla lives in San Francisco. She has a top position at a large computer company there. She has been working at the same corporation for over 10 years.

Morally relevant outcomes
[...] Grace puts the powder in the coffee. Her friend drinks the coffee and dies.

Your own and close others' preferences and personality
Like to be in the center of attention? Dislike mushrooms on pizza? Lazy? Talkative? Ambitious?



Meta-representation

False signs
The sign to the monastery points to the path through the woods. While playing the children make the sign point to the golf course. According to the sign, the monastery is now?

False photographs
A photograph was taken of an apple hanging on a tree branch. The film took half an hour to develop. In the meantime, a strong wind blew the apple to the ground.

Theory of Mind

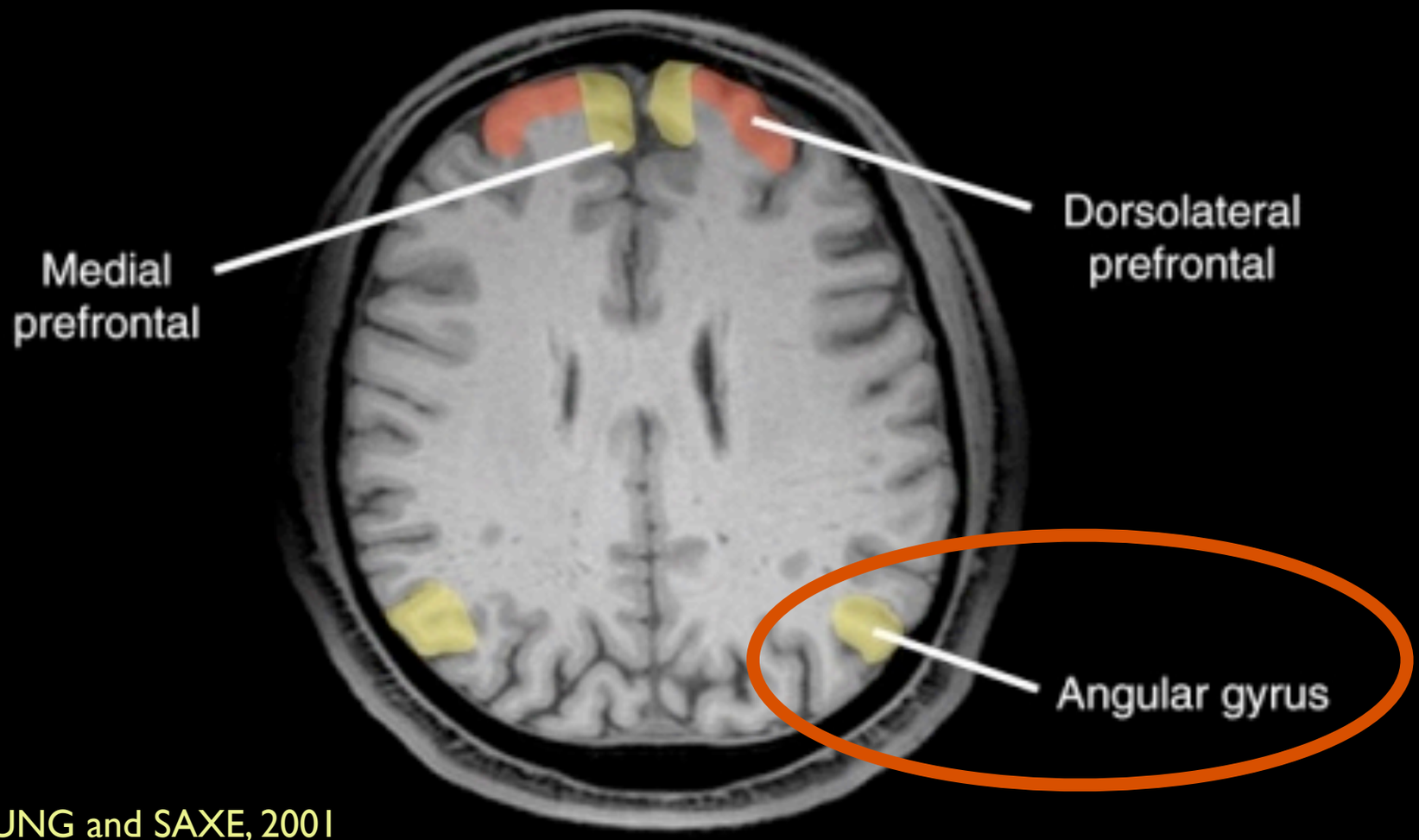
False Beliefs
The path to the castle leads via the lake, but the children tell the tourists, "The way to the castle goes through the woods". The tourists now think the castle is?

