UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Detection of concealed knowledge via the ERP-based technique *Brain Fingerprinting*: Real-crime scenarios

09 Apr 2021

Usman Afzali

PhD Candidate (Forensic neuroscience and Cognitive psychology)

School of Psychology, Speech and Hearing, University of Canterbury

Brain Fingerprinting (BFP)

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha

99% (or above 90%) determination accuracy

Dr. Larry Farwell Has Offered a $100,000 Reward for Beating a Brain Fingerprinting Test

And Reported the Results in a Peer-Reviewed Journal

Dr. Farwell has o[illegible]ed a $100,000 [illegible]ward for beating a Brain Fingerprinting test. Despite this $100,000 reward, no o[illegible] beaten a [illegible]gerprinting test. Dr. Farwell even taught subjects the countermea[illegible]s t[illegible]ave prove[illegible]ec[illegible]gainst other, fundamentally different, non-Brain Fingerprinting methods[illegible]asures had [illegible]f[illegible]rain Fingerprinting.

Lik[illegible] highly m[illegible]ed subjec[illegible] were cr[illegible] suspects in cases where Brain Fingerprinting could ha[illegible]n impact on t[illegible]udicial o[illegible]me -- e.g., wh[illegible]Brain Fingerprinting was ruled admissible as scientific e[illegible]nce in court -- [illegible] subjects w[illegible] were motivate[illegible] Farwell's $100,000 reward were in every case c[illegible]ctly detected by[illegible]rain Finge[illegible]rinting.

Dr.[illegible]ell and [illegible] colleagues Dr. [illegible] Richar[illegible], the former chief of the FBI's chem-bio-nuclear counte[illegible] response team who co[illegible]rain Fingerprinting research with Dr. Farwell at the FBI, and Graham Richardson, published the results of the "Real Crimes Real Consequences $100,000 Reward Brain Fingerprinting Study" in the leading peer-reviewed journal *Cognitive Neurodynamics.* Here is the article:

Independence

How it works?

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

- Lab setting: Hear a story about an incident and turn the relevant facts to stimuli.
- If a subject narrated the story to us = > Ground-truth Information Present (GT-IP)
- Another subject who did not tell us the story = > Ground-truth Information Absent (GT-IA)
- Divide the stimuli into two sets: **probes** and **targets.**
  - Targets: stimuli known to both GT-IP and GT-IA
  - Probes: stimuli known to GT-IP only
- Make up a third type of stimuli: **irrelevant** (two for each target and two for each probe): not known to either, non-relevant to the context being tested

Task

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

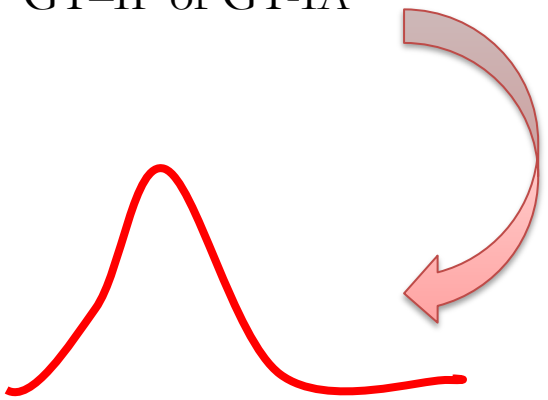
- Look at the screen, identify the targets, and press a button.
- Also, identify anything other than target and press a different button.
- Apparatus: Dry EEG headset that records **Pz**, Fz, Cz and two **EOG** channels.

Stimuli processing

The place the group started their trip from

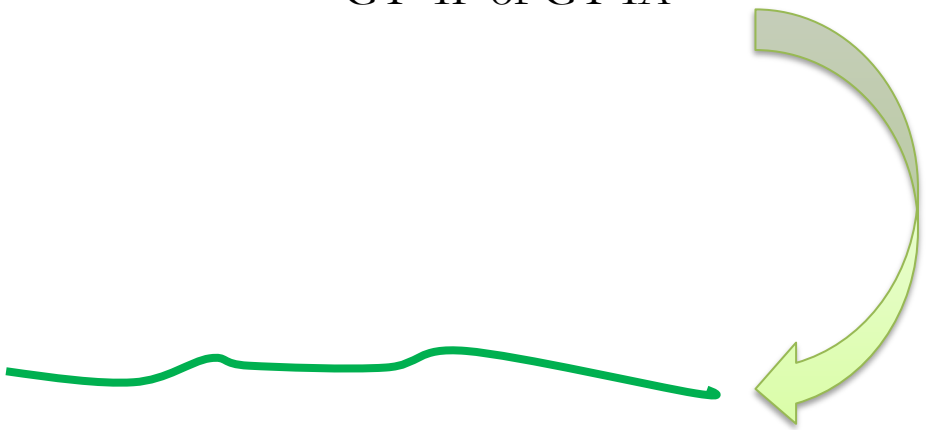
Dunedin Harbour (Target)

