Workshop on:
AR/VR and Psychometric Instruments in Travel Behavior Research

Using EEG to understand how our brain elaborates information in stated choice experiments: Opportunities, and Challenges?

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Background

One of the key research questions in transport relates to …

… understanding how really people make choice.

This has been approached traditionally from:

- Economic perspective
- Psychological perspective
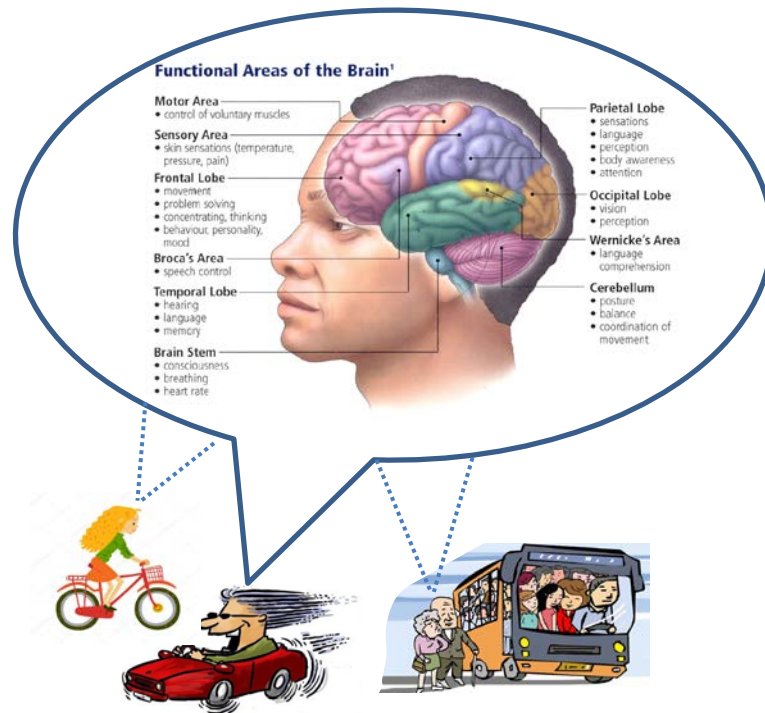- More recently a combination of both

Recent advances in neurosciences have recently opened up new research frontiers and the possibility to explore human behaviour through the lens of the brain activities.

"The way our brains work is key to understanding how consumers really make choices"

Daniel McFadden.
5th Lindau Meeting on Economic Sciences
Article by Phil Thornton (2014)

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The mental processes underlying behaviour are represented in the brain.

Functional Areas of the Brain'

Motor Area
• control of voluntary muscles

Sensory Area
• skin sensations (temperature, pressure, pain)

Frontal Lobe
• movement
• problem solving
• concentrating, thinking
• behaviour, personality, mood

Broca's Area
• speech control

Temporal Lobe
• hearing
• language
• memory

Brain Stem
• consciousness
• breathing
• heart rate

Parietal Lobe
• sensations
• language
• perception
• body awareness
• attention

Occipital Lobe
• vision
• perception

Wernicke's Area
• language comprehension

Cerebellum
• posture
• balance
• coordination of movement

Neuroeconomists have been able to show that, for example:

"*there is a physiological basis for the cognitive anomalies such as loss aversion, the endowment effect … that psychologists have identified*."

Daniel McFadden.
Article by Phil Thornton (2014)

"*there are typically differences in the intensity of neural activation when subjects make real versus hypothetical choices*"
"*more functions are involved in a real choice setting versus a hypothetical one*"

Colin Camerer and Dean Mobbs
Trends in Cognitive Science (2017)

Source: Cherchi, E. (2020) Our IATBR: 45 years of contribution to transport behaviour research. In Mapping the Travel Behavior Genome. K. Goulias (ed.) Elsevier, Chapter 1, 17-28

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Background: Challenges

The mental processes underlying behaviour are represented in the brain.

Transport often involves complex behaviours ➤ This activates several parts of the brain ➤ It is difficult to disentangle which function is playing a role in the behaviour

Transport data often are collected in hypothetical conditions (such as SP) ➤ More functions and with strong intensity are involved in real choice setting ➤ Hypothetical choice tasks give an incomplete picture of brain circuitry that is active during real choice

Transport behaviours often involves choices ➤ In nonchoice domain (such as motor actions) brain scans show substantial overlap between activity during imagined and real movements. ➔ This is not the case in the choice domain.

