UNCONSCIOUS CROSS-MODAL BINDING: A CHALLENGE FOR GLOBAL WORKSPACE THEORY?

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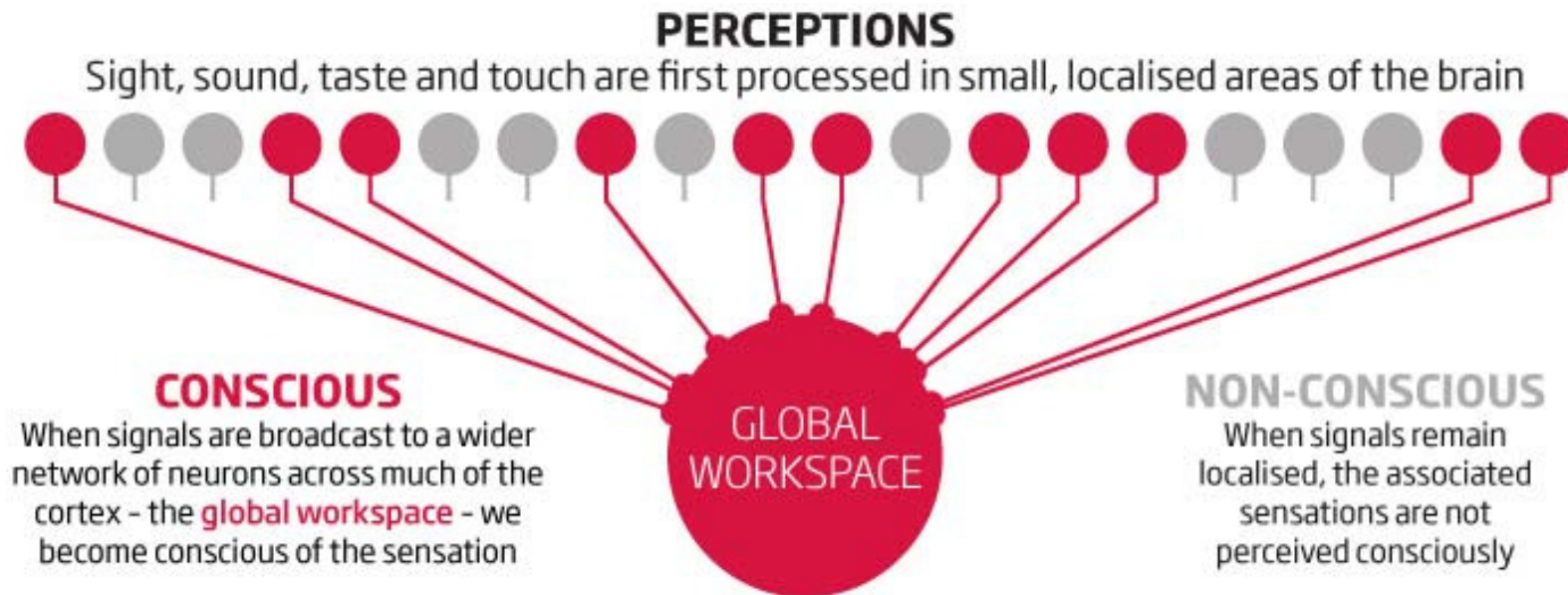Ron Chrisley[4,2]

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Seeking a Test of Global Workspace Theory

PERCEPTIONS
Sight, sound, taste and touch are first processed in small, localised areas of the brain

CONSCIOUS
When signals are broadcast to a wider network of neurons across much of the cortex - the global workspace - we become conscious of the sensation

GLOBAL WORKSPACE

NON-CONSCIOUS
When signals remain localised, the associated sensations are not perceived consciously

- An implication - learning dependent on the broadcast to a wider network should not occur without conscious awareness
- Specifically, *'consciousness is needed to integrate multiple sensory inputs'* (Baars, 2002)
- Unconscious 'cross-modal binding' should not be possible

Background

Unconscious Associations within a Single Modality

- Pessiglione et al., (2008) – Subliminal Instrumental Conditioning
- Duss et al., (2011) – Subliminal Face-Profession Pairs
- Reber & Henke, (2012) – Subliminal Word Pairs
- Atas et al., (2013) – Subliminal Sequence Learning

Unconscious Cross-modal Priming

- Kouider & Dupoux (2001) – Failed to find cross-modal priming visual to auditory

- Lamy et al. (2008) – Found cross-modal priming auditory to visual (using PDP).