GT–IP or GT-IA



Marlborough Sounds (Irrelevant)

GT–IP or GT-IA

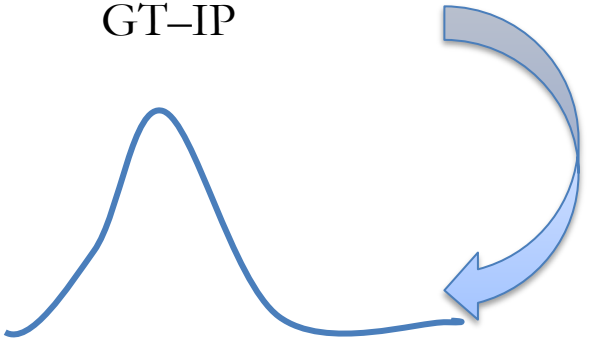


Stimuli processing

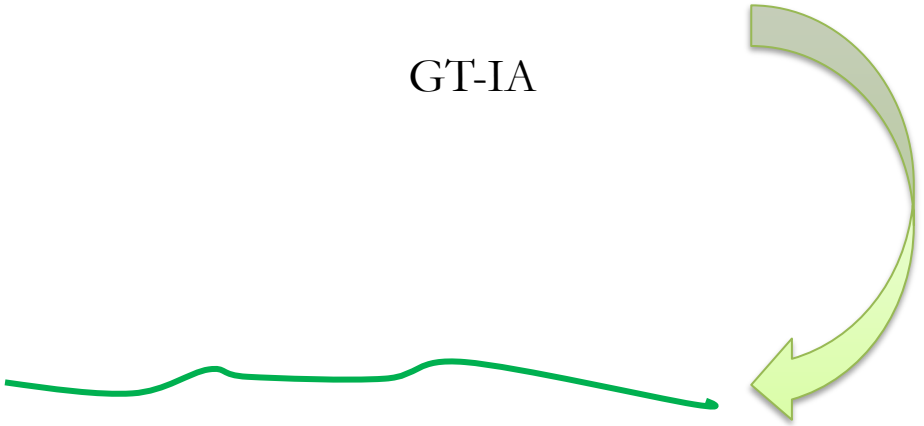
The name of the bay group sailed to

Waikouaiti (Probe)

