



Application of EEG signals in neuromarketing

Introduction and case studies

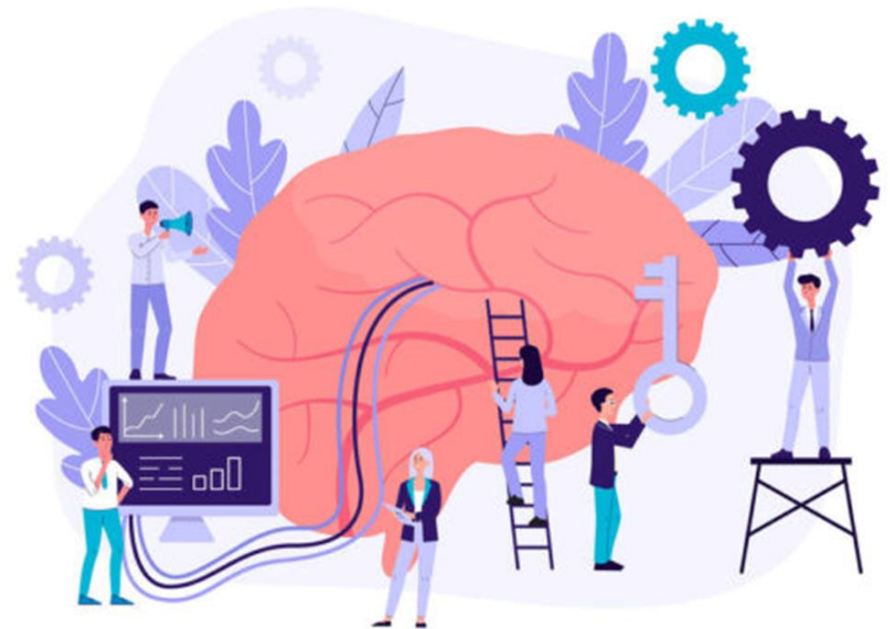
Salameh Sadat Hosseini (MSc. student of Information Technology Engineering - E-commerce)

salame.hosseini@gmail.com

Wednesday, 08 September, 2021; 19-21:00.

Contents

- Introduction to neuromarketing and EEG signals
- Examples of neuromarketing studies
- Applications, Challenges and Promises



1

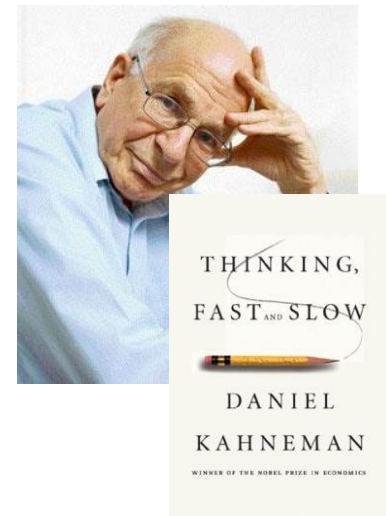
Introduction to neuromarketing

Daniel Kahneman's System 1 vs. System 2

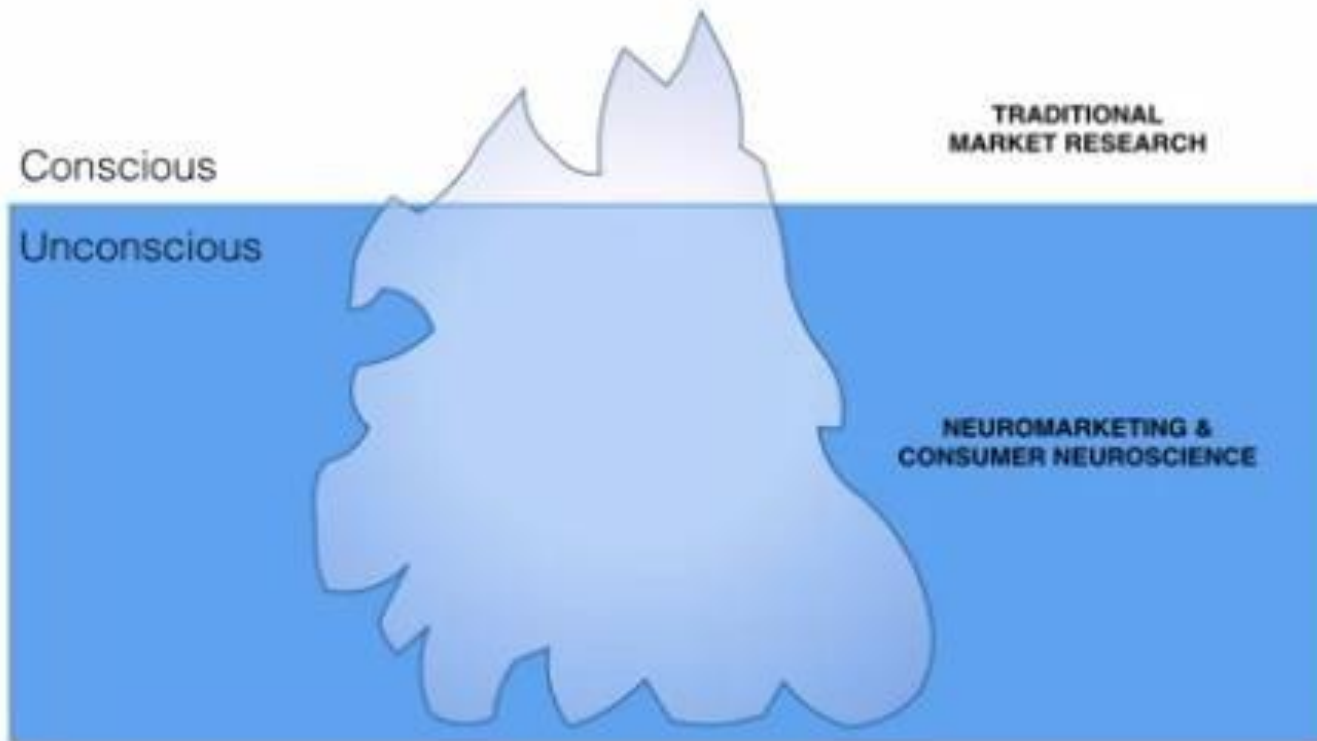
- Daniel Kahneman's posit regarding thinking

Figure 1: A Comparison of System 1 and System 2 Thinking

System 1 "Fast"	System 2 "Slow"
DEFINING CHARACTERISTICS Unconscious Effortless Automatic	DEFINING CHARACTERISTICS Deliberate and conscious Effortful Controlled mental process
WITHOUT self-awareness or control "What you see is all there is."	WITH self-awareness or control Logical and skeptical
ROLE Assesses the situation Delivers updates	ROLE Seeks new/missing information Makes decisions



WHY neuromarketing?



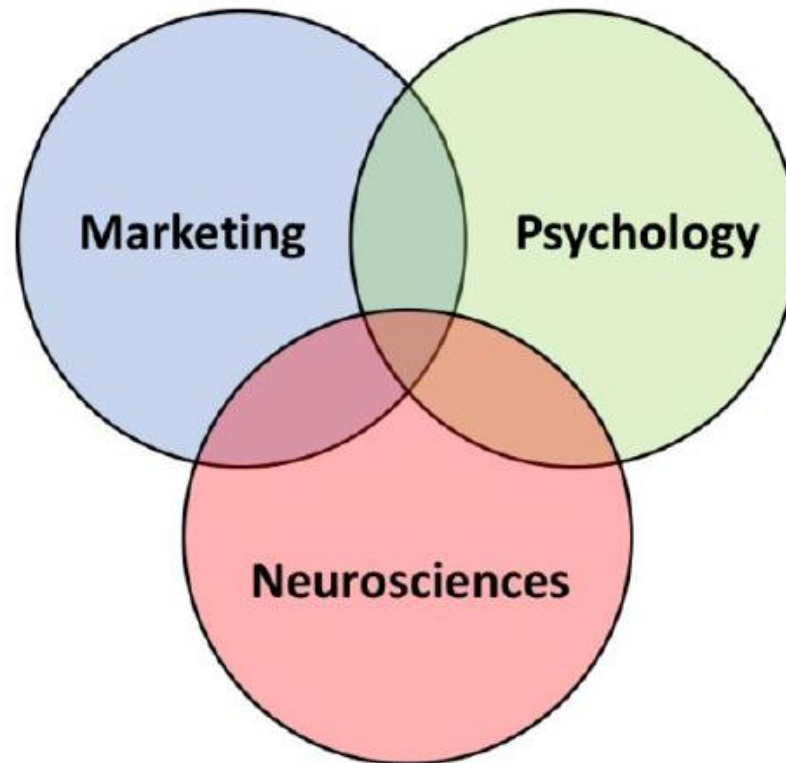
Neuromarketing?

NEUROMARKETING

NEURO**MARKETING**

Definition of neuromarketing

- Background knowledges



First neuromarketing

Gerry Zaltman (1999) from Harvard university

First marketer to use fMRI

Ale Schmidt (2002) from Erasmus university

First to name neuromarketing

Neuromarketing VS Consumer neuroscience

Neuromarketing

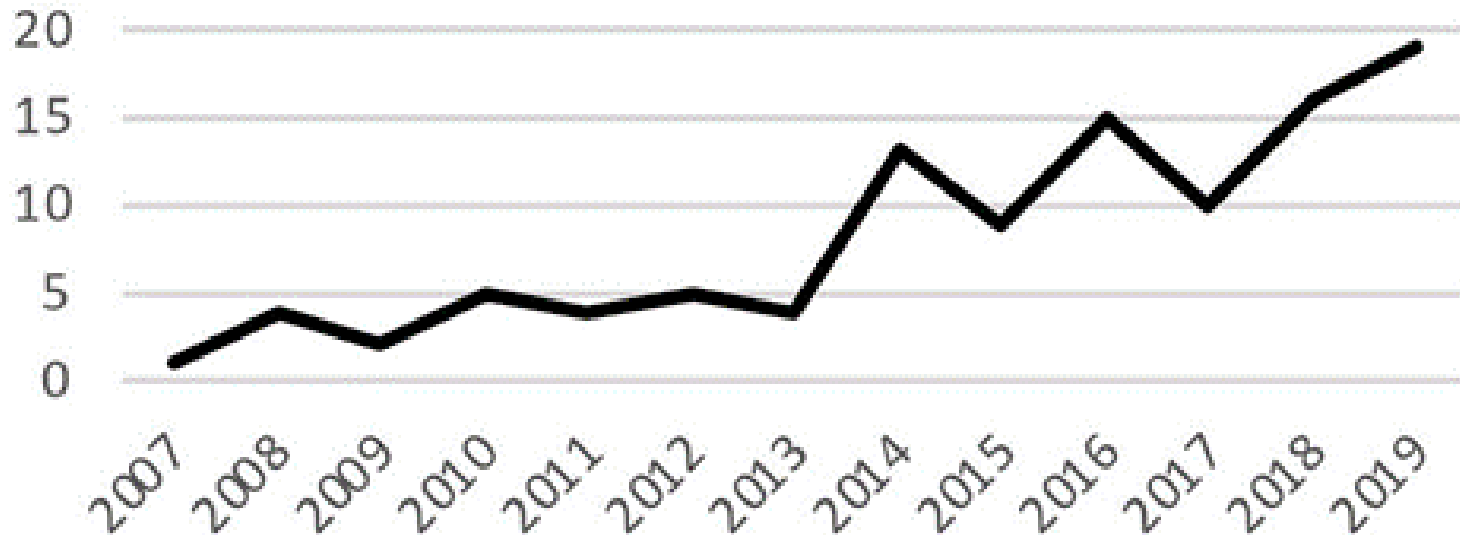
Commercial application of neuroscience technologies and insights to drive business