'Unconscious' Cross-modal Associative Learning

- Arzi et al. (2012) – Cross-modal associative learning during sleep

Experimental Approach

A Linguistic Paradigm

- Strong existing representations should facilitate association
- Task remains the same whether auditory or visual

Reaction-time as dependent variable

- Previous work (e.g. Henke) had shown greater sensitivity in reaction times than classification responses.

A trial-by-trial test of awareness

- Avoids issues of drifting thresholds and variable attention
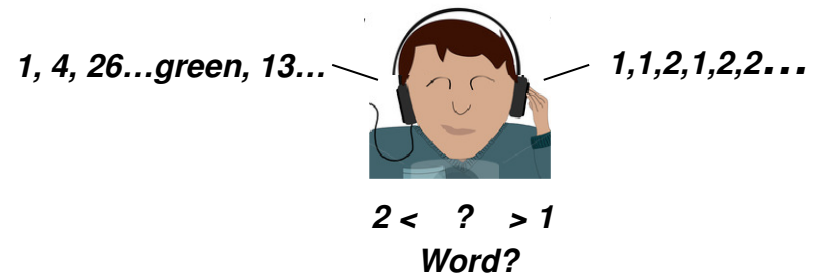- Permits use of optimal subjective threshold for each participant

Adopted a Three Study Sequence

- Auditory modality, visual modality, cross-modal
- Informative irrespective of cross-modal success.

Experiment 1: Auditory Modality

Pre-test stages

- Find auditory threshold in right ear
  (Report the non-number word)

  1, 4, 26...green, 13...

  Word?

- Introduce attentional task in left ear
  (Press left for 1, and right for 2)

  1, 4, 26...green, 13...   *1,1,2,1,2,2...*

  2 <   ?   > 1
  Word?

- Train the classification of professions
  (e.g. Pianist, Banker, Composer)

  Pianist   *Pianist*

  creative <   ?   > uncreative

Experiment 1: Auditory Modality

32 Test Trials – three stages per trial

- Two name-profession pairs presented below threshold (one creative profession, one uncreative profession) while doing the attentional task

$x2$
10, 4, *Mike Pianist*, 21…

1, 1, 2, 1, 2, 2 …

2, 2, 2, 1, 2, 1 …

$x2$
5, 2, *Paul Banker*, 7 …

2 < ? > 1
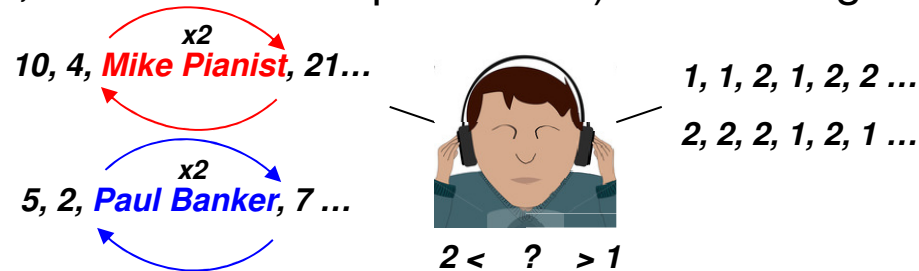
- Asked to report whether any non-number words had been heard