GT–IP



GT-IA

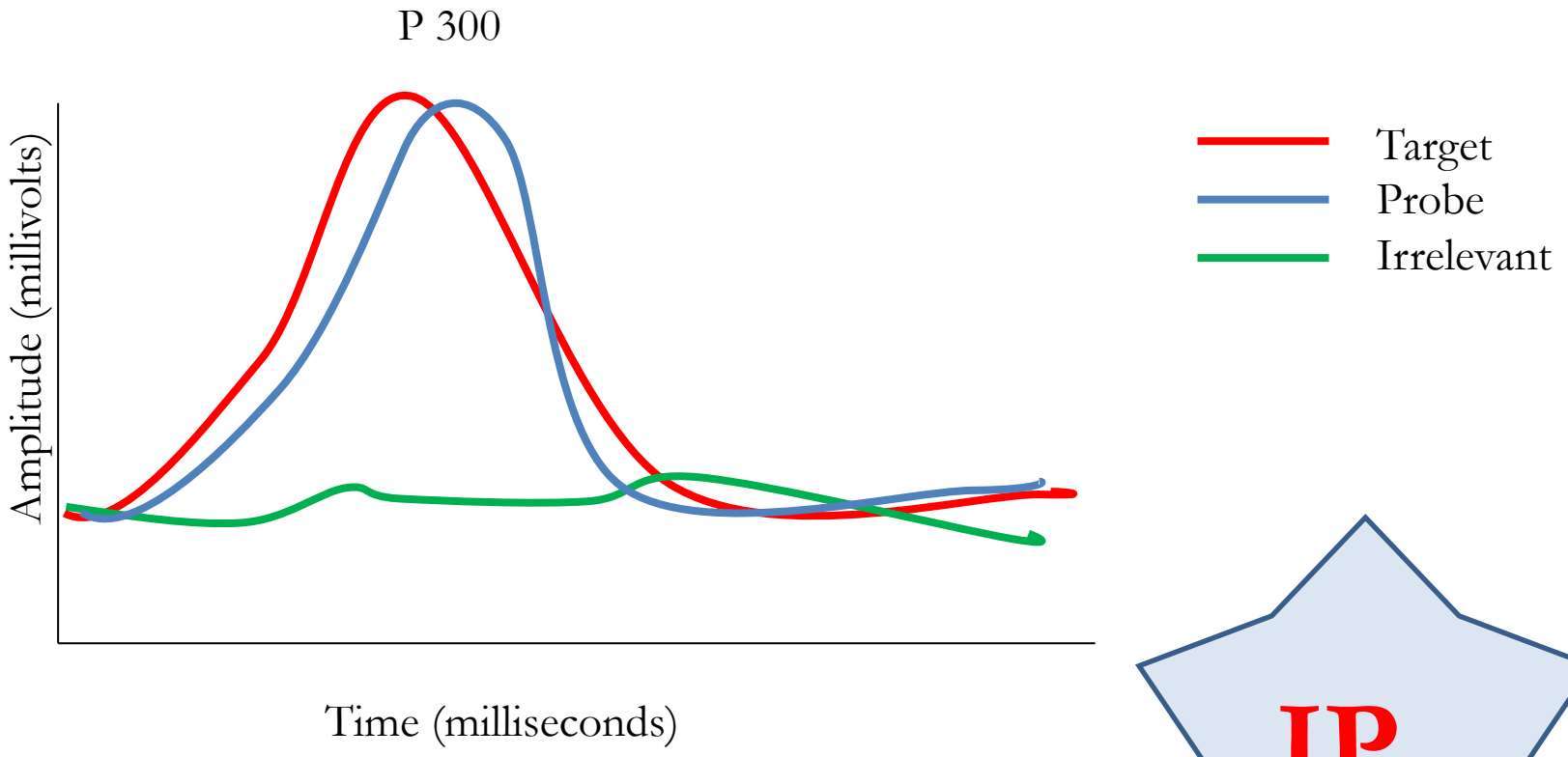


Analysis

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

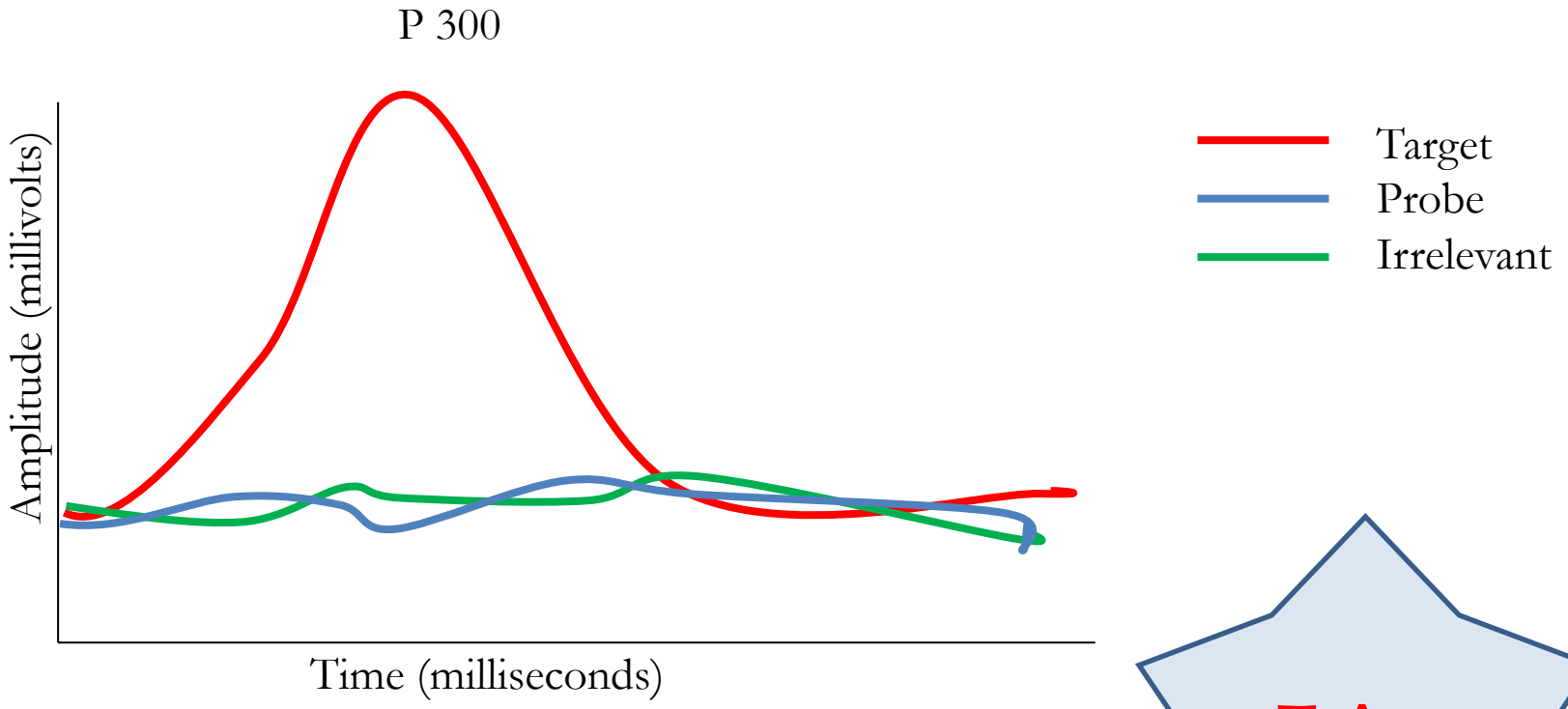
- Compare if the **probe** amplitude is closer to the **target** amplitude or to the **irrelevant** amplitude
- A random sub-sample of probe, target, and irrelevant ERP responses, use a double-centred correlation to compare them, and repeat it 1000 times. [add MERMER, or time-series; and that the epoch was up to 1500]
- The **frequency** of probe-target correlation being **greater** than probe-irrelevant correlation is calculated as a percentage, that is termed *bootstrapping probability*.

