When auditory mismatch negativity deviates from simple probabilistic inference.

**Presenter:** Juanita Todd

**Team**
Andrew Heathcote, Alex Provost, Lisa Whitson, István Winkler

**PhDs:** Daniel Mullens, Karlye Damaso, Jade Frost

**Honours:** Jessica Woodley, Gabriel Heaton, Kaitlin Fitzgerald, Kelly McDonnell
Mismatch Negativity (MMN)

\[ \text{MMN} = \text{prediction} - \text{error signal} \]

Elicitation = Model based on probabilistic inference is active.
MMN = Confidence-weighted prediction-error

**Amplitude** = Modulated by confidence in the model.

Confidence is complex:
- Sensitive to model stability.
- Subject to order-driven “first impression” bias.
- Is modulated by not just local but super-ordinate sequence patterns.

**Elicitation** = MODEL IS ACTIVE

Probability & transition statistics:
- Good account of what you will predict and when you will see MMN
THE QUESTION: What affects confidence?

Standard probability ↑

- p = 0.90
- p = 0.70

Graph showing probability changes over time.
THE DESIGN: Multi-timescale paradigm

SLOW CHANGE Stable over 2.4 mins
FAST CHANGE Stable over 0.8 mins

Equal # of two sounds: 30ms & 60ms
Alternate probabilities: Standard p=0.875, deviant p=0.125
Interval onset-onset: 300ms
Hypothesis: Slow MMN > Fast MMN
Why do we have order-driven bias?

Weighted First-Impression

$X = \text{probable sound} = \text{predictable}$

$Y = \text{rare sound} = \text{unpredictable}$

$C = \text{confidence (stability/precision)}$

**SLOW CHANGE**

- Stable over 2.4 mins
- $C = \text{HIGH}$

**BIG MMN**

**FAST CHANGE**

- Stable over 0.8 mins
- $C = \text{LOW}$

**SMALL MMN**
Evidence at transition points

SLOW CHANGE  Stable over 2.4 mins

FAST CHANGE  Stable over 0.8 mins
Transition Points

SLOW CHANGE  Stable over 2.4 mins

High confidence 1st scenario

FAST CHANGE  Stable over 0.8 mins

Low confidence 1st scenario

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**Transition points**

**SLOW CHANGE**  Stable over 2.4 mins

High confidence 1st scenario
Suppressed confidence in reversal

**FAST CHANGE**  Stable over 0.8 mins

Low confidence 1st scenario
Minimal impact on reversal

2014 - Brain Topography, 27, 578-89.
Weighted first impression is not enough...
Learning super-ordinate pattern or pattern of errors?

- High confidence
- Low confidence
- Slow
- Fast

- High confidence
- Low confidence
What if we remove the gap?

Does high confidence in roles remain?
• Big MMN to 1st deviant small MMN to 2nd deviant in both?

What if we remove the gap?

Does low confidence in roles remain?
• Small MMN to 1st deviant in both, MMN to 2nd deviant free to grow.

WRONG: Second-order PE
First impression confidence drops

Mullens, Damaso et al. in prep
Amplitude of MMN

- Not governed by transition statistics alone
- Subject to order-driven bias/heuristics……why?
- Modulated by predictions based on super-ordinate structure
- Operating over a long timescale and subject to learning

= A very sophisticated relevance-filtering system
Andrew Heathcote, Alex Provost, Lisa Whitson, Daniel Mullens, Jade Frost, Karlye Damaso, Jessica Woodley, István Winkler, Kelley McDonnell, Kaitlin Fitzgerald, Gabriel Heaton, Maria Chait

Published Data

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Stable over 2.4 mins

Stable over 0.8 mins

SLOW CHANGE

FAST CHANGE

Short (30ms) Target Group

Long (60ms) Target Group

MMN Amplitude (µV)

Fast Slow
60 FIRST

60ms
30ms
60ms
What if we prevent 1:1 mapping?

- **30ms** = probable sound = predictable/redundant?
- **60ms** = rare sound = unpredictable/important?

\[
\begin{align*}
p=0.75 &= 30\text{ms} \ 1000\text{Hz}, \\
p=0.125 &= 60\text{ms} \ 1000\text{Hz}, \\
p=0.75 &= 60\text{ms} \ 1000\text{Hz}, \\
p=0.125 &= 30\text{ms} \ 1000\text{Hz}, \\
p=0.125 &= 30\text{ms} \ 1500\text{Hz} \\
p=0.125 &= 60\text{ms} \ 1500\text{Hz}
\end{align*}
\]

**Property of 30ms belongs to common and rare tones.**

**Should disrupt the bias because...**
No unambiguous mapping of duration to relevance.
What if we add another sound?

SLOW CHANGE: Stable over 2.4 mins

FAST CHANGE: Stable over 0.8 mins

Order 1: Slow > Fast both

Order 2: Slow > Fast 1st deviant only

[Graphs showing mean μV responses for Fast and Slow with deviants in Duration and Pitch for both orders]
What if we add another sound?

**MMN to a deviation in pitch** is being modulated by **sound duration** (a non-error property)

30ms in length Slow > Fast  60ms in length Slow < Fast

pitch deviant

pitch deviant