Consumer neuroscience

Academic use of neuroscience to better understand marketing effects on consumer behavior

Sky-rocketed neuromarketing

A. NUMBER OF PUBLICATIONS



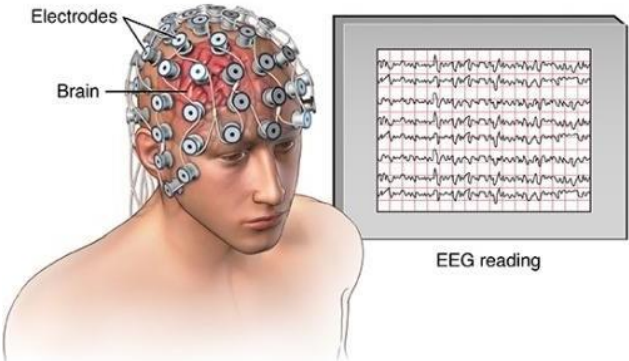
Why was neuromarketing sky-rocketed ?

Neuromarketing strategies by the successful brands

Company	Industry	Purpose of Neuromarketing
GMTV	Television	Conduct a study to teach advertisers how viewer's brains act during morning hours.
VIACOM	Media	Study reactions to advertising.
HAKUHODO	Advertising	Observe responses to products, brands, advertising and video content.
PHD	Media Planning	Measure the relative effectiveness of advertising.
Martin Lindstrom (Neurosense)	Author	Neurosense designed and analyzed all the fMRI studies used for Lindstrom's book research.
Yahoo	Media	Study consumer's reaction to a television commercial.
Hyundai	Automotive	Study consumer's reaction when viewing a sport's car.
Microsoft	Technology\software	Understanding consumer's interaction with computers including their feelings of surprise, satisfaction and frustration.
Ebay	Online auctions	Adopted ad campaign on the basis of neuromarketing research.
Frito-Lay	Food	Adjusted commercials, products and packaging on the basis of neuromarketing based research.
Neurofocus (Conducted neuromarketing research for among others Google, Chevron and Walt Disney company)	Neuromarketing research	Consulting based neuromarketing research
The weather channel	Television	Study viewers reactions to promotions
Daimler Automotive	Automotive	Study consumers reaction to car headlight characteristics
Pepsico	Food	idea for single-serve packaging and corresponding ad campaign
Porsche	Automotive	Consumer response to advertisement
Facebook	Social Networking	frequently a page should post, how to plan out an ad campaign
Coca Cola	Food	Effective advertisement of product
PayPal	Money transfer	Advertisement emphasising speed and convenience
Volvo	Automotive	Study related to car designing.
Microsoft	Software	Eye tracking and EEG measures to analyse the brain's response to the various content, aesthetics and web design combinations
Budweiser	Food	Study positive emotional response in advertisement

Methods

Electroencephalography (EEG)



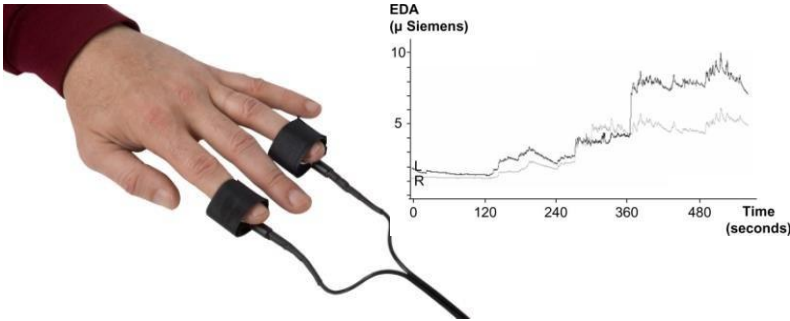
Functional magnetic resonance imaging (fMRI)



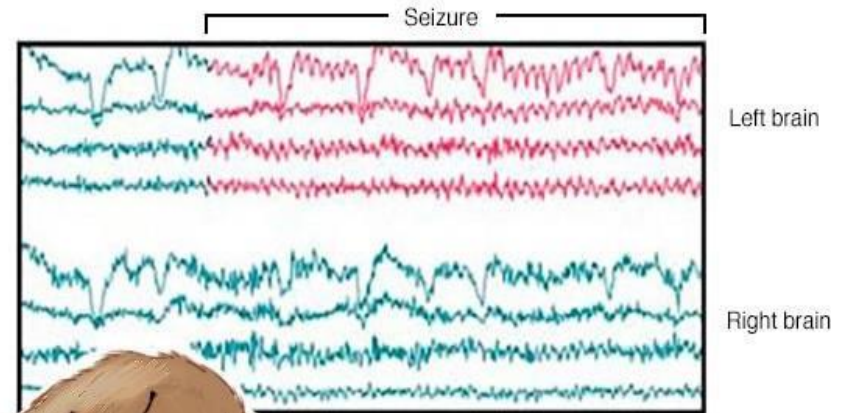
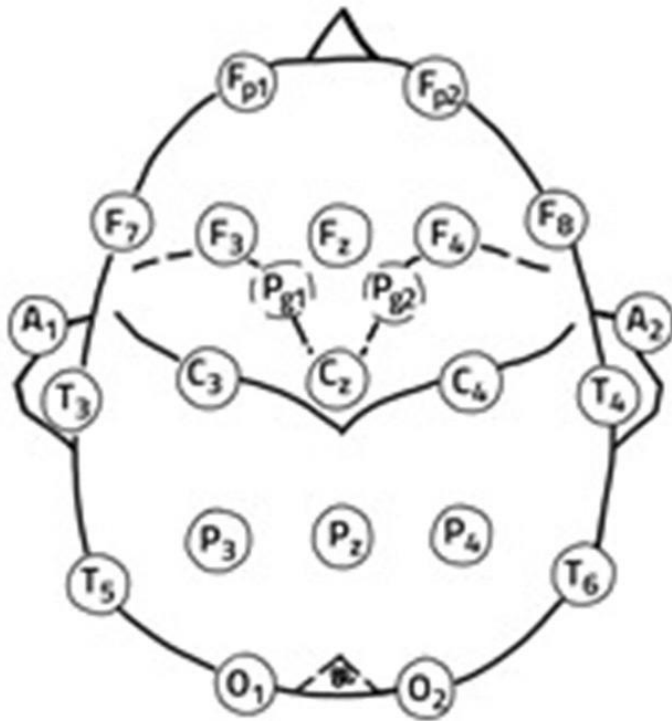
Eye tracking



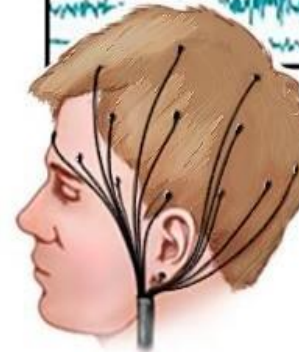
Electrodermal activity



Neurometric measure: EEG



An electroencephalogram (EEG)



• Strength

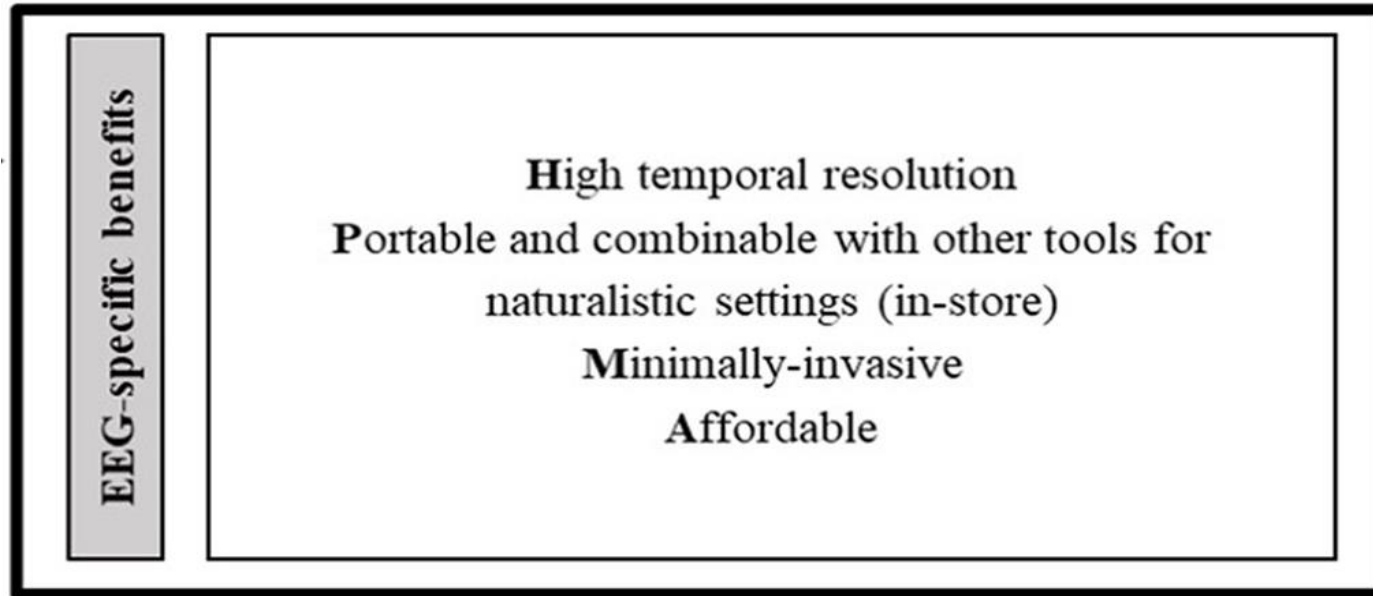
- The only portable brain scanner
- Preferable brain scanning technique
- Affordable and easy to use
- Good at relating marketing stimuli to subsequent changes

• Weaknesses

- Captures activity underneath the skull
- Low spatial resolution
- Time consuming to connect participants
- Timely calibration procedure

WHY EEG ?

Is EEG Suitable for Marketing Research?