Information Present Confirmation



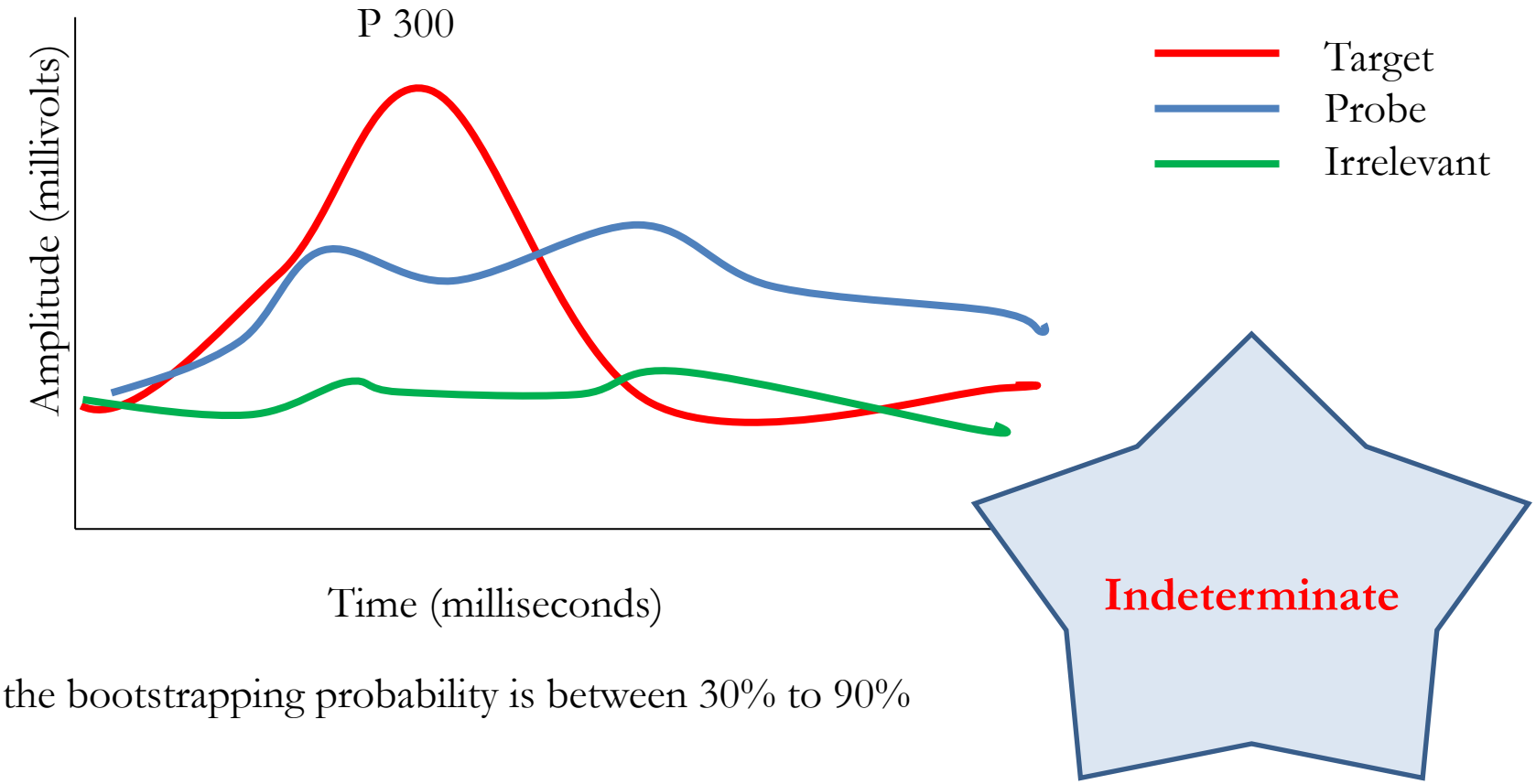
90% or more bootstrapping probability that probe-target correlation is greater than the probe-irrelevant correlation

