Freddie says hello!
UEL BabyDevLab

**Current members - PhDs**

- Environmental transmission of emotion dysregulation
- Endogenous attention, emotion reactivity and regulation
- Educational environment, attention and learning
- Interpersonal neural synchrony, endogenous attention, parental sensitivity

**Postdocs**

- Neural correlates of 'active' and 'passive' learning

- Default Mode and State Switching
- Home stress and neural sensitivity
- Environmental transmission of emotion dysregulation

- Naturalistic stress and attention in Rett Syndrome

- National Institute for Health Research
- rett syndrome research trust
- Horizon 2020 Programme
Interpersonal synchrony and responsivity during early life
“Contra Fodor, I argue that...”
Current approaches:
Current approaches:

- Non-interactive
Current approaches:

• Non-interactive

  Neural responses to the same social stimuli differ widely between interactive and non-interactive settings (Redcay & Warnell, 2018)
Current approaches:

One-way flow of information

Bi-directional information exchange

Even early learning is bi-directional – ‘active learning’ (Begus & Southgate, 2018)
Current approaches:

- **Massively simplified**
Current approaches:

- Massively simplified
Naturalistic interactions
Giving as few instructions as possible...
Social influences on attention and learning are *transient and dynamic*:
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- When an 16-month-old infant initiates a learning exchange by pointing to an object, their memory retention for functions subsequently demonstrated on that object is increased (Begus, Gliga, & Southgate, 2014).
Social influences on attention and learning are *transient and dynamic*:

- When an 16-month-old infant initiates a learning exchange by pointing to an object, their memory retention for functions subsequently demonstrated on that object is increased (Begus, Gliga, & Southgate, 2014).

- When a parent pays attention to a particular object while they are engaged in shared activity with their 12-month-old infant, this immediately increases the duration of attention that the infant pays to that object (Yu & Smith, 2016).
Neural synchrony
Take-away

- During social interaction, interpersonal neural phase synchrony transiently increases following mutual gaze and decreases during episodes of object play
Neural synchrony

Take-away

- During social interaction, interpersonal neural phase synchrony transiently increases following mutual gaze and decreases during episodes of object play

How?
Two completely different routes to neural phase synchrony:

- naturally occurring ‘edges’ in social interactions (such as gaze onsets) cause phase entrainment in both interacting brains
  -> behavioural synchrony causing neural synchrony

- shared understanding involves temporally co-occurring patterns of brain activity
  -> neural synchrony in the absence of behavioural synchrony

Wass et al., under revision, TICS
Neural synchrony
Take-away

• End on the question:
  Are neural and physiological synchrony best seen just as epiphenomena of behavioural synchrony? Or do they play a distinct, mechanistic role in early attention, and learning?
Neural synchrony
Take-away

- End on the question:
  Are neural and physiological synchrony best seen just as epiphenomena of behavioural synchrony? Or do they play a distinct, mechanistic role in early attention, and learning?
  The jury’s still out!
- Adult recited nursery rhymes
• Just looked at C3/C4 and 3-6 and 6-9Hz.
• Calculated Generalised Partial Directed Coherence to look at whether changes in the parent’s brain activity anticipate changes in the child’s brain activity, and *vice versa*...
During live interaction found both adult->infant AND infant->adult Granger-causal influences.

Both influences were stronger during direct gaze.
Free tabletop play

Phase-Locking Value

1-16Hz.
Phase-locking increases around mutual gaze onsets – whether it’s the parent joining the look...
Phase-locking increases around mutual gaze onsets – for parent-initiated mutual gaze

**Delta (1-3Hz)**

**Theta (3-6Hz)**

**Alpha (6-9Hz)**

**Beta (9-15Hz)**
...and for infant-initiated mutual gaze

- Delta (1-3Hz)
- Theta (3-6Hz)
- Alpha (6-9Hz)
- Beta (9-15Hz)

Seconds relative to look onset
Phase locking increases following non-reciprocated parent looks to infant

Delta (1-3Hz)

Theta (3-6Hz)

Alpha (6-9Hz)

Beta (9-15Hz)

Seconds relative to look onset

Seconds relative to look onset
...whereas looks to objects lead to decreases in phase synchrony...
Neural synchrony

Take-away

- During social interaction, interpersonal neural phase synchrony transiently increases following mutual gaze and decreases during episodes of object play
How is phase entrainment (at up to 9Hz!!) achieved?
How is phase entrainment (at up to 9Hz!!) achieved?

Speech-brain entrainment: acoustic ‘edges’ (i.e. sharp increases in signal intensity) in the speech amplitude envelope that drive theta- and delta-rate EEG oscillations to entrain to the rhythms in natural speech (Doelling, Arnal, Ghitza, & Poeppel, 2014)
How is phase entrainment (at up to 9Hz!!) achieved?