CONSUMER GRADE EEG PRODUCTS

Product	Sensor	Channel	Sampling rate [Hz]	Wireless connection	Raw data access	Battery Life [Hours]	Price [USD]	Released Year
NeuroSky MindSet* [12]	Dry	1	512	Bluetooth	Yes	-	-	2007
Neural Impulse Actuator*	Dry	-	-	-	No	-	-	2008
Emotiv EPOC* [13]	Wet	14	128	Bluetooth	Yes	-	-	2009
Mindflex** [14]	Dry	1	512	No	No	***	99	2009
MindWave* [12]	Dry	1	512	Bluetooth	Yes	-	-	2011
XWave headset [15]	Dry	1	512	No	No	***	-	2011
Necomimi** [16]	Dry	1	512	No	No	***	69	2012
Emotiv EPOC+ [13]	Wet	14	128/256	BLE	Yes	12	799	2013
Melon HeadBand* [17]	Dry	3	-	Bluetooth	-	-	-	2014
MyndPlay Myndband [18]	Dry	1	512	BLE	Yes	10	299	2014
Muse [19]	Dry	4	220/500	BLE	Yes	5	199	2014
OpenBCI [20]	Dry/Wet	8/16	250	BLE and Wifi****	Yes	26	750/1800	2014
Aurora DreamBand [21]	Dry	1	-	BLE	Yes	-	299	2015
Emotiv INSIGHT [13]	Semi-dry	5	128	BLE	Yes	8	299	2015
Muse 2 [19]	Dry	4	256	BLE	Yes	5	249	2016
FocusBand [22]	Dry	2	128	BLE	No	12	600	2016
SenzeBand [23]	Dry	4	250	BLE	Yes	4	299	2016
MindWave Mobile 2 [12]	Dry	1	512	BLE	Yes	8	199	2018

Sawangjai, P., Hompoonsup, S., Leelaarporn, P., Kongwudhikunakorn, S. and Wilaiprasitporn, T. (2020). Consumer Grade EEG Measuring Sensors as Research Tools: A Review. IEEE Sensors Journal, 20(8), pp.3996–4024.

2

Examples of neuromarketing studies

- Yadava et al
- P. Golnar-Nik, et al.



Analysis of EEG signals and its application to neuromarketing

Mahendra Yadava¹ · Pradeep Kumar¹ ·
Rajkumar Saini¹ · Partha Pratim Roy¹ ·
Debi Prosad Dogra²

Material and methods :

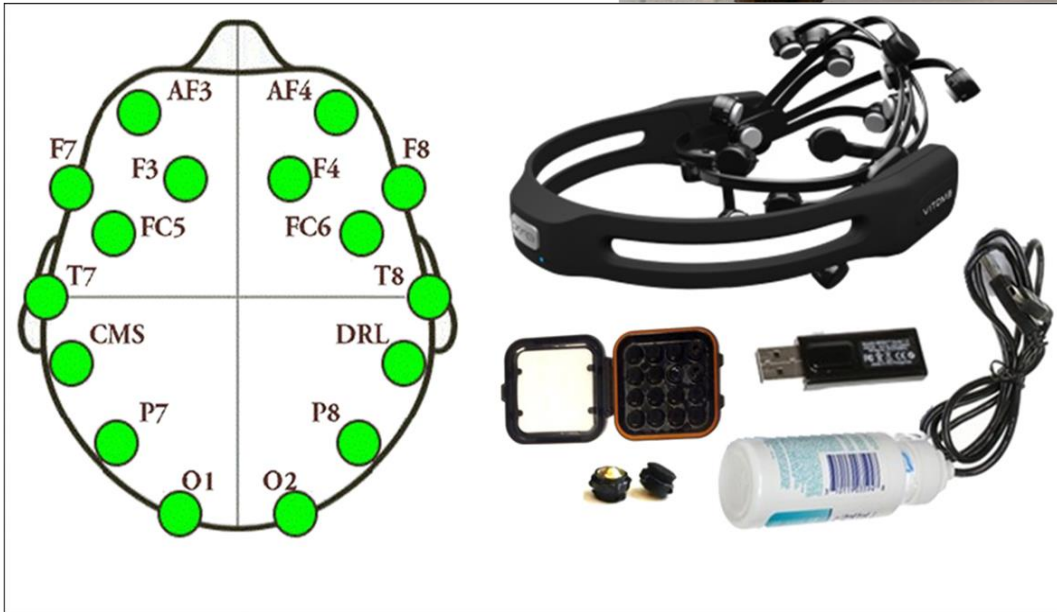
Experimental procedure:

- Liking/Disliking products
- 25 participants participants (25 males and 15 females, age: 18-38)

EEG data acquisition and preprocessing:




























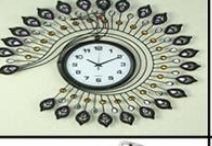
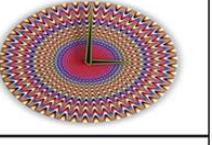










- Emotiv EPOC+ device has been used for capturing the EEG signals
- Each image was displayed for 4 seconds
- International 10 - 20 system

User watching consumer products

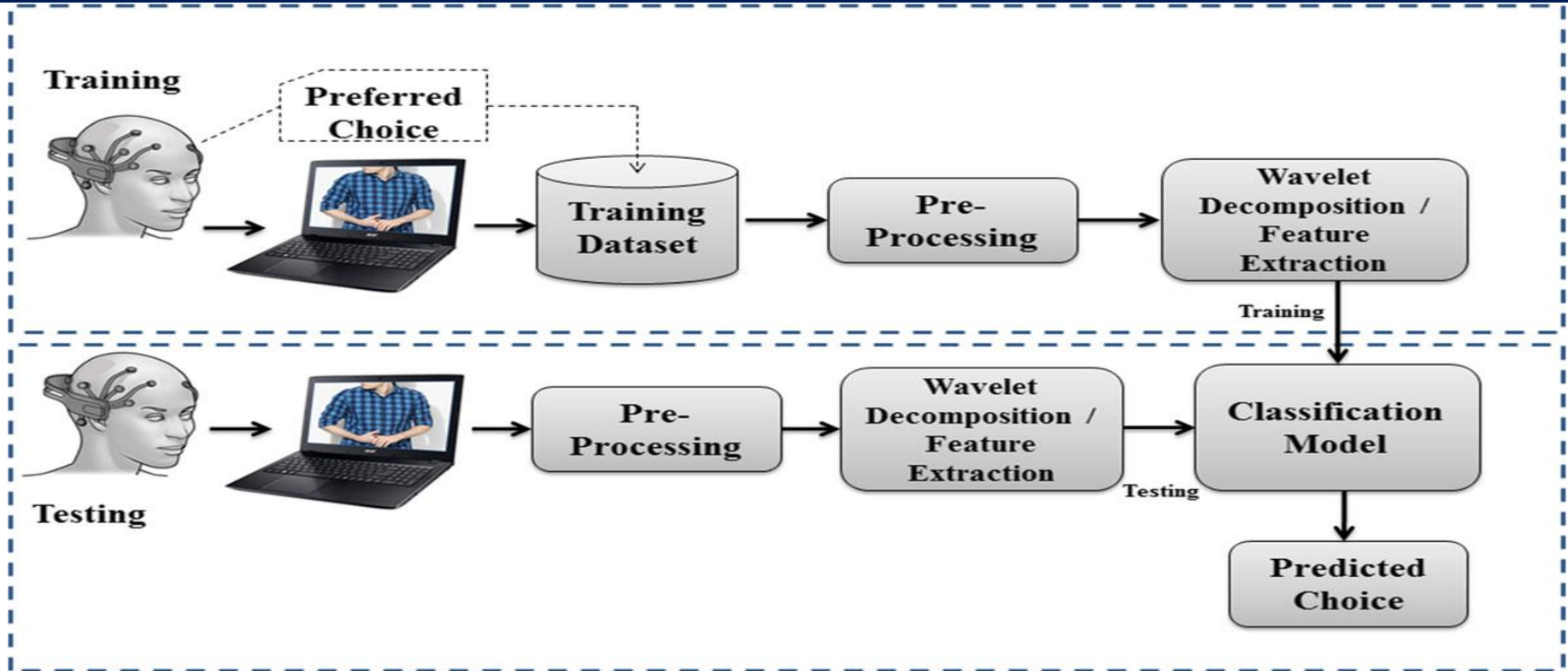


Yadava, M., Kumar, P., Saini, R., Roy, P.P. and Prosad Dogra, D. (2017). Analysis of EEG signals and its application to neuromarketing. *Multimedia Tools and Applications*, [online] 76(18), pp.19087–19111. Available at: <https://link.springer.com/article/10.1007/s11042-017-4580-6>.

Items

Item-Type	Sample 1	Sample 2	Sample 3	Item-Type	Sample 1	Sample 2	Sample 3
Shirts				Gloves			
Shoes				Sun Glass			
Ties				Sweater			
School Bag				Socks			
Muffler				Wall Clock			
Belt				Pen			
Bracelet				Wrist Watch			

Prediction model



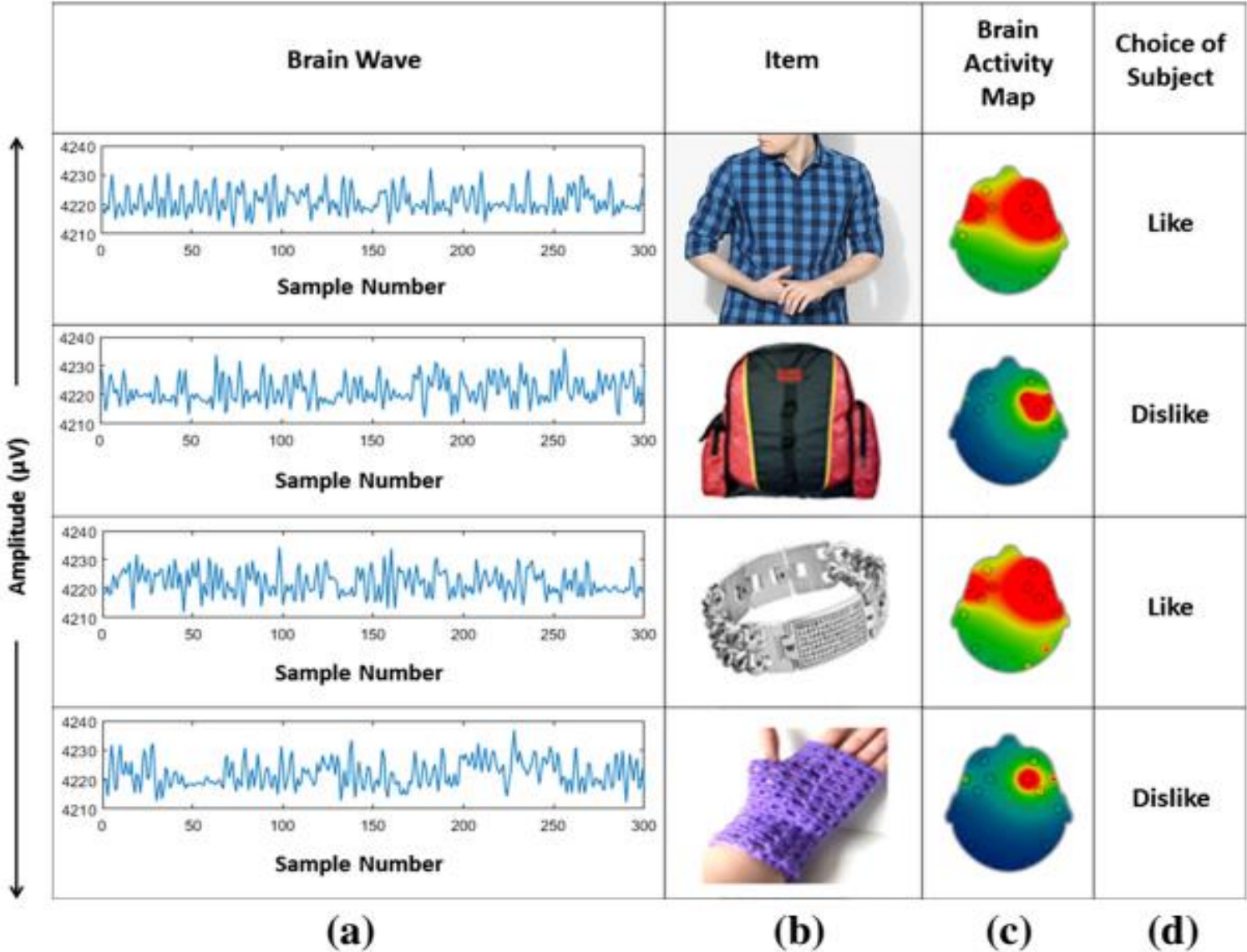
preprocessing: Savitzky-Golay (S-Golay) filter