Information Absent Confirmation



Less than 30% bootstrapping probability that probe-target correlation is greater than the probe-irrelevant correlation.
Usually >90% bootstrapping probability that the probe-irrelevant correlation > the probe-target correlation

Indeterminate



If the bootstrapping probability is between 30% to 90%

The Study (Afzali, Palmer, Neumann, Grace, Makarious, Wilson, and Jones)

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

- $n = 17$ ($n = 5$ ground-truth IP and $n = 12$ ground-truth IA) from a parolee housing facility in Christchurch
- All male, aged from 27 to 75 ($M = 47.5$, $SD = 14.8$).
- Offences: homicide, robbery, arson, assault, and sexual offences.
- Hypothesis: The ground-truth IP convicted criminals would be classified as IP_C for their own crime incidents and the ground-truth IA subjects would be classified as IA_C.

Results

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

- Three groups of subjects were identified:
  - Group 1: Unable to complete the test
  - Group 2: Invalid test
  - Group 3: Satisfactorily completed the test
- Group 1: Four subjects (23.5%). They could not complete either due to health reasons (1 subject) and excessive blinking (3 subjects)
- Group 2: One subject (5.9%). Excluded due to insufficient number of trials (<100) being recorded.
- Group 3: Twelve subjects (70.6%).

Group 3 Summary

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

	n	%
Total subjects who met BFP requirements	12	
Correct determination	8	66.7
Correct IP_C (out of 2 IP)	2	100.0
Correct IA_C (out of 10 IA)	6	60.0
Errors (out of 12 subjects)	1	8.3
Indeterminate (out of 12 subjects)	3	25.0
Correct determination Bootstrapping Probability (overall)		99.3
Correct determination Bootstrapping Probability (IP_C)		98.8
Correct determination Bootstrapping Probability (IA_C)		99.4
Classification accuracy [a]		91.7

[a] Calculated as: 100 – percentage of false positives and false negatives.

Re-testing the false positive subject

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

- On another incident: GT-IA => IP_C
- On his own crime incident: GT-IP => Indeterminate
- What if this was in the applied setting?

Conclusions

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

- The BFP results correctly matched crime-incident episodic memories in all tested Ground-truth IP subjects.
- And for a majority of Ground-truth IA subjects.
- One subject was a false positive
- Three Ground-truth IA subjects were classified as Indeterminate.
- Claims from previous studies that BFP has no false positives, no false negatives, and no Indeterminates have not been confirmed by our study. Therefore, our research hypothesis has not been supported.
- Contrary to what Farwell claims and practices, we conclude that BFP is not yet at a stage in which it can be used as a robust and completely accurate crime-detection tool.

Comparing to previous BFP publications

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

- Indeterminate classification
- False positive classification
- Subjects' inability to satisfactorily complete the BFP test.

Possible explanation for the unlikely findings

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Substance Abuse

US: **65**% in prison population vs. **6**% in general population
Thomas (2020)

Traumatic brain injury

US: **25-87**% in prisoners vs. **10-38**% in general population (Im et al., 2014)

NZ: **88**% in prison population vs. **<1**% in general population
(Lambie, 2020)

Substance abuse and TBI lead to neurocognitive disorders → reduced cognitive efficiency and concentration, cognitive impairment, inability to pay attention, and decline in ability to perform usual cognitive activities

(DSM – V, APA 2013)

Related studies

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

1. Detection of concealed knowledge via the ERP-based technique Brain Fingerprinting: Real-life incidents (**completed**)
2. BPF Countermeasures study with the Think/No-Think paradigm (**completed**)

- Planned future studies to address questions/limitation of the completed studies (including the present one) and elaborate further.

Contact and more information

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Email: usman.afzali@pg.canterbury.ac.nz

Website: usmanafzali.com