True / Justified Beliefs
[...] There's white powder in a container by the coffee machine. Grace thinks the white powder is sugar, because the container is labeled sugar. Grace puts the powder in her friend's coffee. It is in fact the sugar left out by the kitchen staff. [...]

Emotions
John was on a hike with his girlfriend. He had an engagement ring in his pocket and at a beautiful overlook he proposed marriage. His girlfriend said that she could not marry him and began crying. John sat on a rock and looked at the ring.

REBECCA SAXE, 2006

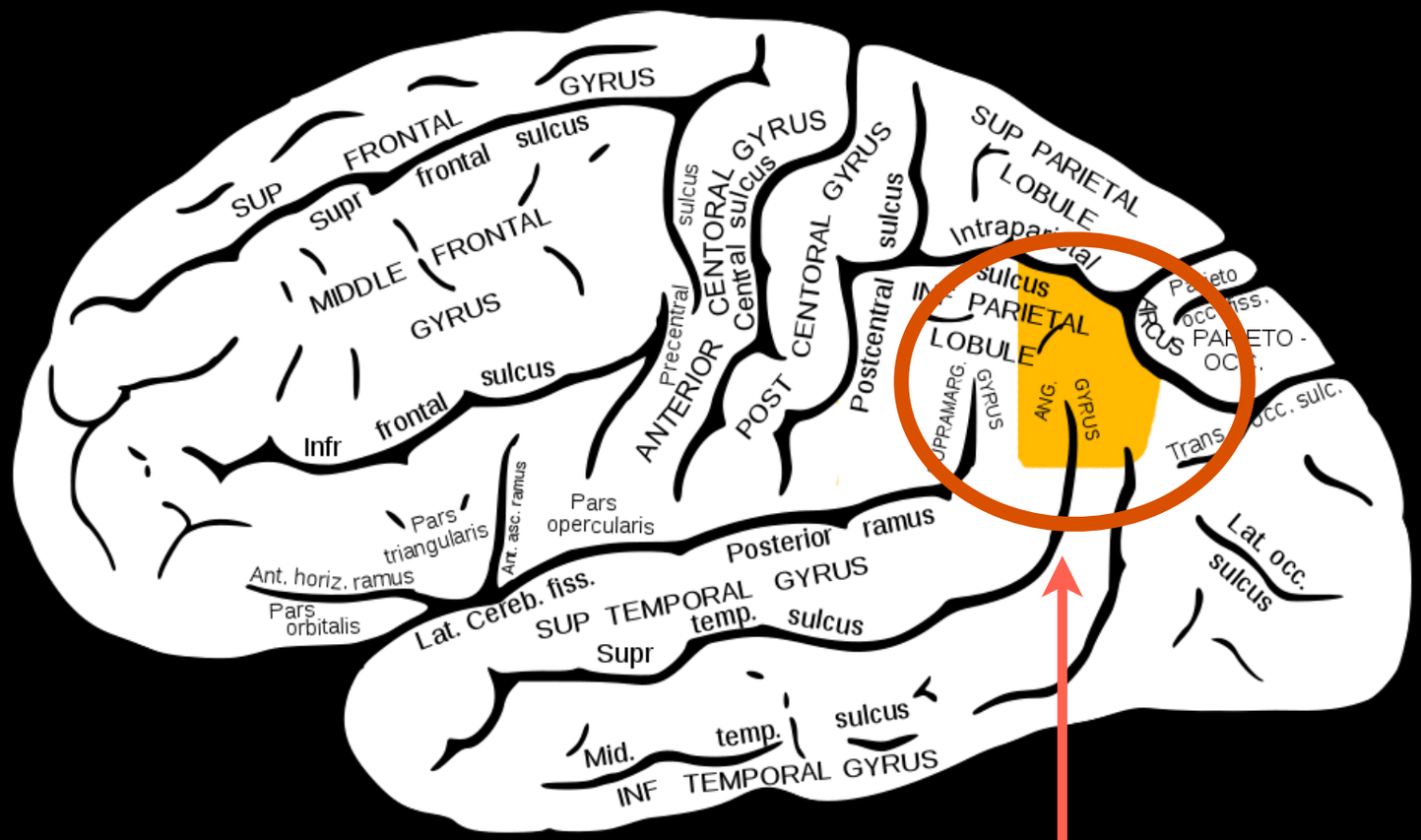
Angular gyrus (right)



