Simulating Emotions in the Brain

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INTRODUCTION

ATTENTION
(cognition)

EMOTION
(feeling)
APPROACHES

- DATA: IMAGING ON HUMANS

- DATA: ANIMAL EXPERIMENTS

- USE CONTROL MODEL OF ATTENTION
PEOPLE

- Nickolaos Fragopanagos (KCL: ERMIS-BBSRC Emotional AB)
- Neill Taylor + Matthew Hartley
- (KCL: EPSRC Attention/ABC)
- Nienke Korsten (KCL/Antwerp: Language/Cb)
- Andy Ioannides (BSI: MEG)
- BBSRC (Jane Raymond & Kim Shapiro +..)
CONTENTS

1. EMOTION v ATTENTION IN HUMAN BRAIN

2. SIMULATING EMOTION EXPERIMENTS

3. EMOTION RECOGNITION ARCHITECTURE

4. CONCLUSIONS
1. EMOTIONS IN HUMAN BRAIN

- Emotion = automatic v attended

- Automatic: Limbic regions (amygdala, hypothalamus)

- Attended = Feeling (attention)

- Emotion = Valence (in limbic: rewards)
BASIC EMOTION CIRCUIT

- Valence in amygdala & OBFC
- Attention in parietal & PFC
- Interaction in ACG
EMOTION SYSTEM:

- AMYGDALA: coupled reciprocally to CX biases attention by reps of emotional valence of stimuli
- ORBITOFRONTAL CX: receives emotion activity from amygdala influence behaviour via OBFC connections to PFC
- Depression model of Mayberg (ACG is bridge)
ARCHITECTURE:

DLPFC / DORSAL ATTENTION CIRCUIT

VENTRAL ATTENTION CIRCUIT

OFC ←→ AMYGDALA / LIMBIC CIRCUIT
Attention control (CODAM) (Prog Neurobiol 41:305-55 2003):

- **CONTROLLER** (PFC/PL/TPJ) to **CONTROLLED** (Sensory/Motor CX)

- **Goals** (PFC) to **Monitor (errors)** (PL/ACG) and **Attention Controller** (PFC/PL) to **Forward (predicts)** (PL) and **Visual CX** (TL/VLPPFC)
EXTEND TO SENSORY-MOTOR ATTENTION CONTROL
AB: BASIC AB INHIBITION PROCESS
BASIC AB ARCHITECTURE
RESULTS FOR WM RESPONSE TO T2
BIASED EMOTION/ATTENTION CONTROL MODEL
AB extended by AMYG: ERPs for T2 in Lag3 when no amygdala
ERPs for T2 in Lag3: amygdala receives input from T2’s object map representation and feeding back to same site
Basic Message: need to check against data

DLPFC / DORSAL ATTENTION CIRCUIT

VENTRAL ATTENTION CIRCUIT

OFC ↔ AMYGDALA / LIMBIC CIRCUIT

/ face(emotional) \

- Cndn 1: classify orientation of bars
- Cndn 2: identify gender of face
- Results:
  1. faces attended=>amygdala active,
  2. faces unattended, amygdala inactive
DETAILED ARCHITECTURE for BAR CLASSIFICATION
DETAILED ARCHITECTURE FOR FACES CLASSIFICATION gender
Simulation (LFPs into fMRI BOLD by convolution with Gaussian in time) ≈ real data
Similar (for fusiform face area) \( \approx \) real data
2) YAMASAKI ET AL (2002)

- Targets = circles
- Standards = squares (84%)
- Classify stimuli: targets v others
- + Distracters = emotional stimuli
- RT> RT to all other stimuli
- Explain: inhibit cognitive goals (tgts coded in DLPFC) by emotions (coded in AMYG/OBFC)
- fMRI results support reciprocal inhibition
FEATURES OF MODEL

- MFG_(cogtgt),_(emotgt)
- IFG_(cogtgt)_(emotgt)
- Reciprocal inhibition (OFC+IFG)_ MFG
ARCHITECTURE FOR SIMULATION
## DATA