Feature extraction: Discrete Wavelet Transform (DWT)

Classification: Hidden Markov Model (HMM)

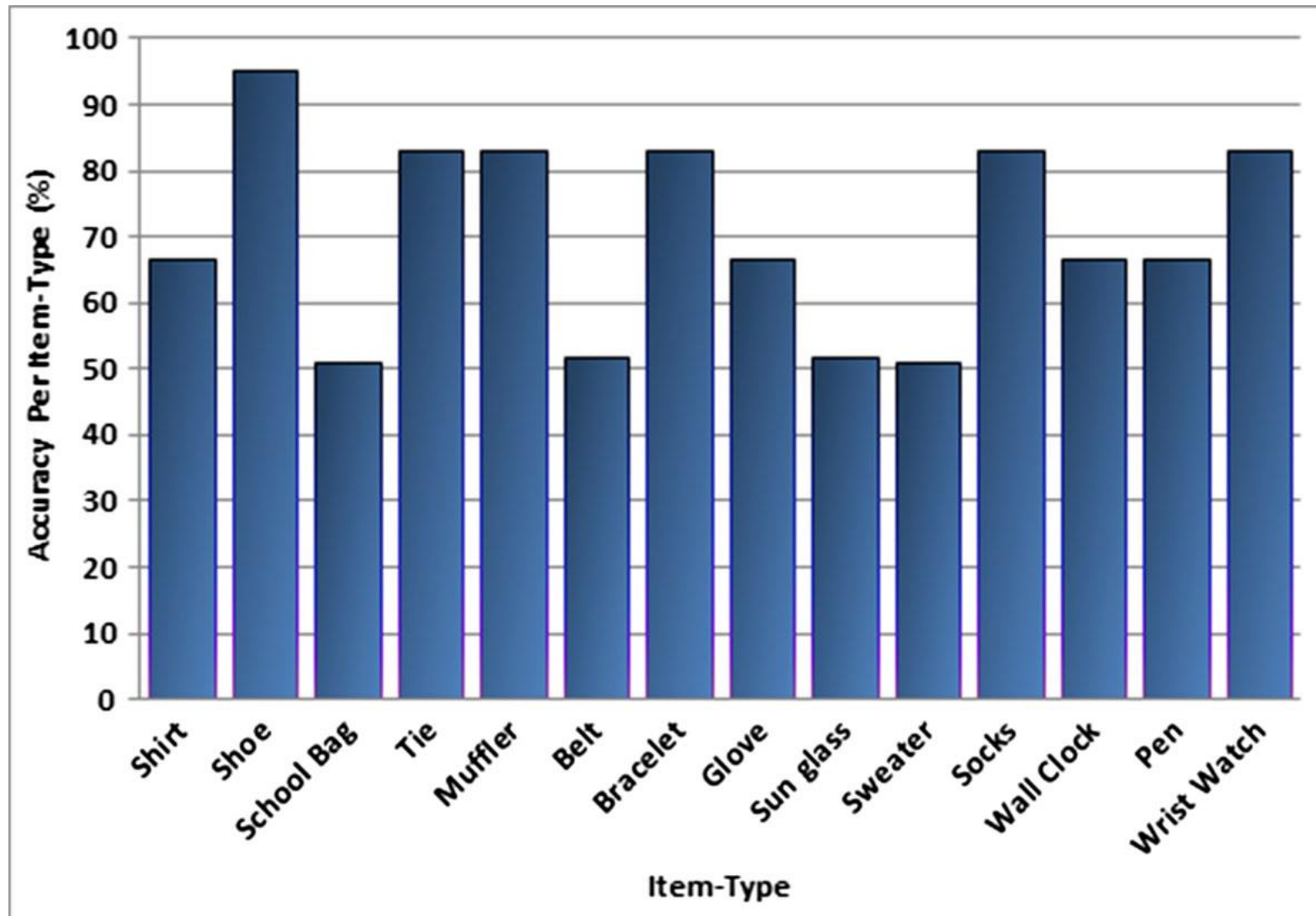
evaluated the performance of the proposed framework : using popular classifiers, such as, Support Vector Machine (SVM) ,Random Forest (RF) and Artificial Neural Network (ANN) .

Result

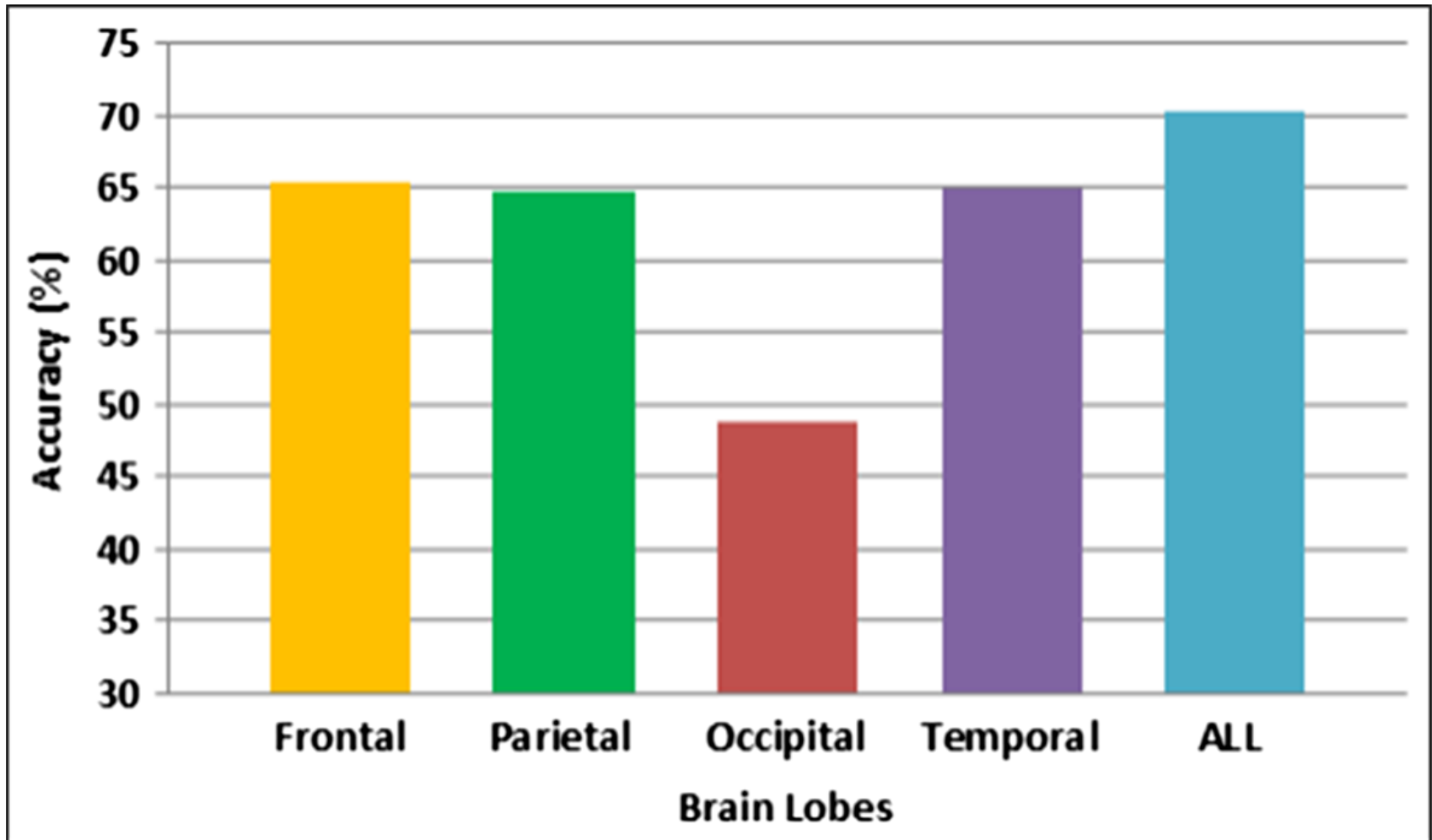


Yadava, M., Kumar, P., Saini, R., Roy, P.P. and Prosad Dogra, D. (2017). Analysis of EEG signals and its application to neuromarketing. *Multimedia Tools and Applications*, [online] 76(18), pp.19087–19111. Available at: <https://link.springer.com/article/10.1007/s11042-017-4580-6>.