YOUNG and SAXE, 2001

Moral decision making

Crossmodal processing

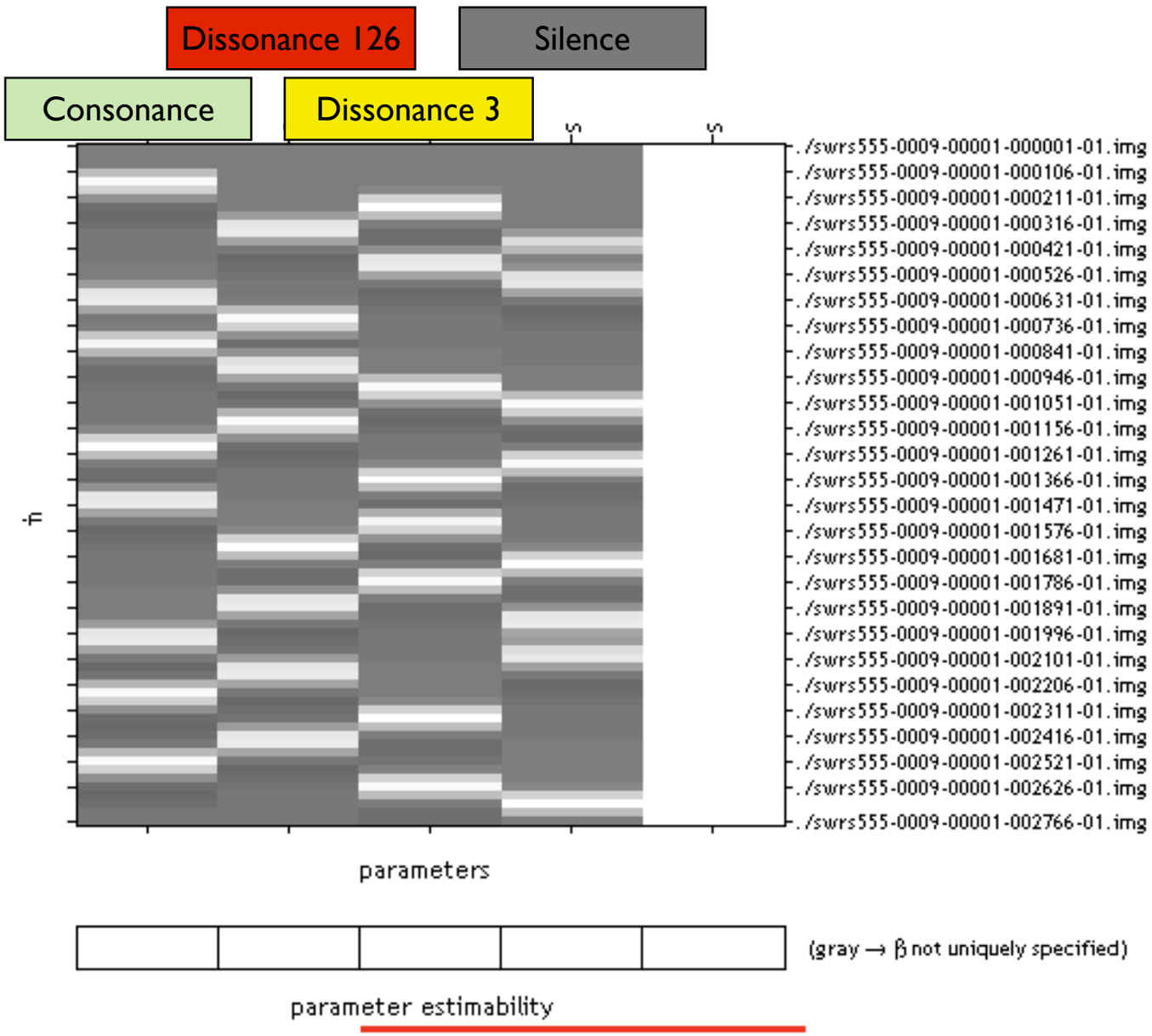


Angular gyrus (right)