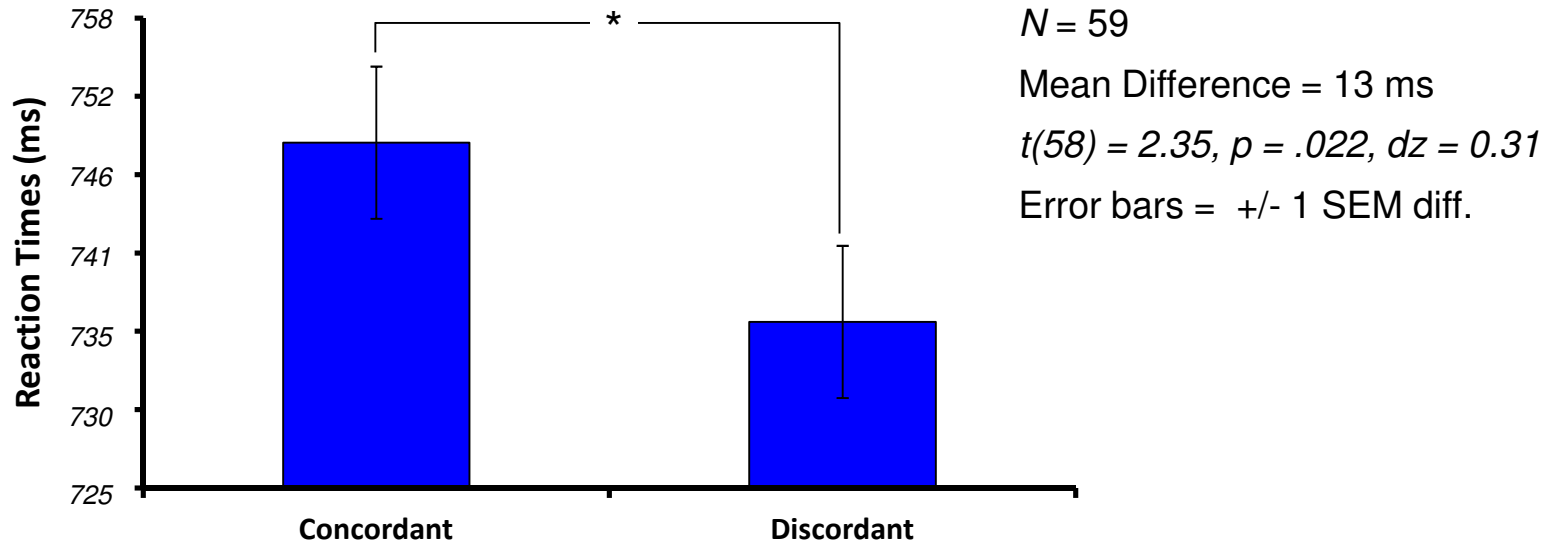- Timed classification of profession – primed by a name (above threshold)

Concordant with subliminal

Mike Pianist   *Mike Pianist*

OR

Discordant with subliminal

Mike Banker   *Mike Banker*

creative < ? > uncreative

creative < ? > uncreative
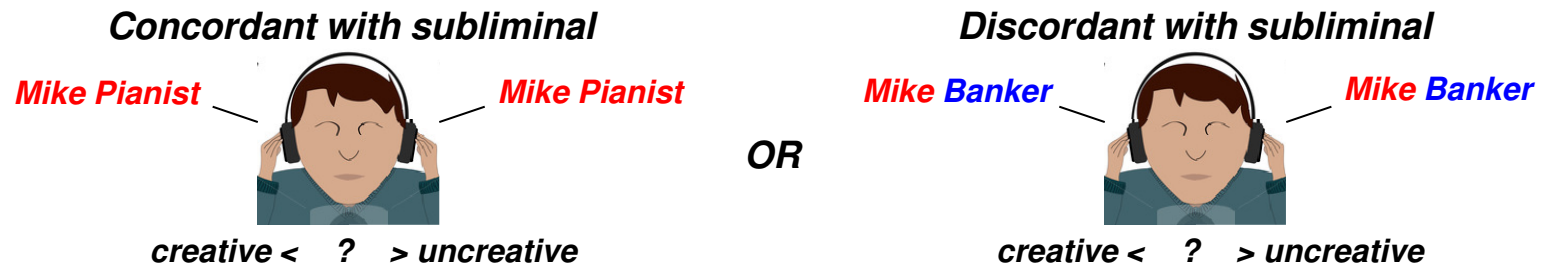
Delay (>200 ms) predicts negative priming in masked priming contexts (Eimer, 2006)