Item Type



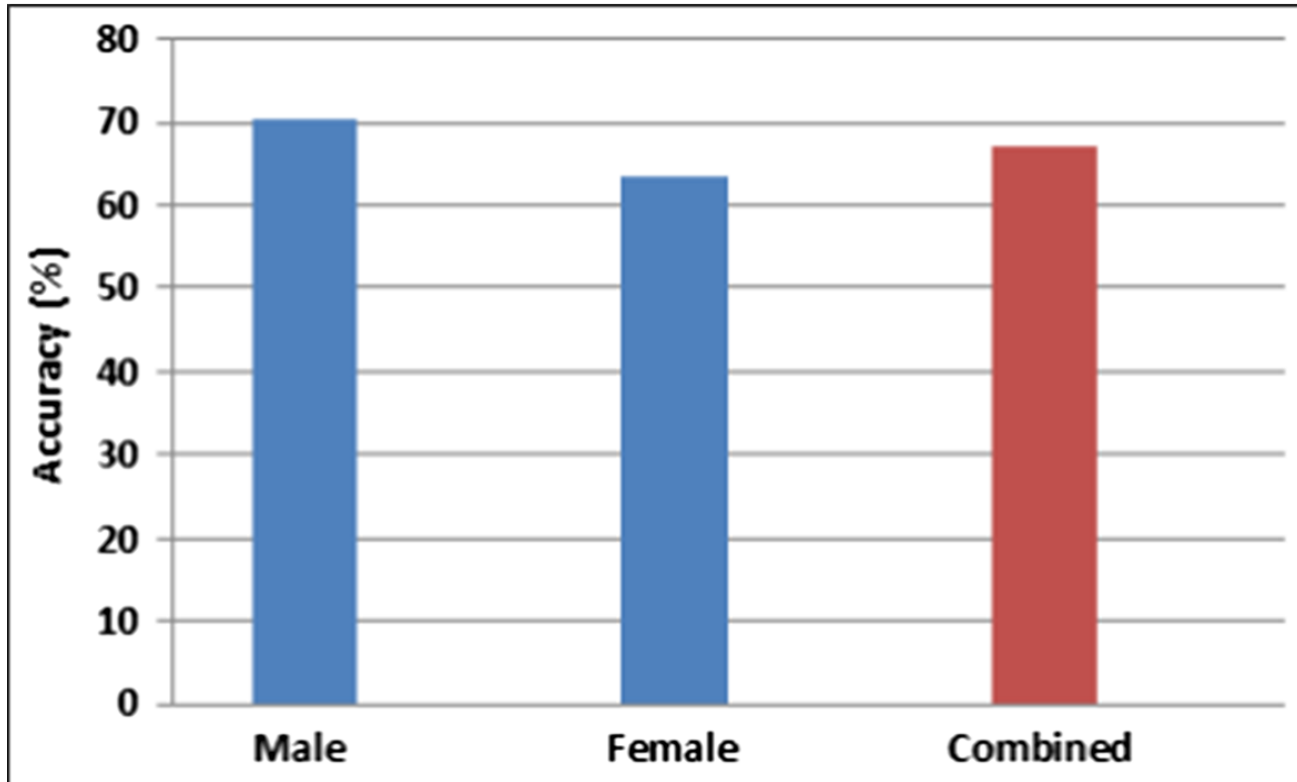
Brain Lobes



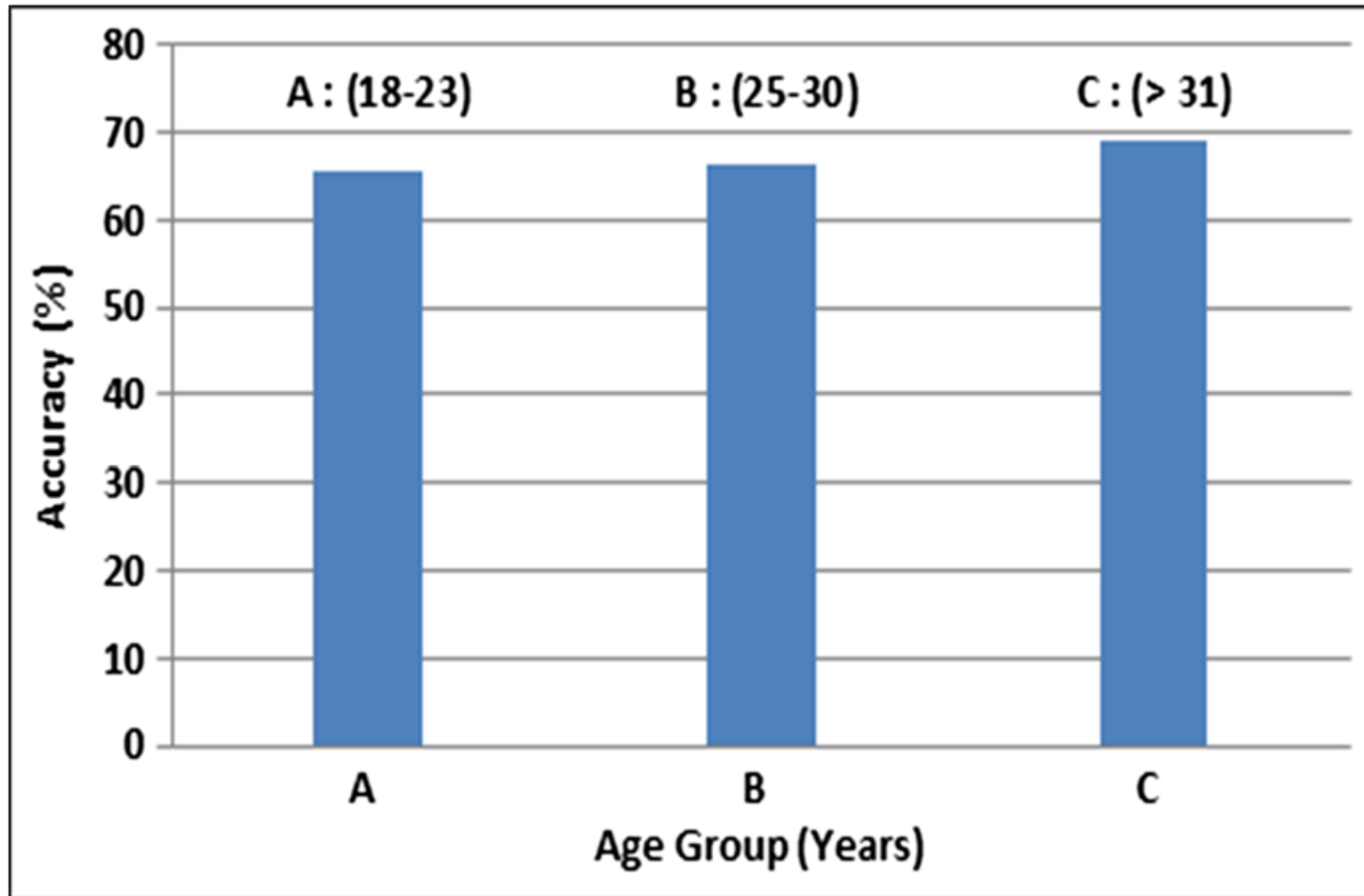
Gender Group

Description of aging groups for the analysis of choice prediction

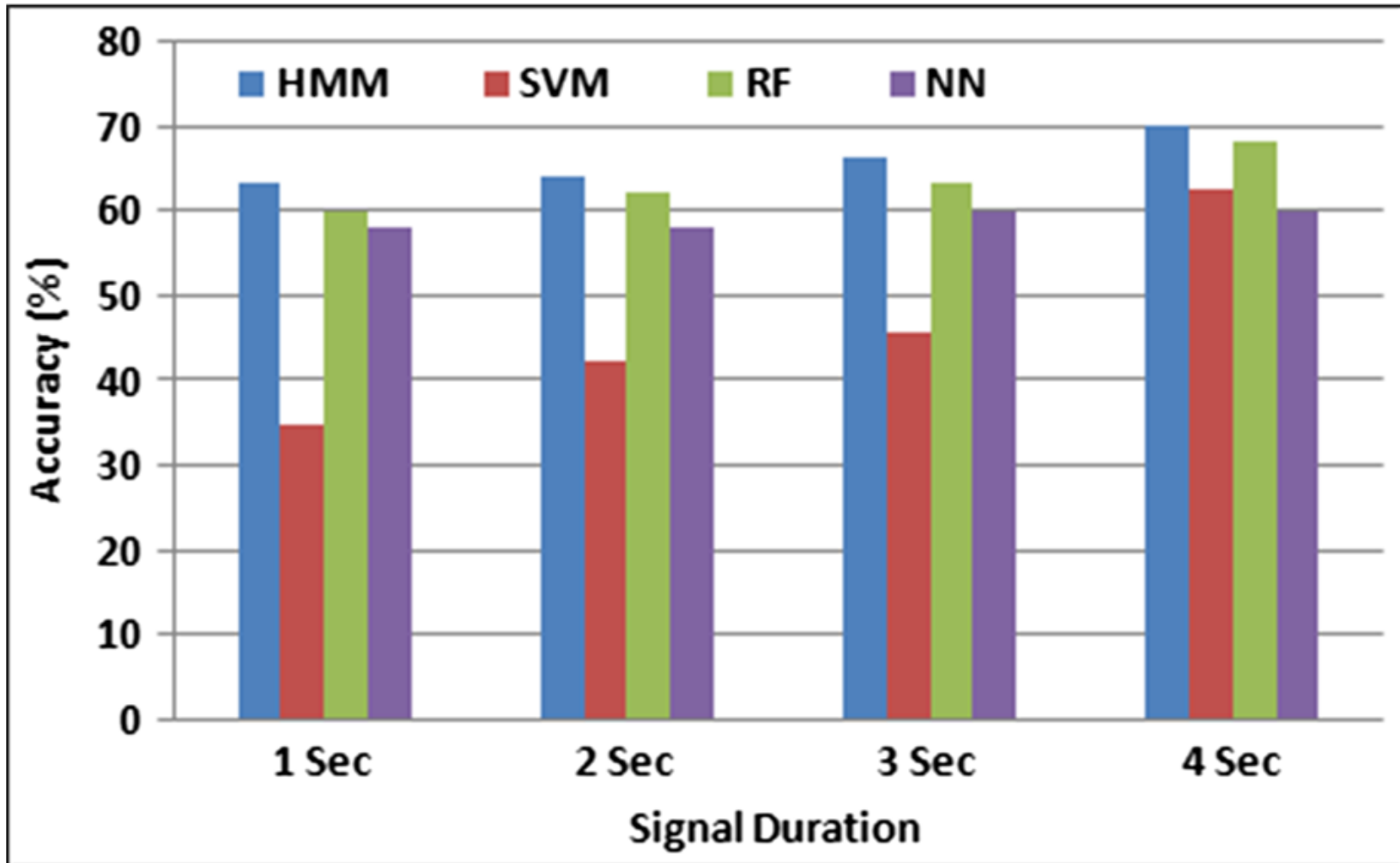
Age-Group	Year	Male	Female	Total
A	18-23	10	6	16
B	25-30	8	5	13
C	>31	7	4	11



Age-Group



Signal Duration

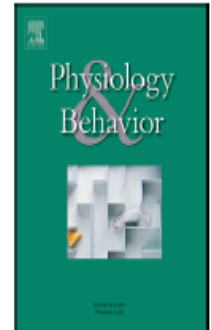




Contents lists available at [ScienceDirect](#)

Physiology & Behavior

journal homepage: www.elsevier.com/locate/physbeh



The application of EEG power for the prediction and interpretation of consumer decision-making: A neuromarketing study



Parnaz Golnar-Nik^a, Sajjad Farashi^{b,c}, Mir-Shahram Safari^{a,d,*}

^a Neuroscience Research Center, Shahid Beheshti University of Medical Sciences, Tehran 19615-1178, Iran

^b Deputy of Research and Technology, Hamadan University of Medical Sciences, Hamadan, Iran

^c Autism Spectrum Disorder Research Center, Hamadan University of Medical Sciences, Hamadan, Iran

^d Brain Future Institute, Tehran, Iran

Two purposes were focused:

1. The potential of EEG spectral power for prediction of consumers' preferences
2. Interpretation of the alteration of consumers' decision-making in shopping behavior when the content of an advertisement including background color and promotions was changed.