Do gaze onsets act as ‘edges’ in the same way – causing phase-resetting in two brains concurrently during social interaction?

[Diagram showing phase entrainment with labels: Random phase, Alligned phase, Phase-locked value.]

Phase-sorted trials
Inter-trial coherence
Mutual gaze onset
Time (ms)
-1000ms 0ms 1000ms
Phase
-1000ms -800ms -600ms -400ms -200ms 0ms 200ms 400ms 600ms 800ms 1000ms
How is phase entrainment (at up to 9Hz!!) achieved?

Do gaze onsets act as ‘edges’ in the same way – causing phase-resetting in two brains concurrently during social interaction?

Might also be true for vocalisations, touch...
Neural synchrony
Take-away

Two routes to neural synchrony:

• both brains show common patterns of phase entrainment to naturally occurring ‘edges’ in social interactions (such as gaze onsets)
  -> behavioural synchrony causing neural synchrony

• shared understanding involves temporally co-occurring patterns of brain activity
  -> neural synchrony in the absence of behavioural synchrony

Wass et al., under revision, *TICS*
Correlated Neural Activity and Encoding of Behavior across Brains of Socially Interacting Animals

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SUMMARY

Social interactions involve complex decision-making tasks that are shaped by dynamic, mutual feedback between participants. An open question is whether and how emergent properties may arise across brains of socially interacting individuals to influence social decisions. By simultaneously performing microscopic calcium imaging in pairs of socially interacting mice, we find that animals exhibit interbrain correlations of neural activity in the prefrontal cortex that are dependent on ongoing social interaction. Activity synchrony arises from two neuronal populations that separately encode one's own behaviors and those of the social partner. Strikingly, interbrain correlations predict future social interactions as well as dominance relationships in a picture that reflects the dynamic nature of social interactions, as well as the emergent neural properties that arise from multiple individuals as a single integrated system (Adolphs, 2010; Chen and Hong, 2018; Ochsner and Lieberman, 2001; Schilbach et al., 2013).

In recent years, much effort has been made to explore how neural systems coordinate across individuals engaged in social interaction. Simultaneous recordings from multiple human subjects using non-invasive techniques (e.g., functional MRI [fMRI]) and electroencephalography (EEG) have revealed striking patterns of interbrain neural activity coupling during social engagement (Babiloni et al., 2008; King-Casas et al., 2005; Liu and Pečuković, 2014; Montague et al., 2002). Despite these remarkable findings, little is currently known about how interbrain synchrony arises from social interactions. Moreover, it remains unclear how synchrony emerges from individual neurons and neuronal populations, in part due to the limited spatial resolution of recording techniques in humans, which cannot resolve single-cell activity.
Simony et al., 2016

- Synchrony in default mode network areas was higher during comprehensible vs incomprehensible video clips
Adult brain dynamically tracks and responds to infant attention
Is neural synchrony ‘just an epiphonemon’ of behavioural synchrony?
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Receptivity is higher for stimuli presented at high excitability oscillatory phases compared to inhibitory oscillatory phases are better remembered (Busch et al., 2009).
Is neural synchrony ‘just an epiphenomenon’ of behavioural synchrony? Or does it play a distinct, mechanistic role in learning?

Receptivity is higher for stimuli presented at high excitability oscillatory phases compared to inhibitory oscillatory phases are better remembered (Busch et al., 2009).

Maybe phase synchrony during social interactions allows us to judge when to deliver learning items so that they are an optimal stage for the learners encoding.
Is neural synchony ‘just an epiphenomon’ of behavioural synchrony? Or does it play a distinct, mechanistic role in learning?

The jury’s still out on this one!
Neural synchrony

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Neural synchrony
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• Are neural and physiological synchrony best seen just as epiphenomena of behavioural synchrony? Or do they play a distinct, mechanistic role in early attention, and learning?
We’re hiring!

1 postdoc starting early 2020
3 PhD positions starting Sept 2020
THANK YOU!!

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Twitter: @drsamwass
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No man (or woman) is an island, entire to themselves...
We also found that infants who vocalised for longer had a stronger influence on adult brain activity.
Child gaze onset to mutual gaze

Adult gaze onset to mutual gaze

Child gaze
- Inattentive
- Partner
- Object 1
- Object 2

Adult gaze

Child EEG

Adult EEG

Child vocalisations

Adult vocalisations

Time (seconds)
We can also look at gaze onsets to non-mutual gaze...
Parental frontal brain activity tracks and predicts infant attention during shared play

...Parise & Csibra, 2013

Wass et al., in prep
Parental frontal brain activity tracks and predicts infant attention during shared play

During joint play, the adult responds to the actions of the child by matching their own neural state to that of the child

Wass et al., in prep
People interested in social interaction should actually study social interaction?