Experiment 1: Results

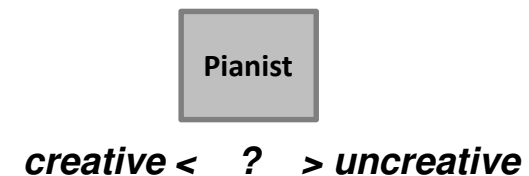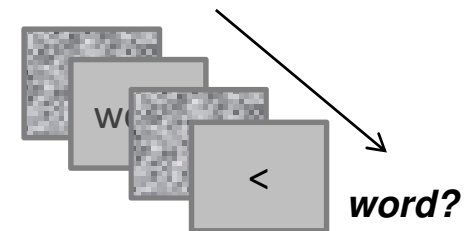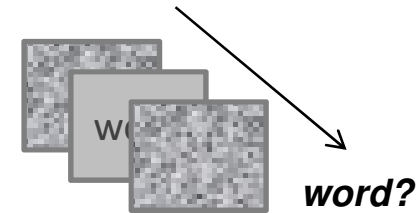**Pre-processing and exclusions (Identical for all 3 experiments)**

- RTs transformed using a reciprocal transformation to normalise
- Participants making > 25% classification errors ($N = 1$)
- Trials where a 'subliminal' word was identified ($M = 0.5\%$)
- Trials where the classification judgement was wrong ($M = 5.0\%$)
- Trials where the RT < 200ms or > 2SD from mean ($M = 4.3\%$)

$N = 59$

Mean Difference = 13 ms

$t(58) = 2.35, p = .022, dz = 0.31$

Error bars = +/- 1 SEM diff.

# Experiment 2: Visual Modality

Pre-test Stages

- Find visual threshold for low contrast words
  (Report any word seen)

word?

- Introduce attentional task)
  (Press left arrow or right arrow as seen)

<

word?

- Train the classification of professions
 (Press left for uncreative, right creative)

Pianist

creative <   ?   > uncreative

Experiment 2: Visual Modality

32 Test Trials – three stages per trial

- Two name-profession pairs presented below threshold (one creative profession, one uncreative profession) while doing the attentional task
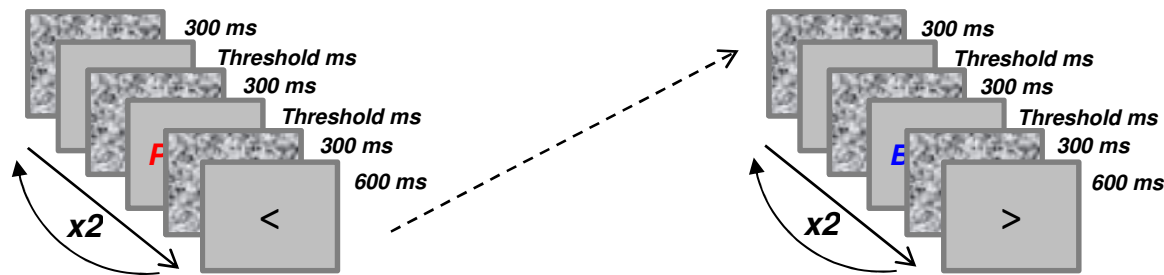
- Asked to report whether any words had been seen

