On the nature, and nurture, of childhood shyness

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Outline

1. What is the phenomenon?
2. Is the phenomenon open to change?
3. What are the origins of the phenomenon?
Question #1: What is the phenomenon?

- Temperamental shyness

- Small percentage of typically developing children (5 to 10%) exhibit stable fear and wariness in response to novelty and unfamiliar and familiar social situations across childhood

- Associated with early appearing differences in infant motor activity and affect in response to novelty in the first 6 months of post-natal life

- Linked to individual differences in excitability of the amygdala (particularly its central nucleus)?
What is the phenomenon?

- Approach-withdrawal

- Fundamental behavioural dimension conserved across animals, including insects, birds, fish, mammals

- Neural circuitry is well-mapped and conserved across mammals, particularly nonhuman primates and humans
Brain electrical activity and its decomposition

Fourier applications in the neurosciences

Spectral analysis reveals the fractions contributed by several natural frequencies to the total energy generated by the brain

Frequency content changes with development, as well as cognitive/affective state

Jean Baptiste Joseph Fourier
1768 - 1830

Hans Berger, 1920’s
Neurodynamic Models: Information processing and event-related oscillations

- ERP responses to novel auditory tones and shyness in children

- EEG power in theta oscillations in response to novel auditory tones partially related to P3a wave; however, theta power uniquely predicted levels of shyness and better fit of the data than ERP peaks

- Information inherent in event-related oscillations can model individual differences in childhood shyness in a more sensitive manner than traditional ERP amplitude measures
What do we know about its biological correlates?

(Our Published Studies from 1994-2011)

- **Studies of Typically Developing Infants**
  - greater relative right frontal EEG asymmetry
  - increased startle responses

- **Studies of Typically Developing Preschoolers and Early School Age Children**
  - greater relative right frontal EEG asymmetry
  - high and stable heart rate
  - high morning basal and reactive salivary cortisol

- **Studies of Healthy Young Adults**
  - greater relative right frontal EEG asymmetry
  - high and stable heart rate and low vagal tone
  - low baseline salivary cortisol
  - greater right amygdala activation to affective faces
Question #2: Is the phenomenon open to change?

Coupling in the EEG Spectrum

- Traditional EEG spectrum extends from delta to gamma frequencies
- Brain rhythms represent the activity of functionally and spatially distinct neuronal assemblies
- Cross-frequency coupling may represent a mechanism for integration across brain regions
Delta-beta spectral coupling is presumed to reflect cortico-subcortical interactions.

- Sensitive to steroid hormones (endogenous and exogenous) such as cortisol (Schutter & van Honk, 2005; van Peer et al., 2008) and testosterone (Miskovic & Schmidt, 2009; Schutter & van Honk, 2004).

- Coupling:
  - increased by: anxiety, natural/synthetic cortisol;
  - decreased by: natural/synthetic testosterone (anxiolytic)
Cross Frequency Interactions

- Power-to-power

- Phase-to-power
Physiological Origins

- Slow Wave activity originates in deep cortical/subcortical structures
  - Animal evidence
  - Human evidence
  - Evolutionary evidence

- Fast Wave activity originates in the neocortical mantle
  - Higher cognitive functions

- Delta-beta spectral power coupling (i.e., correlation) may reflect cortico-subcortical cross-talk

- Spatial smearing caveat
Study Overview

**Design**
- Double baseline, repeated measures design in which participants served as their own controls

**Participants**
- Individuals ($n = 25$; 12 females, 13 males, $M$ age = 35.9 years) with principal confirmed diagnosis of Social Anxiety Disorder underwent 12 sessions of standardized, therapist-administered group CBT

**Procedure**
- Regional EEG spectral power (in uV^2) recorded during
  - relaxed wakefulness;
  - public speech anticipation (symptom provocation);
  - post-speech recovery.

**Measures**
- Delta-beta coupling
- Clinician and Self-ratings of symptom changes

**Assessments**
- Pre-treatment 1
- Pre-treatment 2
- Mid-treatment (after session six)
- Post-treatment
Changes in delta-beta correlation during CBT for SAD at rest
Changes in delta-beta correlation during CBT for SAD in response to speech anticipation
What does coupling reflect in social anxiety?

- Previous work suggests that correlated activity in delta and beta bands may be an electrophysiological index of cortico-subcortical interactions (Schutter et al., 2006; Velikova et al., 2010).

- One argument is that the decreased information transfer (reflected in low delta-beta coupling) is associated with less limbic excitability being transmitted to regions of the neocortex (e.g., van Honk & Schutter, 2007).

- Decoupling of delta and beta frequencies following CBT treatment may reflect reduced prefrontal inhibition of reward-related motivational networks
Caveats

- What is baseline?
- What is the source?
- What is the causal nature?
Question #3: What are the origins of the phenomenon?
On the nature, and nurture, of childhood shyness: An Interactionist model (individual X context) guiding research program

**Genotype(s)**

**Endophenotypes** (middle level)

**Phenotype**

**Exogenous Environmental influences** (e.g., parenting, attachment, peers, trauma, prenatal and extra-familial influences)

**Endogenous environmental influences** (e.g., gene-gene interactions; modifier gene interactions; gene-physiology interactions)

**Stress-reactivity system and measures:**

- frontal lobe – HPA – autonomic circuit

**Genes**

- DRD4
- 5-HTT

**Outcomes**

- Social anxiety
- Social withdrawal
Evidence for a gene-environment interaction in predicting behavioural inhibition and shyness in middle childhood

Multiple meanings of context: Gene-”endo”environmental interactions


- Risk alleles and differential sensitivity (orchids versus dandelions metaphor)

- E.g., DRD4 long (risk allele) in the presence of…
  - Exogenous environments (good parenting) “for better”
  - Exogenous environments (bad parenting) “for worse”
Evidence for a gene-*endo*environment interaction in predicting children’s behaviour

**Long DRD4 allele in the presence of left frontal EEG asymmetry = easily soothable (“for better”)**

**Long DRD4 allele in the presence of right frontal EEG asymmetry = attention problems (“for worse”)**
Concluding Thoughts

- Electrocortical measures as moderating factors
- Or “Endophenotypes” (i.e., middle level between gene and behavior)
- Conceptually these endophenotypes also provide unique and distinct “Endoenvironmental” conditions
- Identification of distinct moderating factors which can be manipulated
- Theoretical implications = mechanism
- Practical implications = intervention can be targeted at altering endophenotype (i.e., brain activity) to alter behaviour
Augmentation of Exposure Therapy With d-Cycloserine for Social Anxiety Disorder

Stefan G. Hofmann, PhD; Alicia E. Meuret, PhD; Jasper A. J. Smits, PhD; Naomi M. Simon, MD, MSc; Mark H. Pollack, MD; Katherine Eisenmenger, MD; Michael Shiekh, MD; Michael W. Otto, PhD

Arch Gen Psychiatry. 2006;63:298-304

Figure 2. Social Phobia and Anxiety Inventory (SPAI) scores at pretest, posttest, and 1-month follow-up assessments of treatment completers. Error bars indicate standard errors.
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