Experimental design

A

Product Properties
Like/Dislike by other customers

Mobile Images

iPhone X

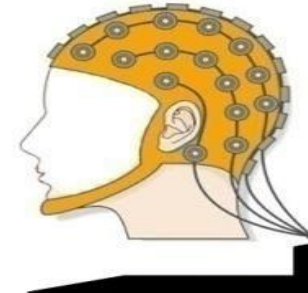
B



C

EEG Feature Extraction

Customer Promotion Prediction



methods

Experimental procedure:

- Liking/Disliking or Buying the mobile phones advertising
- 16 healthy Caucasian participants (9 males and 7 females, age: 23 ± 3 years)

EEG data acquisition

preprocessing:

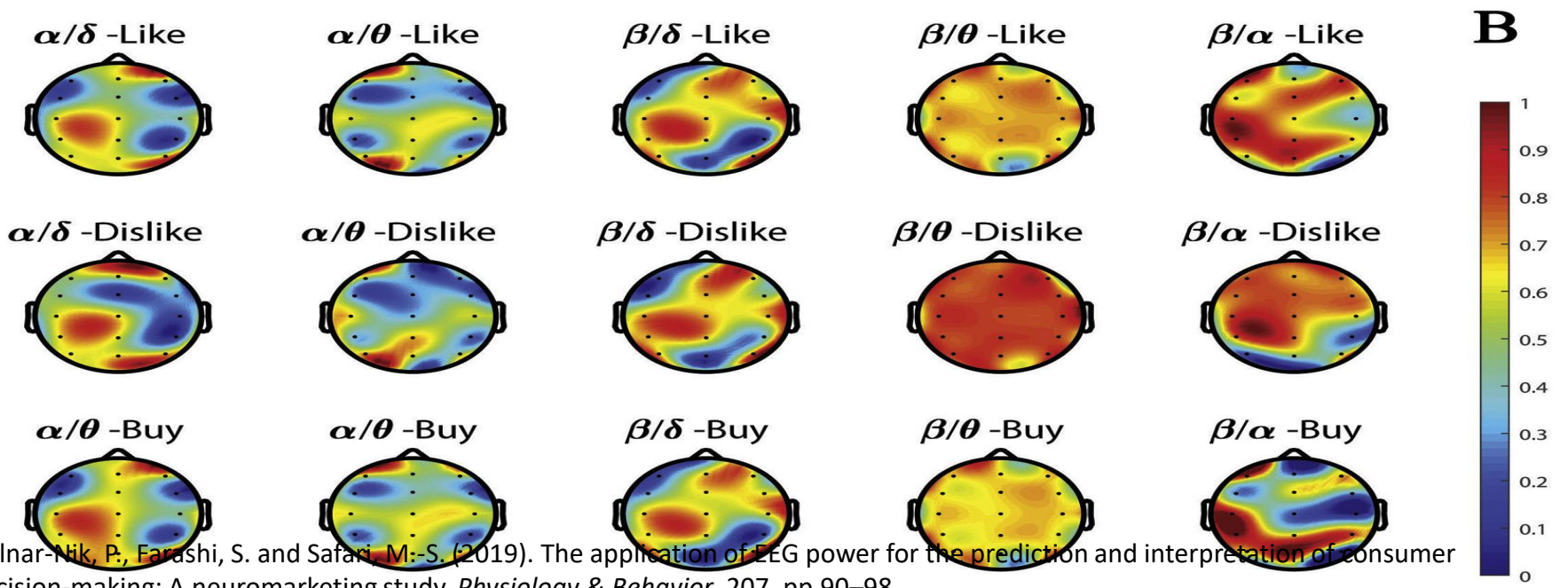
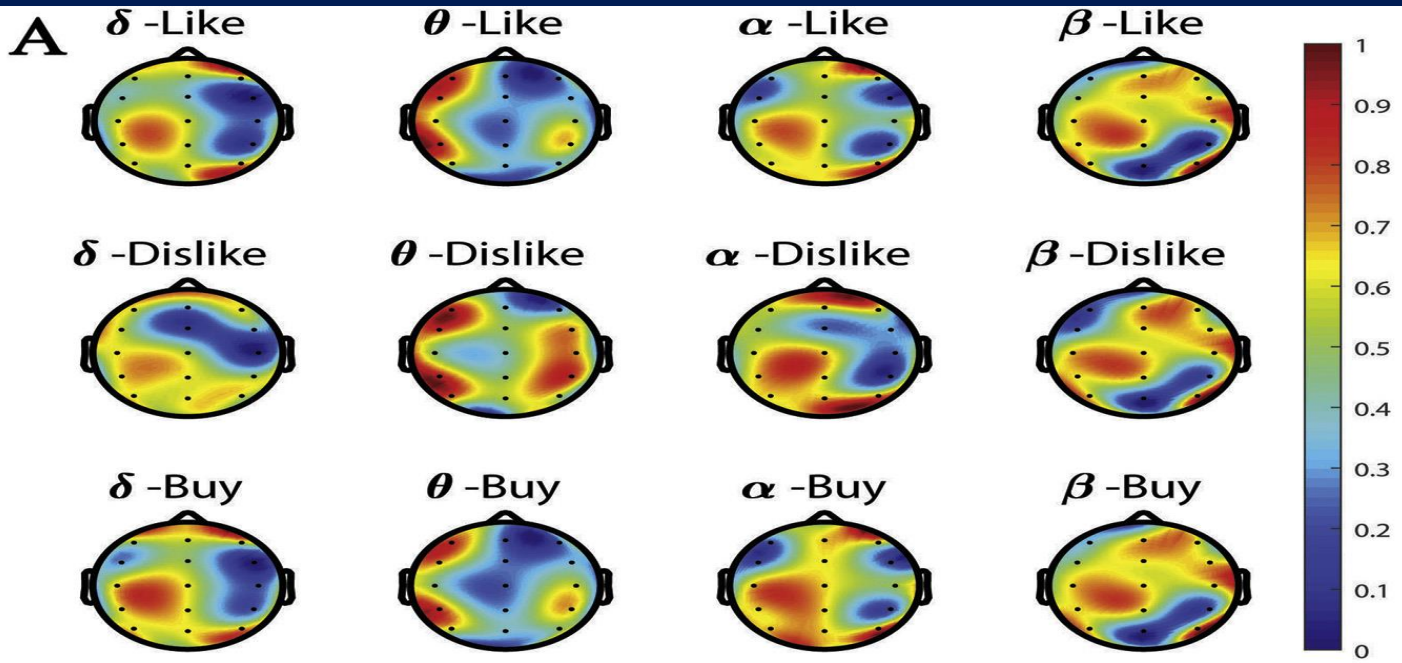
- independent component analysis (ICA)

Classifiers:

- SVM and LDA

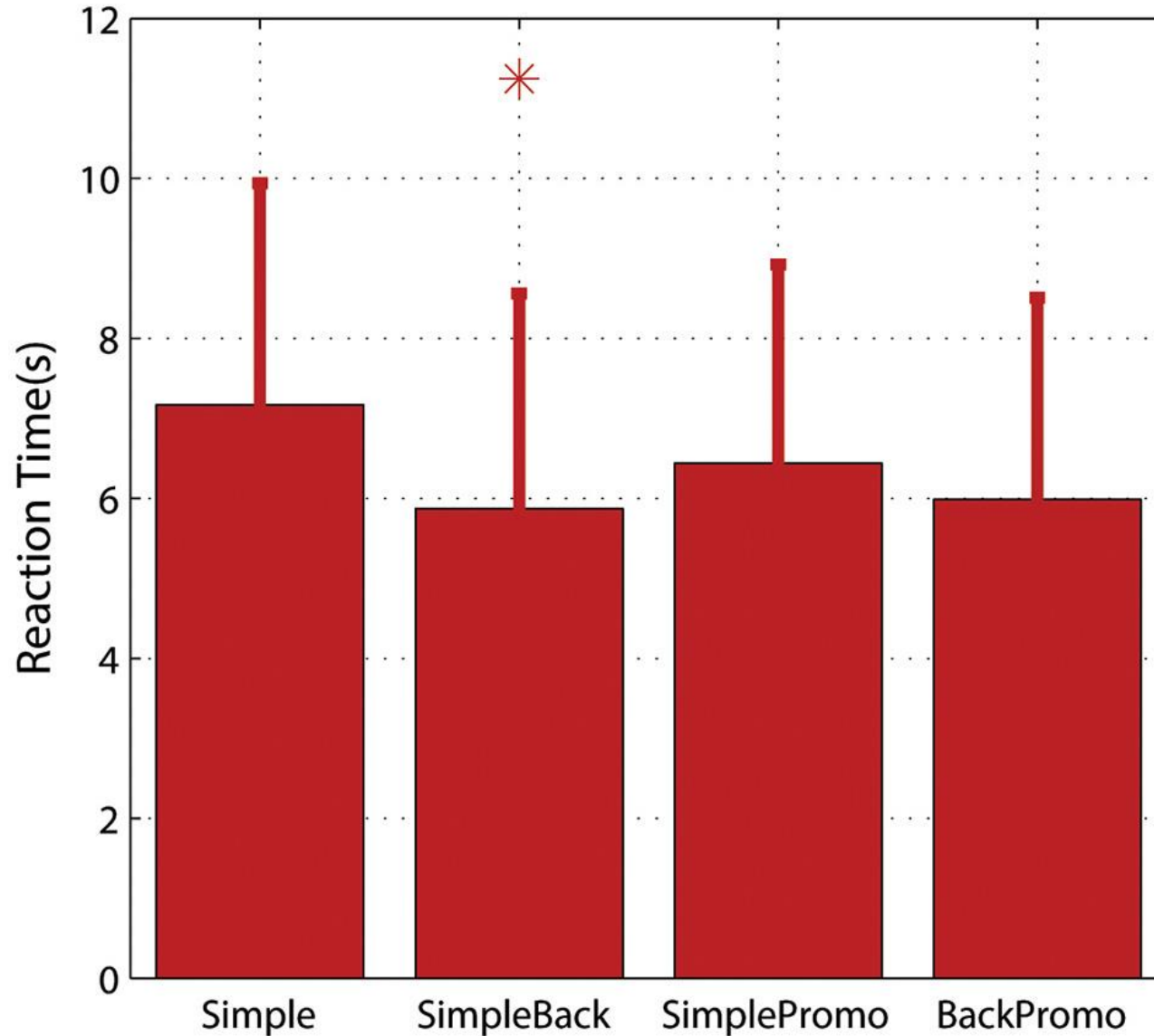
Statistical analysis:

- ANOVA analysis



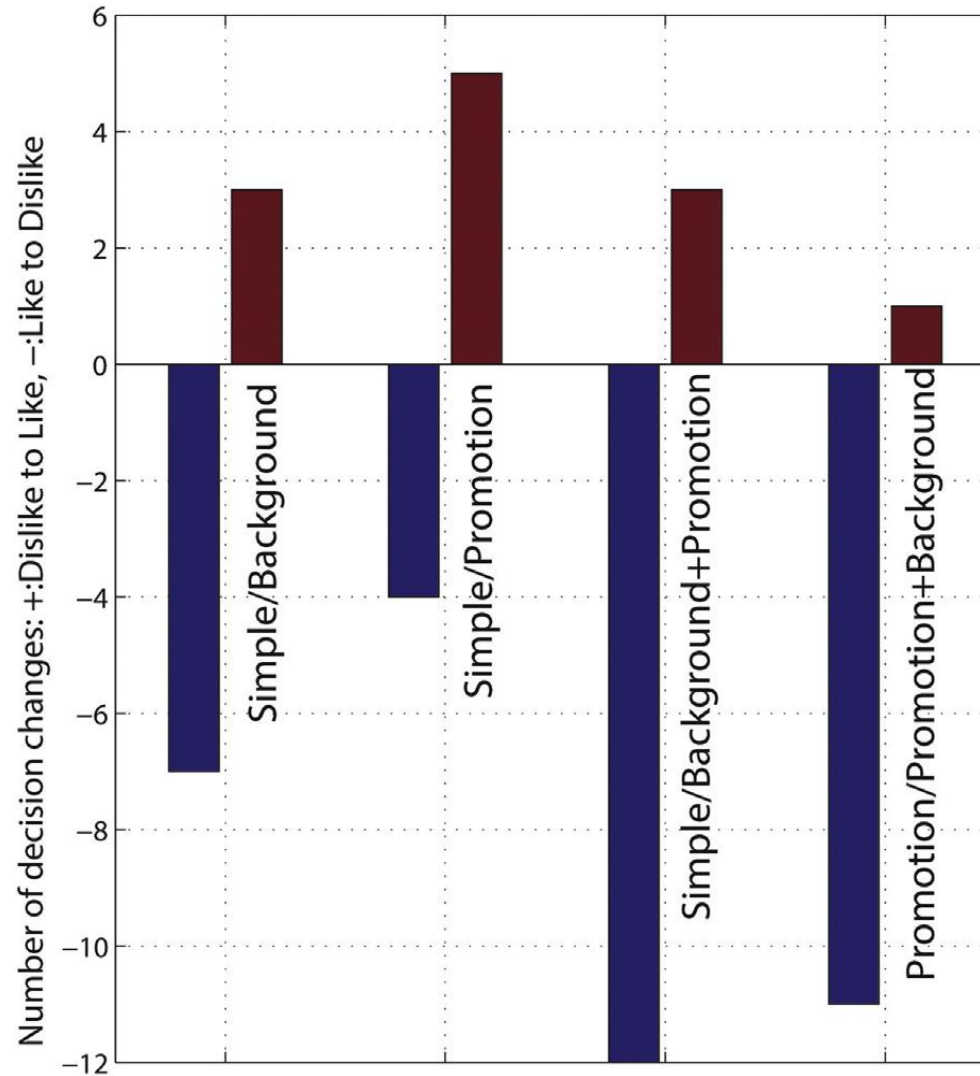
Golnar-Nik, P., Farashi, S. and Safari, M:-S. (2019). The application of EEG power for the prediction and interpretation of consumer decision-making: A neuromarketing study. *Physiology & Behavior*, 207, pp.90–98.

Average reaction time for making a decision



Golnar-Nik, P., Farashi, S. and Safari, M.-S. (2019). The application of EEG power for the prediction and interpretation of consumer decision-making: A neuromarketing study. *Physiology & Behavior*, 207, pp.90–98.

The effect of adding background and promotion



Decision change by adding new content to advertisement

Golnar-Nik, P., Farashi, S. and Safari, M.-S. (2019). The application of EEG power for the prediction and interpretation of consumer decision-making: A neuromarketing study. *Physiology & Behavior*, 207, pp.90–98.

Results

- showed that the extracted features from EEG power could predict consumer's decision-making incidence with relatively high accuracy (> 87%)
- distinguished between “Like” and “Dislike” preferences with accuracy higher than 63%.
- Also, the most discriminative channels for predicting the incidence of decision-making about liking/disliking or buying a product were found to be frontal and Centro-parietal locations
- the difference between “Like” and “Dislike” decisions was observed mostly in the frontal electrodes.
- the results showed that adding the background color to the designed advertisement had a negative impact on the degree of liking a product.

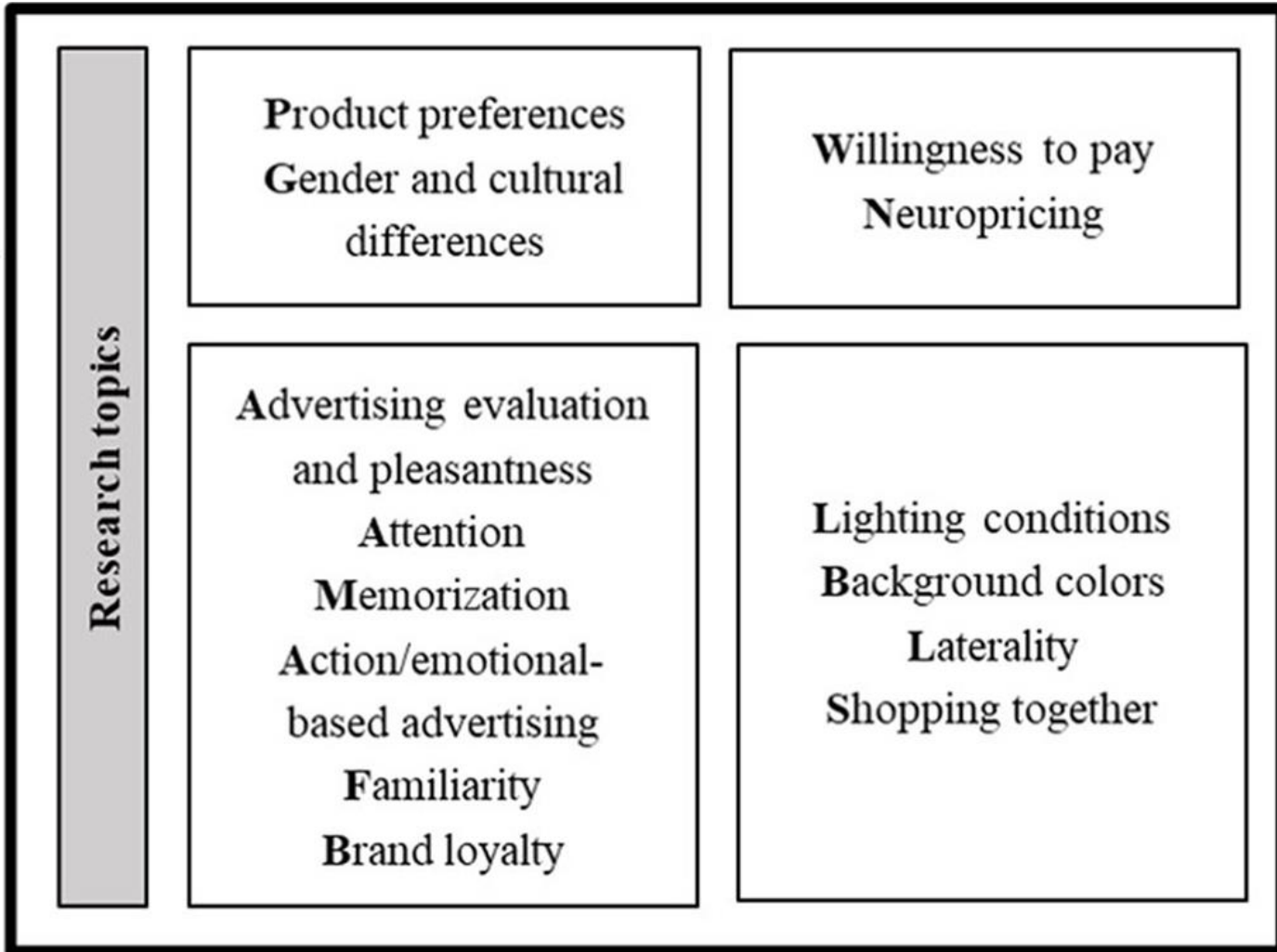
3

Applications, Challenges and Promises

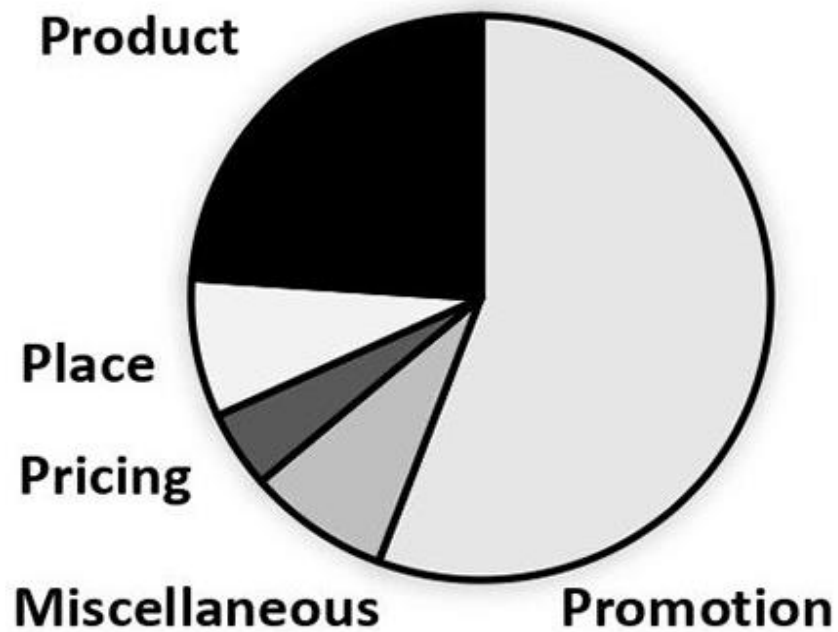
Gathering information

- querying five databases for the titles of articles published up to June 2020 with the terms [EEG] AND [neuromarketing] OR [consumer neuroscience].
- We screened 264 abstracts and analyzed 113 articles, classified based on research topics and the characteristics of the experimental paradigm, including study design and the type of stimuli used