- Perform timed classification of profession – primed by a name

Concordant with subliminal   **OR**   *Discordant with subliminal*
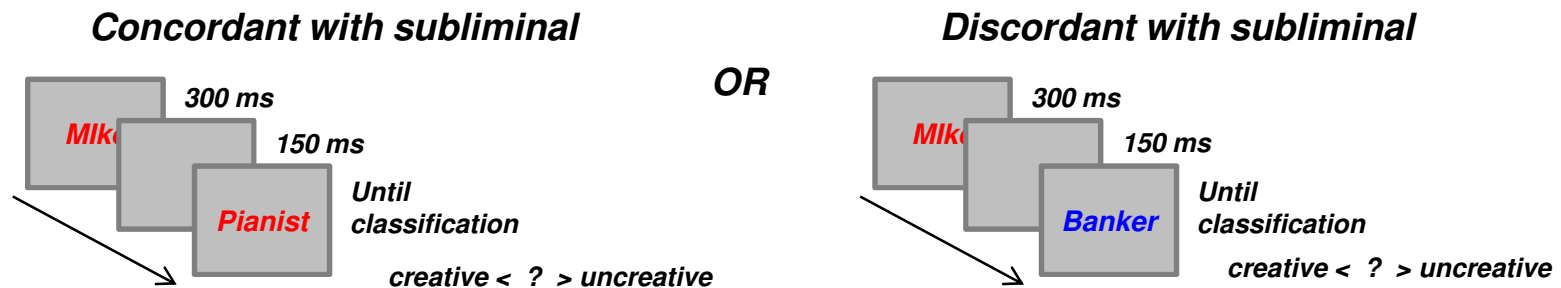
Delay (150 ms) chosen for consistency with auditory paradigm

Experiment 2: Results

Exclusions and pre-processing (Identical to Experiment 1)

- RTs transformed using a reciprocal transformation
- Participants making > 25% classification errors ($N = 3$)
- Trials where a 'subliminal' word was identified ($M = 7.7\%$)
- Trials where the classification judgement was wrong ($M = 7.5\%$)
- Trials where the RT < 200ms or > 2SD from mean ($M = 5.0\%$)

$N = 57$

Mean Difference = 19 ms

t(56) = 2.07, p = .044, dz = .27

Error bars = +/- 1 SEM diff
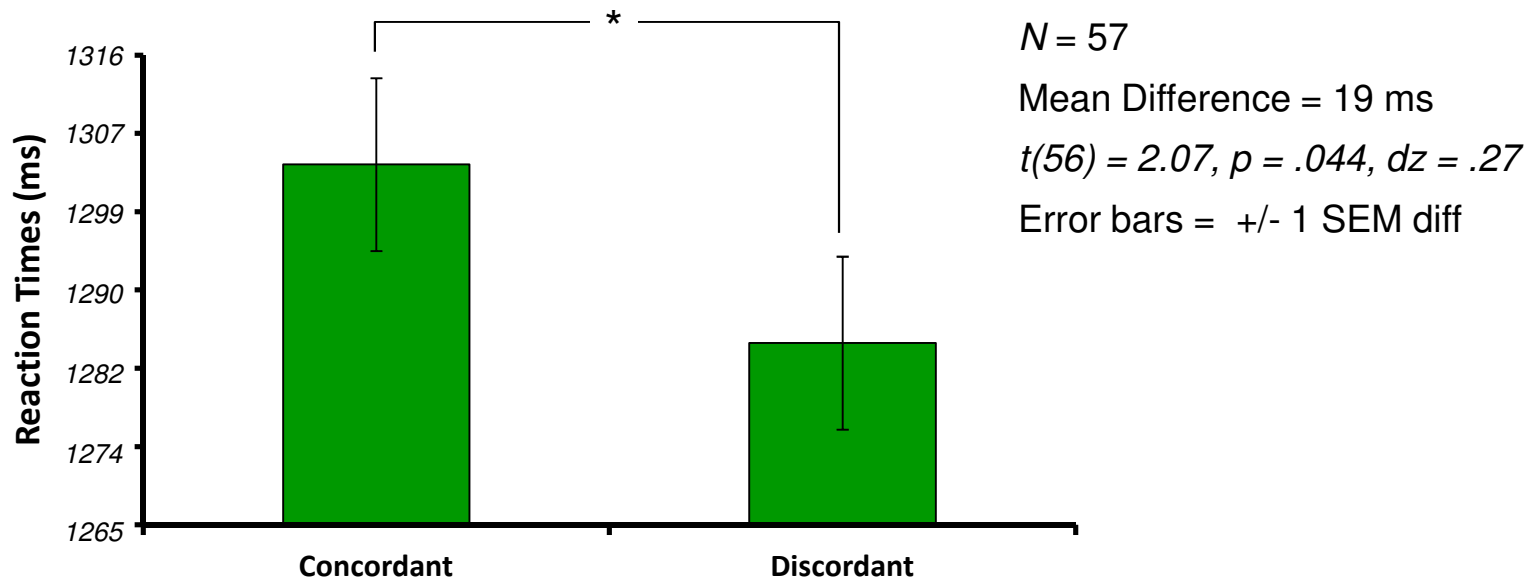
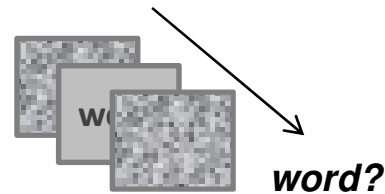# Experiment 3: Cross-Modal