SPM8 (nanobravo): Graphics

File Edit View Insert Tools Desktop Window SPM Figure Help

Statistical analysis: Design

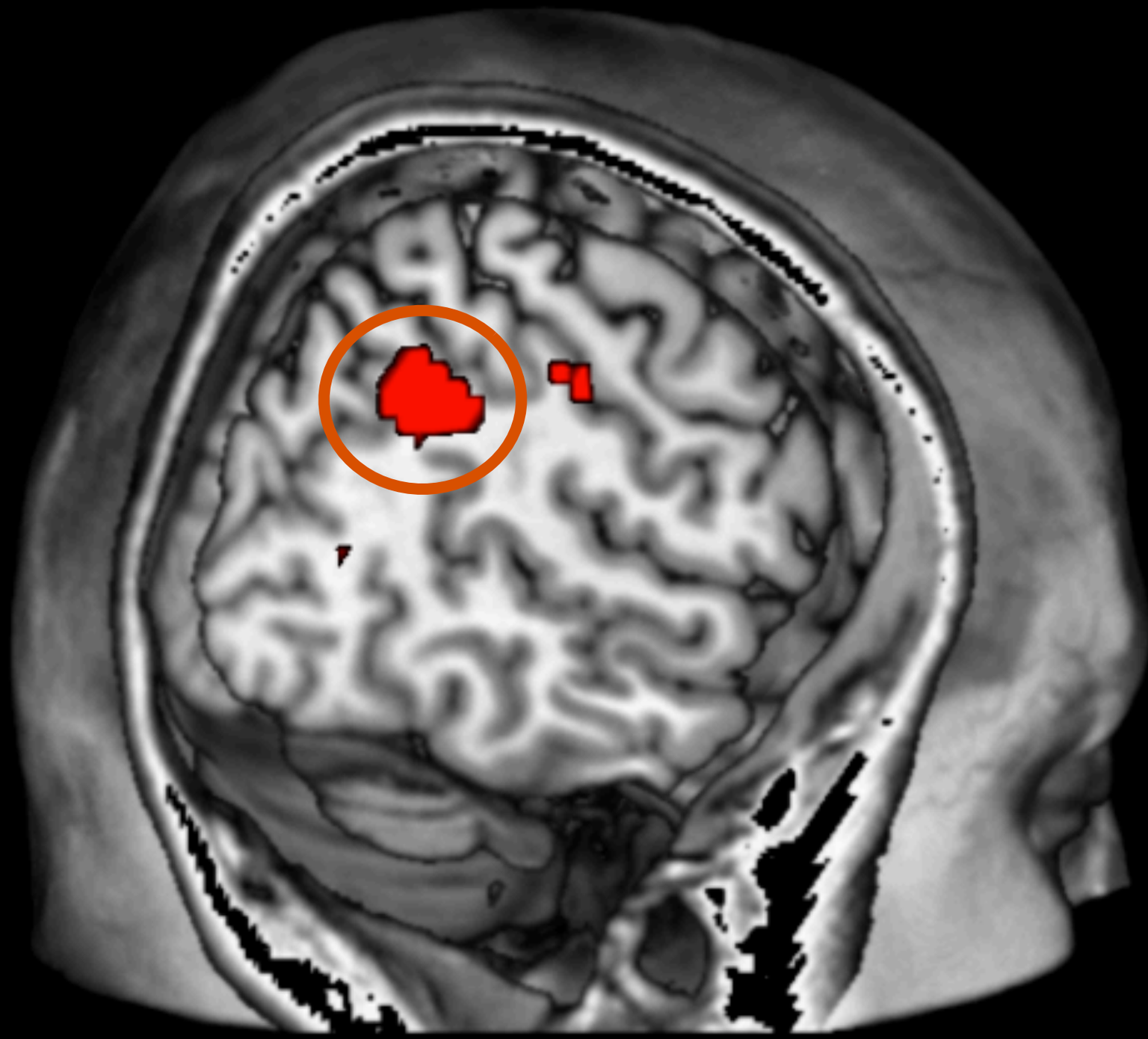


Design description...

Basis functions	hrf
Number of sessions	1
Trials per session	4
Interscan interval	3.00 {s}
High pass Filter :	Cutoff: 1024 {s}
Global calculation	mean voxel value
Grand mean scaling	session specifi
Global normalisation	None

You will listen to these sounds and your task is to think and decide if they were produced by good or bad aliens.