Specific lab settings is required to correctly measure brain activities ➤ Different from how we typically measure transport choices ➤ It is difficult to compare or combine information or results

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Combine EEG and SC experiments

I will discuss a study conducted to explore the potentiality of electroencephalogram (EEG) recordings in improving our understanding of how people make choices in a stated choice (SC) context.

Source:
Cherchi, E., Vuong. Q and Stergiou, A. (2020) Using EEG to understand how our brain elaborate information in stated choice experiments: Easy versus hard tasks in the choice of vehicles. bioRxiv doi: 10.1101/2020.01.29.926162

Specific aim:

Provide preliminary evidence that complex consumer choices depends on cognitive processes and executive functions that may not be fully captured by current SC approaches.

A persistent problem in using Stated Choice (SC) is that when respondents are presented with a complex task, it is likely that they show disengagement, adopting simplifying strategies to reduce the mental effort required solving the problem.

Making complex decisions involves <u>executive functions</u> such as working memory, retrieving relevant long-term information, inhibition of irrelevant information and cognitive flexibility.

EEG

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SC experiment

Electric Vehicle Survey

	Petrol car	Electric car
New car, Small		
Purchase price *Price for a standard version without special equipment*	£ 11,000	£ 11,000
Driving costs *Expenses for fuel or electricity*	16.0 p / mi	13.6 p / mi
Operation range *The distance it is possible to drive on a full tank or fully charged battery in optimal conditions*	150 miles	110 miles
Carbon emissions *The total emissions per mile of driving*	130 g/mi	0 g/mi
You are also informed that …		
In 2019, the average number of new EV registered in the UK is *Compared to the total number of new cars registered in the same period, this means*		4,988 EV new registrations Still only 3% of the Market share

The SC experiment was customised based on the car size that respondents intended to buy, according to 3 types of cars: small, medium and large car.

Screening information was collected to guarantee realism.

Cherchi, E. (2017) A stated choice experiment to measure the effect of social conformity in the preference for electric vehicles. *Transportation Research* A 100, 88-104.

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SC experiment

A total of 16 scenarios were generated.

To be able to study the effect of hard versus easy choices, scenarios were built such as to have:

- 8 "hard" scenarios,
  i.e. where the decision is expected to be difficult ➔ probabilities to choose EV and ICV within 39% and 59%

- 8 "easy" scenarios
  i.e. where the decision is expected to be simpler ➔ probabilities to choose EV and ICV higher that 59% or lower than 39%

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Sample

Step 1: Online survey

A sample of 118 participants was randomly selected from members of a panel, trying also to match the gender, age and education balance.

Step 2: Survey in the lab

After completing the online survey, 20 participants from the above sample were invited to participate in the lab experiment, where they completed the same SC scenarios while we recorded EEG responses.

Each participant completed 2 blocks of 16 SC scenarios each, with a break in between. The 16 SC scenarios included the same 8 from the online survey plus 8 new ones.

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EEG experiment challenges

It is not possible to directly relate the EEG stimulus to choice behaviour on each trial.

A sufficient number of trials for the same subject is needed to ensure a high signal-to-noise ratio in the EEG data.