Pre-test stages

- Find auditory threshold
  (Report the non-number word)

1, 4, 26...green, 13...

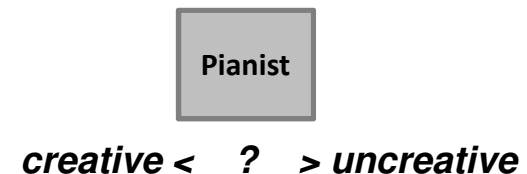*Word?*

- Find visual threshold
  (Report any word seen)

word?

- Combine visual and auditory with
  attentional task (left or right arrow)

1, 4, 26...green, 13...

words?

<

- Train the classification of professions visually
  (e.g. Pianist, Banker, Composer)

Pianist
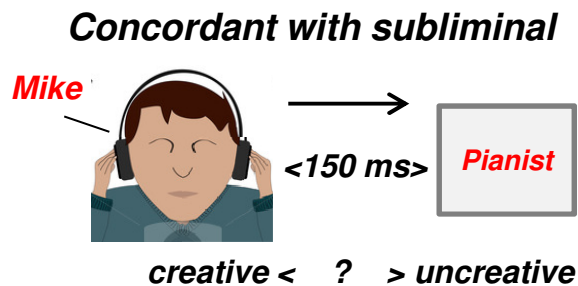
creative <   ?   > uncreative

Experiment 3: Cross-Modal
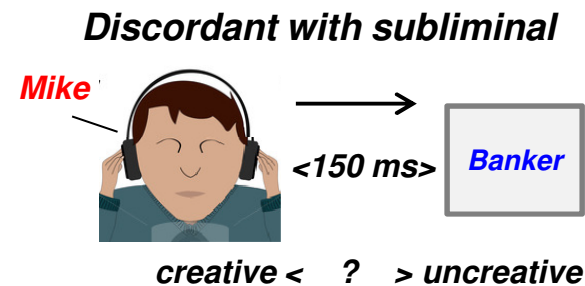
32 Test Trials – three stages per trial