Angular gyrus (right)

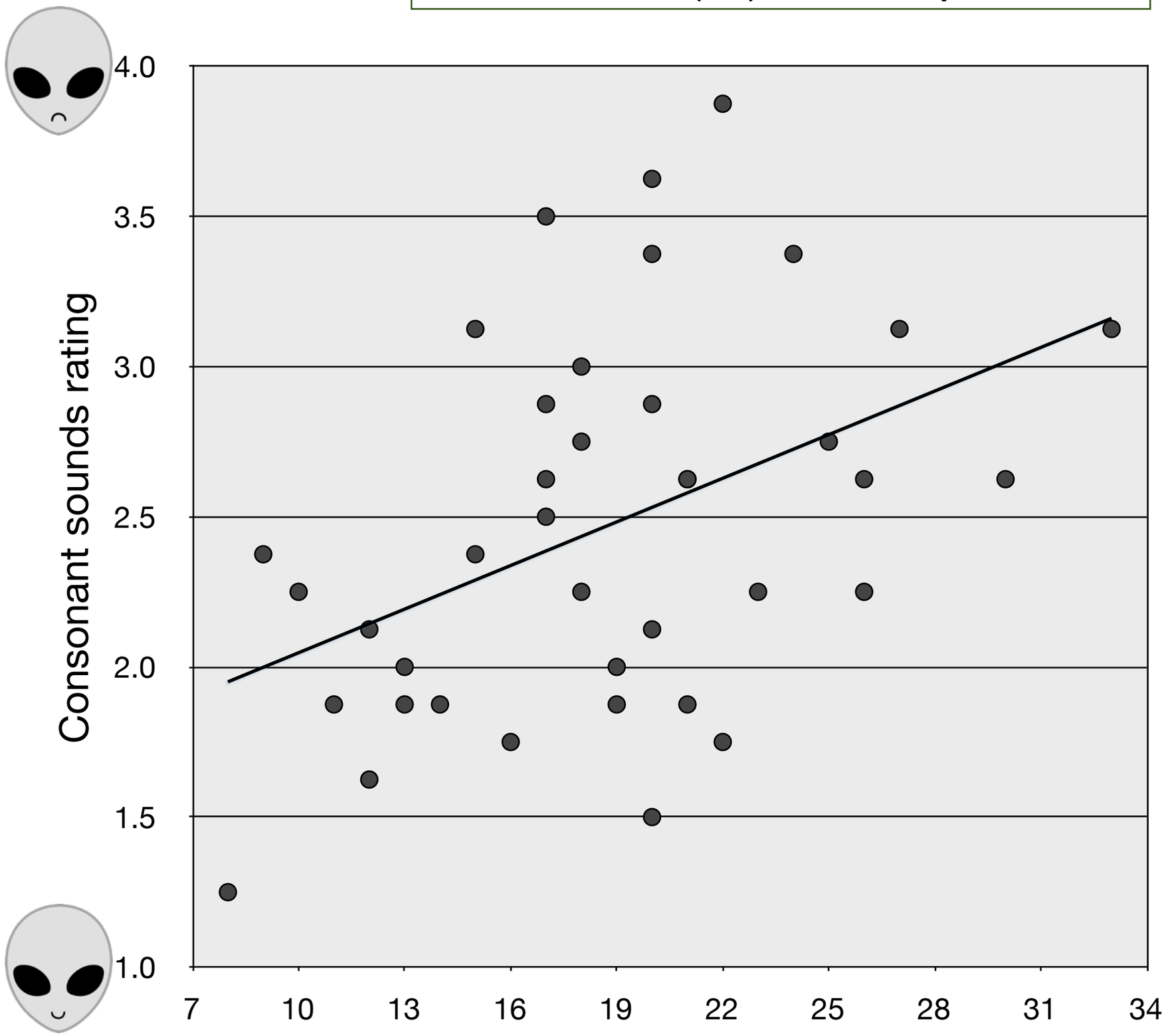


Strong Dissonance > Consonance

Angular gyrus (right) / Peak MNI coordinates 36 -58 43

Online Experiment

Pearson rho (37) = 0.434, p = 0.006



Thank you for your attention

Questions? Comments?

Thank you very much to:

- Emmanuel A. Stamatakis, Ian Cross, Sarah Hawkins
- Researchers at the Centre for Music and Science (Cambridge University)
- Fundacion Cientifica del Sur (Buenos Aires - Argentina)
- Iowa State University of Science and Technology
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- Fabia Franco and Asma Azam (Middlesex University London)

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Cambridge Studentship

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