<table>
<thead>
<tr>
<th>Type of Input</th>
<th>Description of Input</th>
<th>Freq of Input</th>
<th>RT (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standards</td>
<td>Squares of various sizes &amp; colors</td>
<td>84%</td>
<td>536</td>
</tr>
<tr>
<td>Targets</td>
<td>Circles of various sizes &amp; colors</td>
<td>~8%</td>
<td>691</td>
</tr>
<tr>
<td>Emotional</td>
<td>Unpleasant pictures</td>
<td>4%</td>
<td>728</td>
</tr>
<tr>
<td>Neutral</td>
<td>Neutral pictures</td>
<td>4%</td>
<td>680</td>
</tr>
</tbody>
</table>
SIMULATION RESULTS

- RT to emotional stimuli > RT to targets/neutral
- Emotional slowing (by inhibition) of goal signal by emotional input -> ventral PFC valence (AMYG-OBFC)
- Inhibition => slower response (by about 50 ms) to unpleasant stimuli
- Found by simulation
3) PERLSTEIN ET AL (2002)

- Pictures with single picture cue, then probe of 9 pictures
- Target respond to in probe by button press if = picture contained in previous cue (held 11.5 secs)
- In DLPFC signal intensity _ most for pleasant, less for neutral, and least for unpleasant stimuli, during delay period from cue to probe.
- In OFC, variation exactly converse.
Model explanation

- Expect from architecture
- Mutual inhibition OFC _ DLPFC
- Larger strength of activity for fearful vs neutral compared to pleasant stimuli, in OFC
4) ARMONY & DOLAN (2002)

Divided attention to 2 fearful simultaneously-presented faces.
- One face conditioned by pairing with burst of white noise, other not.
- Brief presentation of two faces side-by-side causes delayed response to target dot by conditioned face ~ 20 msecs.
Model explanation

- fMRI _ activity to conditioned face in amygdala and occipital & ventral temporal (face) regions
- Amygdala activity to conditioned face _temporal face region & occipital cortex
- OBFC observed
- Explain delay to conditioned faces by inhibition from OFC -> dorsal attention network.
5) BEAUREGARD ET AL (2002)

fMRI of allowed/inhibited emotions to erotic videos
- Reciprocally active sites in DLPFC and (amygdala+anterior temporal pole)
- Inhibitory cognition _ emotions (DLPFC _ medio-ventral)
- No amygdala activity in emotional inhibited case => need attention biased by valence-directed activity
3. EMOTION RECOGNITION (ERMIS: ANNA)

- Architecture for recognition of emotion, especially basic emotions (fear, anger, disgust, sadness, happiness & surprise)
- Analyse differences in recognising emotions in faces or speech
- Eg complimentarity between brain sites for recognition through prosody or linguistic content
BASIC ERMIS ARCHITECTURES: General form
Assume linear output:

\[
OUT = \prod_{i} a_{i} y_{i}
\]

Hidden layer response:

\[
y_{i} = f\left(\prod_{j} w_{ij} x_{j} \left[1 + \prod_{k} A_{ijk} z_{k}\right]\right)
\]

IMC node response:

\[
z_{k} = f\left(\prod_{i} B_{ki} y_{i}\right)
\]

Then solve self-consistent equations for \((y, z)\) for each training input by relaxation.
4. CONCLUSIONS

- Neuro-science => attention/emotion interact dynamically
- Automatic emotional component (crucial for survival) can help breakthrough to consciousness (e.g., AB)
- Automatic ‘emotion’ component in limbic & paralimbic circuits of brain
- Emotion feeling in OBFC/ IFG/ insula/…
- Emotion = Bias to Attention
QUESTIONS

- Emotion functions as separate controller?
- Feeling = Only bias to consciousness (in CODAM)?
- Depression => Emotion normally used as bias to cognitive process?
- No separate emotional consciousness?
- Coding of emotions: as dimensionally reps or dissociated states (sad AMYG v angry OBFC)?