- Two name-profession pairs presented below threshold – name presented audially followed by profession visually
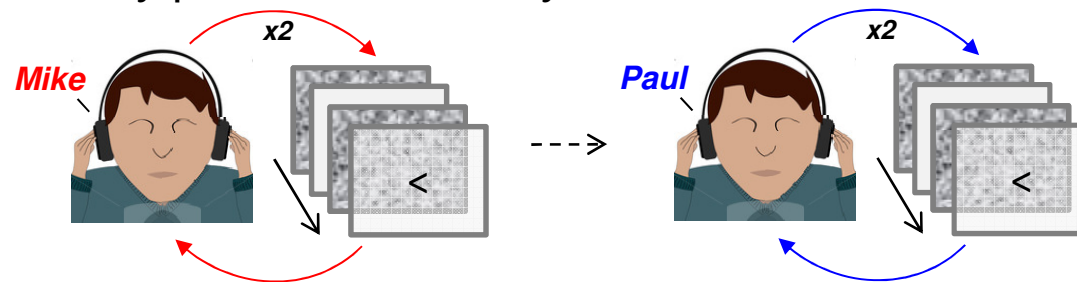
- Asked to report whether any words were either seen or heard

- Timed classification of profession – primed by a name (above threshold)
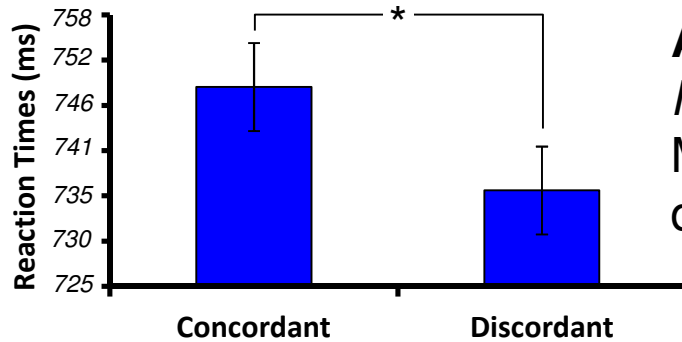
Concordant with subliminal   *Discordant with subliminal*

Mike → **<150 ms>** **Pianist**   **OR**   **Mike** → **<150 ms>** **Banker**

creative < ? > uncreative   *creative < ? > uncreative*

Experiment 3: Results

Pre-processing and exclusions (Identical to Experiments 1 & 2)

- RTs transformed using a reciprocal transformation
- Participants making > 25% classification errors ($N = 1$)
- Trials where a 'subliminal' word was seen or heard ($M = 0.5\%$)
- Trials where the classification judgement was wrong ($M = 7.3\%$)
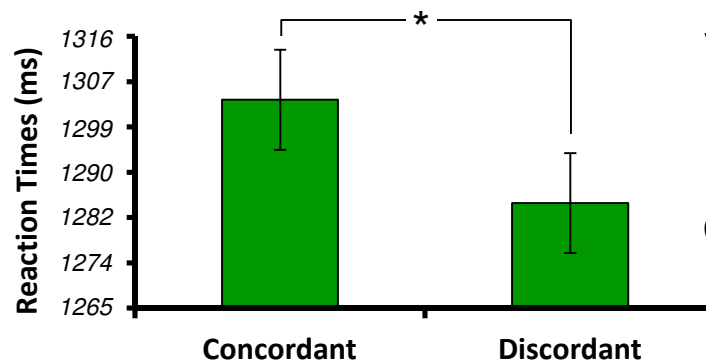- Trials where the RT < 200ms or > 2SD from mean ($M = 5.0\%$)

