Neural and cognitive correlates of human decision-making in domestic energy usage

CIBSE ASHRAE Technical Symposium 2014

Michael Keane, Alan F. Smeaton, Lorraine Boran, Graham Healy, Miriam Kennedy, Yang Yang, Cathal Gurrin
Aims

• Measure implicit / unconscious attitudes towards nature (important in influencing energy efficient decisions)

• Measure conscious decisions about energy usage: domestic heating energy choices – heat your home at its current comfort level, or adopt a more energy efficient approach (lower temperature)

COGNITIVE

NEURAL

Measure EEG (brain) activity during these tasks
Sample

- N = 30 (14 males, 16 females)
- Age: 18 – 45
- Marital status: 10 single, 13 married, 7 co-habiting
- Work status: 5 academics, 15 non-academic, 10 non-DCU
- 15 had no children
- Accom type: Apartment (5) Terrace (9) Semi-d (13) Detached (3)
- Home age: >60s (6), 70s-80s (5), 90s-00s (8), after 00 (9), other (2)
- Fuel: Gas (24) Oil (2) Elect (1) Combi (3)

- Monitor use: Bills (24) Gauges (2) Combination (3) Other (2)
Methods: questionnaires

- Demographics
- Personality
  - Group Identification Scale
  - Locus of Control Questionnaire
  - Behavioural Inhibition Scale/Behavioural Activation Scale
- Attitudes
  - Connectedness to Nature Scale
  - New Ecological Paradigm
Methods: Implicit Association Task

• Modified connectedness to nature IAT (adapted from Brunei et al.)

**Key outcome?**

**D-score**, based on RT differences between congruent and incongruent stimuli

**Congruent word associations**

- Nature Me
- Built Other
- Mountain
- Nature Built Other
- Chair

**Incongruent word associations**

- Nature Other Me
- Tree
- Nature Other Built Me
- Truck

**SLOWER**

**FASTER**

**HIGHER D-SCORE**
Methods: CPT

• Choice Preference Task

Consciously decide – based on the information presented, would I stay at my comfort level, or would I change?

Key outcomes?
Change %

Nudge Factor (feedback):
Cost
Environment
Peers

Framing:
Positive
Negative

Temperature change:
Small
Big
Neural markers and IAT d-scores

**Significant**: Correlation between mV amplitude and IAT d-score in a time-region -60 → -100ms prior to response for channel Fz.

Between the red vertical lines: time period examined for significant activity using spearman r. *The blue line indicates the time of response*
Neural markers and IAT d-scores

**Significant**: Correlation between mV amplitude and IAT d-score in a time-region 240 ms → 280 ms following **stimulus onset** for channel Cz.

Between the red vertical lines: time period examined for significant activity using spearman r. *(The blue line indicates the time of stimulus onset)*
Neural markers and IAT d-scores: High vs Low d-scorers

Difference in ERP waveforms **response locked** on channel Fz between high and low d-scorers.

Between the red vertical lines we can see the time region that best differentiates between high and low d-scorers.

Difference in ERP waveforms **stimulus locked** on channel Cz between high and low d-scorers.

Between the red vertical lines we can see the time region that best differentiates between high and low d-scorers.
Key observation: We have found a set of neural triggers which can:

(1) predict d-scores

(2) differentiate between high and low d-scorers

(neural event before response at Fz, and after stimulus onset at Cz)

These represent two separate neural correlates which differentiate between d-scorer subtypes
Results:
CPT
Factors influencing response choice

**Significant**: More likely to make an energy efficient choice when positively framed

**Significant**: Environmental information > cost information > peer feedback

Less likely to make energy efficient choice when information provided that peers are behaving in an energy efficient way

**Significant**: More likely to make energy efficient choices when asked to make small temperature change
Reaction times to response choice

**Significant:** Faster responses to *positively framed*

**Significant:** Faster responses when *cost was framed positively* (savings) rather than negatively (lost savings)
Key Findings
Framing home heating decisions in positive terms (e.g. gains or rewards associated with this behaviour) significantly nudges participants to make an energy efficient decision.

The likelihood of making an energy efficient decision is greater when asked to **consider effects on the environment**. In contrast, one is less likely to make an energy efficient decision when provided with peer feedback.
Key Finding 2

IAT d-score:

is correlated with two neural triggers;

is correlated with the perceived influence of nudge factors that promote energy efficient behaviour (e.g. motivation to be more energy efficient; penalty and rewards associated with making an energy efficient decision);

is predictive of response times on CPT and exhibits a strong trend towards predicting particular types of choices.
Acknowledgments

Michael Keane\(^2\), Alan F. Smeaton\(^1\), Lorraine Boran\(^2\), Graham Healy\(^1\), Miriam Kennedy\(^2\), Yang Yang\(^1\), Cathal Gurrin\(^1\)

\(^1\)INSIGHT Centre for Data Analytics, Dublin City University, Glasnevin, Dublin 9; \nschool of Nursing and Human Sciences, Dublin City University, Glasnevin, Dublin 9)