32 trials

For different durations (time to take a decision) there are more frequencies to distribute power throughout
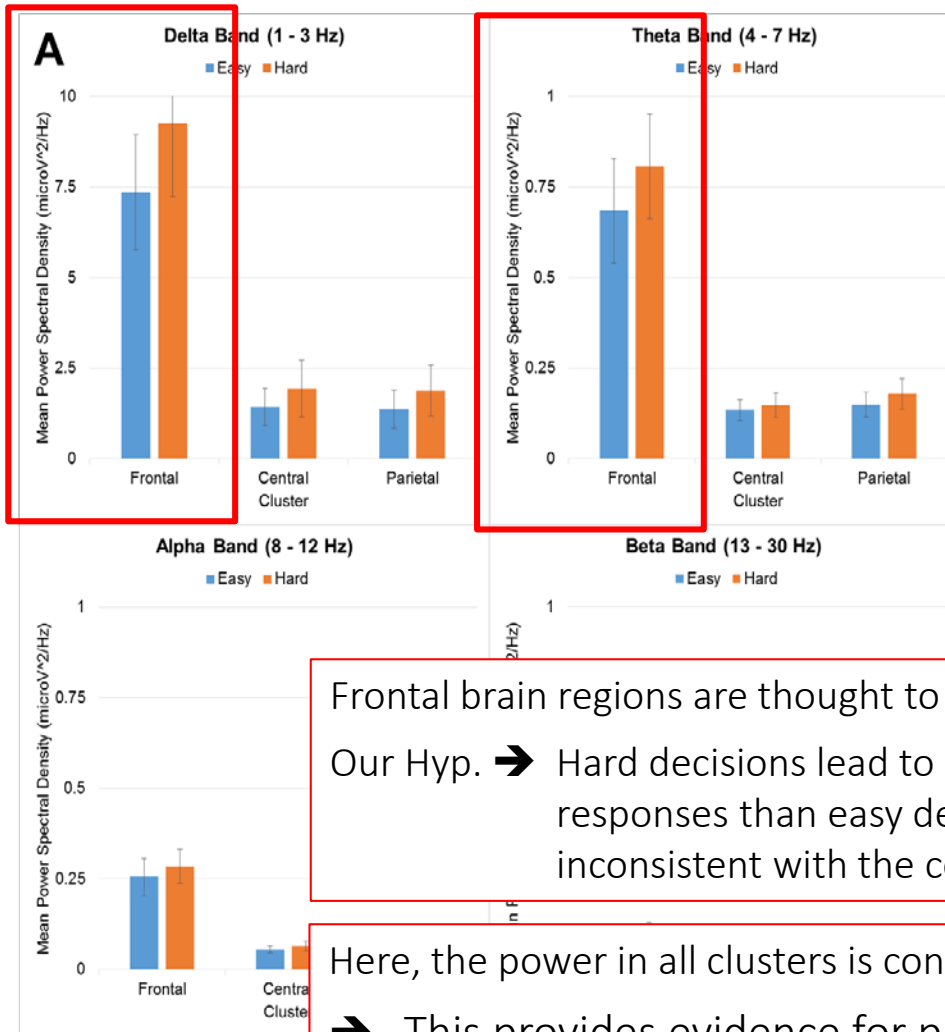
Respondents had 40 sec to make a choice

Making a choice in the mind and
actually recording the choice by pressing a button correspond to different mental states and needs to be recorded separately
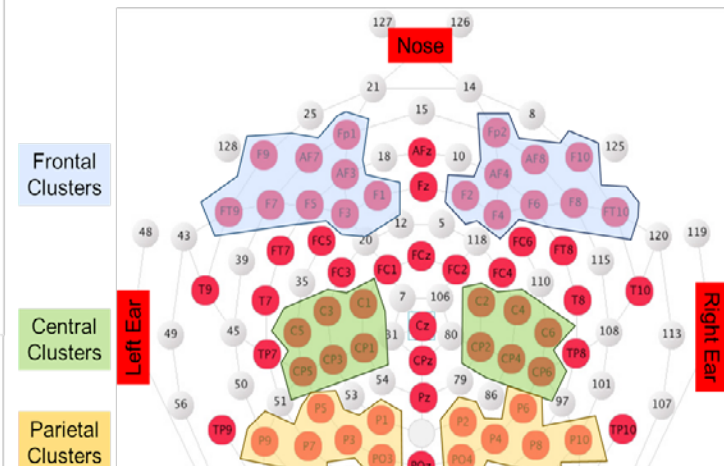
Choice is presented separately from the alternatives

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EEG Results

A

Delta Band (1 - 3 Hz)

Theta Band (4 - 7 Hz)

Alpha Band (8 - 12 Hz)

Beta Band (13 - 30 Hz)

B Location of the electrode clusters

Frontal brain regions are thought to be involved in complex decision making.

Our Hyp. ➔ Hard decisions lead to higher cognitive demands and larger EEG responses than easy decisions. These demands can lead to choices inconsistent with the compensatory assumptions.

Here, the power in all clusters is concentrated in the slow delta (and theta) bands.

➔ This provides evidence for processes like working memory, executive function

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Overall Conclusions

Research is still at its infancy. It is crucial to:

- Collect evidences to understand potentiality and limits.
- Use a rigorous protocol.

High potentials:

- Better understanding of decision process
- More and richer data
- Better predictions ….???

High risk of confounding effects:

- The brain sources generating the EEG signals measured on the scalp cannot be precisely localised so caution is needed when relating EEG power to brain activity.
- The simple movement of eyes to read the text, can cause eye-movement related artefacts.

➔ It is possible to control for these effects, but it requires additional instruments

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Many thanks

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