$N = 59$

Mean Difference = 14 ms

$t(56) = 2.39, p = .020, dz = .31$

Error bars = +/- 1 SEM diff
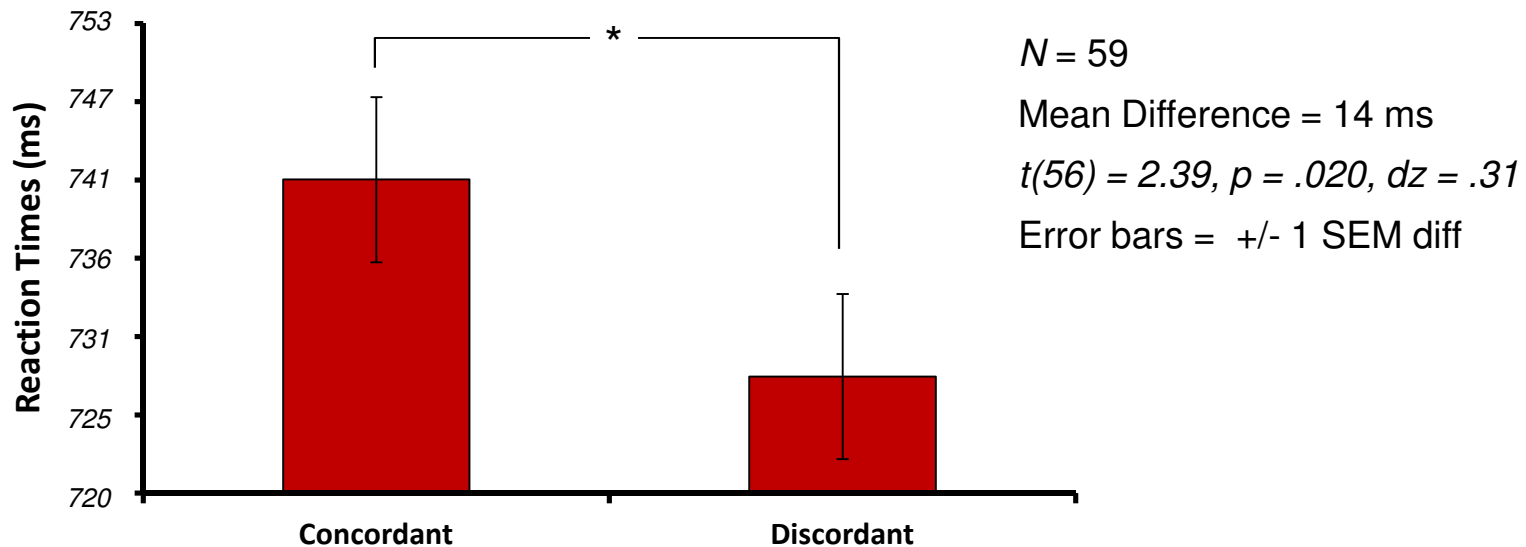
Results Summary

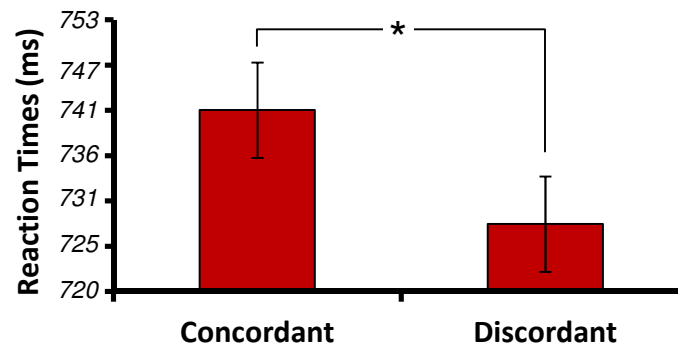**Auditory**
N = 59
Mean Difference 13 ms
dz = .31

Visual
N = 57
Mean Difference 19 ms
dz = .27

Cross-Modal
N = 59
Mean Difference 14 ms
dz = .31

CONCLUSIONS AND FUTURE STUDIES

- We've demonstrated unconscious associative learning both within individual modalities and cross-modally.

- Contrary to the Global Access Hypothesis this suggests that integration between sensory modalities can occur 'locally' without content entering the global workspace

- Faivre et al. (in prep) appear to have a similar finding using a entirely different paradigm

- Might these findings be limited to linguistic stimuli where there is a pre-learnt association between the visual and phonetic representations?

- One future study will seek to replicate the findings with non-linguistic stimuli

- A second study is planned that will replicate the cross-modal linguistic paradigm with stimuli above threshold permitting a comparison of conscious with unconscious performance

Collaborators

Zoltan Dienes

Jason Samaha

Ron Chrisley

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