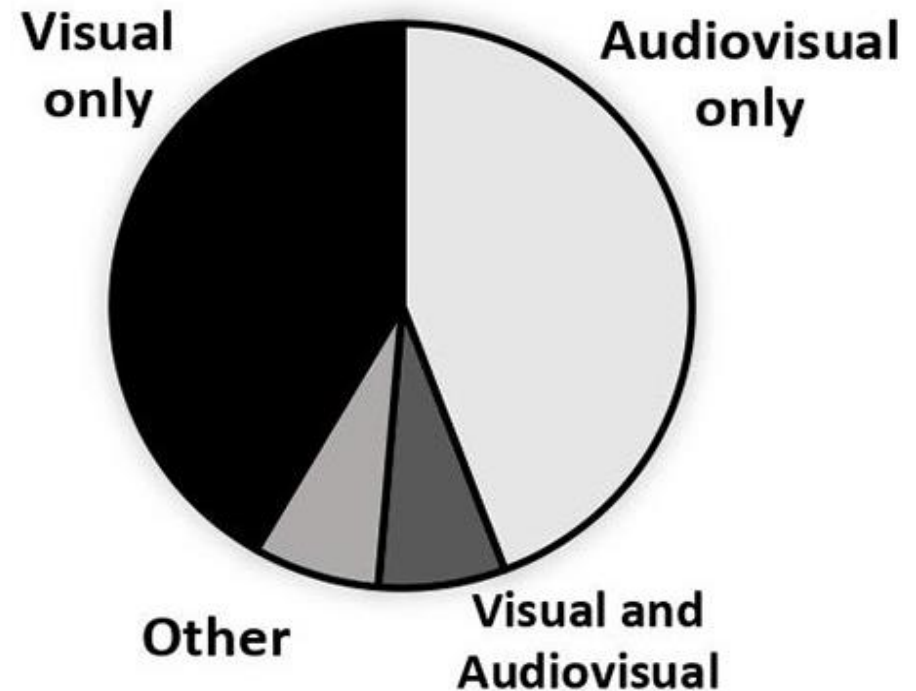
Research Topics



C. TOPICS



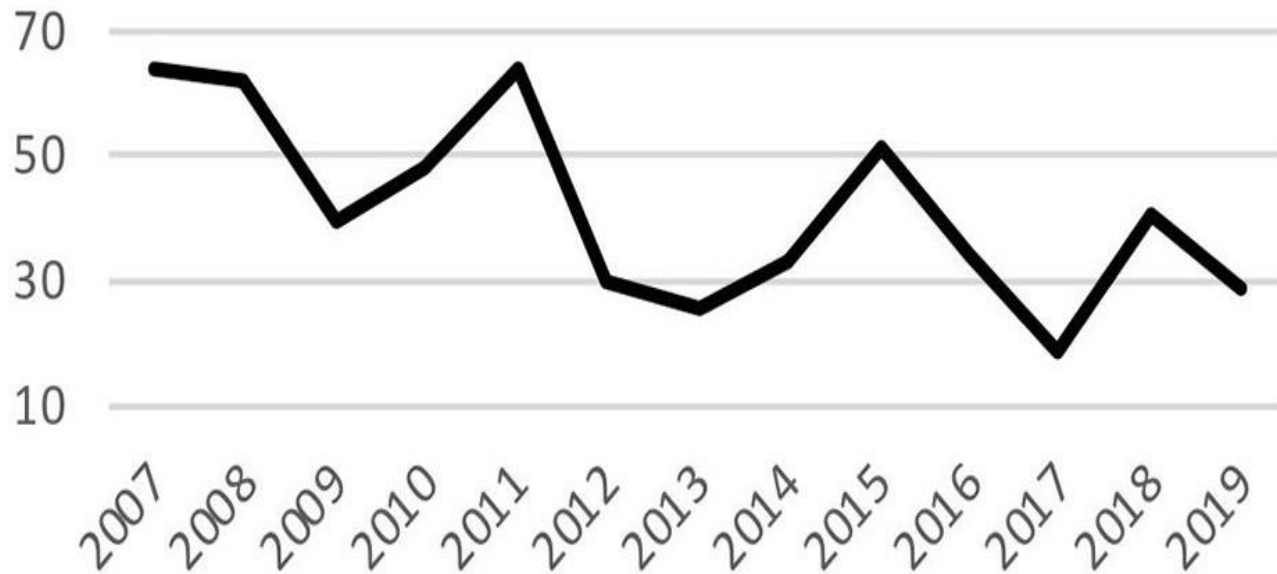
D. STIMULI



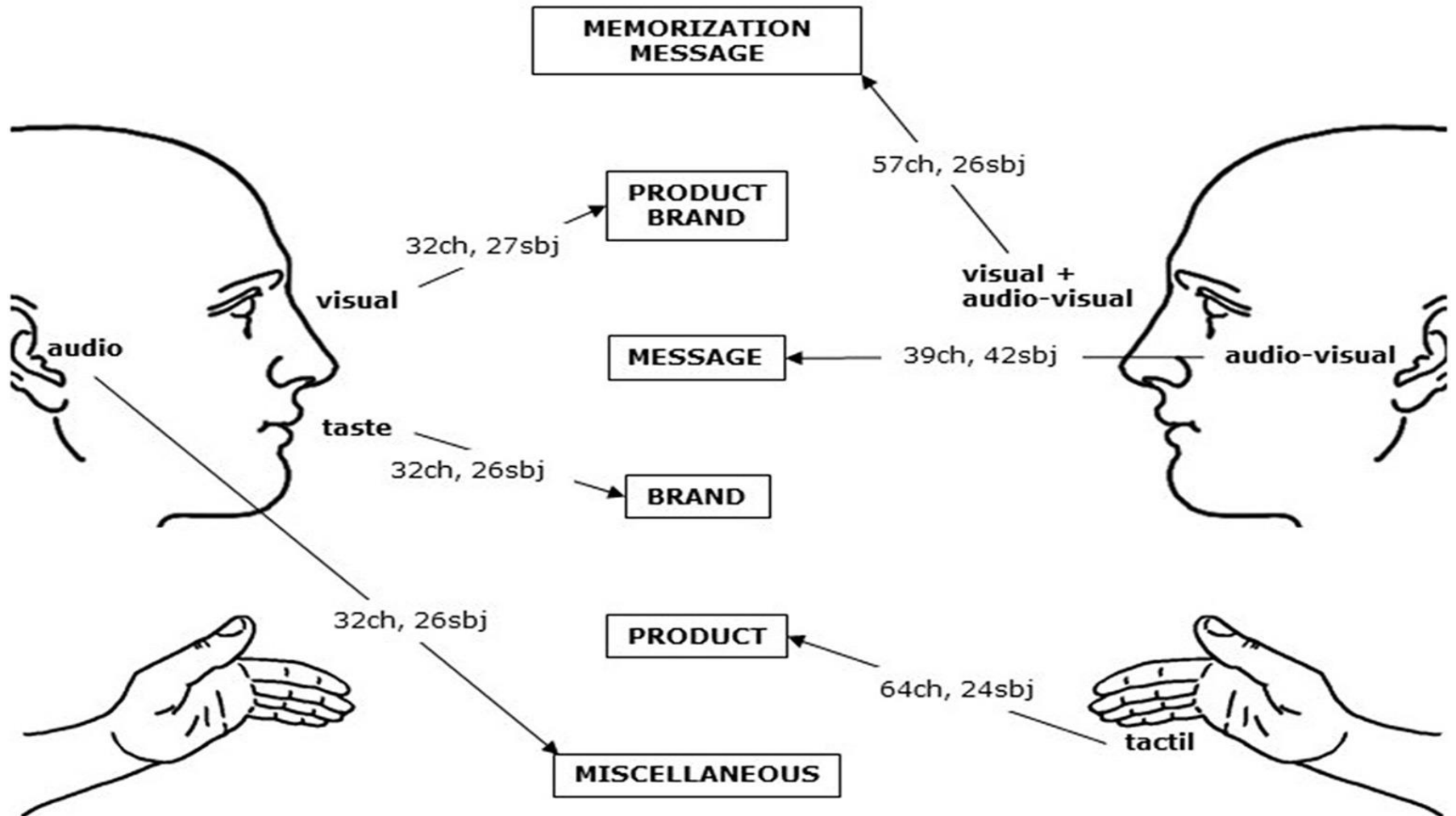
Topic	Stimuli	Audiovisual	Visual	Visual + Audiovisual	Real products	Tactil	Olfactory	Taste	Audio	Tot
Product		3	14	1	2	1	1			22
Message		13	5	4						22
Memorization		14		1						15
Brand			12	1				1		14
Advertising		10	1	1						12
Context		3	4		2					9
Differences		4	1							5
Pricing			5							5
Miscellaneous		3	5						1	9
Tot		50	47	8	4	1	1	1	1	113

Number of electrodes

B. EEG CHANNELS (average)



Average number of participants and EEG channels



Functionalities of brain states used in Neuromarketing research

Brain states	Functionalities in Neuromarketing
Theta (4–8 Hz)	Frontal theta associated with cognitive process [59]. Theta amplitude increase for preferred color [18].
Alpha (8–12 Hz)	Frontal alpha associated with cognitive process [59]. Alpha amplitude is inversely correlated with neural activity used in frontal asymmetry score [21]. Emotional valance corresponds alpha asymmetry, high alpha activity in central–parietal–occipital lobe vigilance [27].
Beta (12–30 Hz)	Medial–frontal beta band activity is associated with reward processing [57]. Right parietal beta corresponds to imagination [59].

Algorithms

Classifiers	Neuromarketing studies	Average accuracy
Support Vector Machine (SVM)	Like/dislike classification for esthetic preference recognition among 3D objects (Chew et al.) [17]	68%
	Attention bias identification between targeted and non-targeted stimuli using NeoCube-based SNN architecture (Doborjeh et al.) [64]	48.5%
	Like/dislike classification among e-commerce product (Yadava et al.) [18]	62.85%
	Emotional valence recognition between excitement and boredom using EEG device and combining SVM, KNN, SVR, LR (Ogino and Mitsukura) [68]	72.4%
	Purchase decision prediction from fMRI data using recursive cluster elimination-based support vector machine (RCE-SVM) (Wang et al.) [30]	55.70%
	Facial emotion recognition using GSR sensor biometric data (Goyal and Singh) [54]	81.65%
	Seven-emotion recognition using EEG signal (Bhardwaj et al.). Happiness and sadness classification accuracy reported here, respectively	87.5%, 92.5%
	Color classification using EEG signal (Rakshit et al.)	78.81%
K-Nearest Neighbor (KNN)	Like/dislike classification for esthetic preference recognition among 3D objects (Chew et al.) [17]	64%
Hidden Markov model (HMM)	Like/dislike classification among e-commerce product (Yadava et al.) [18]. Classification accuracy reported for male and female subject, respectively	70.33%, 63.56%
Linear discriminant analysis (LDA)	Seven-emotion recognition using EEG signal (Bhardwaj et al.) [58]. Happiness and sadness classification accuracy reported here, respectively	82.5, 87.5%
	Like-/dislike classification using car stimuli and ERP signal (Wreissenger et al.)	61%
Naïve Bayes	Purchase decision prediction using Neural Impulse Actuator (NIA) device (Taqwa et al.) [73]	48.5%
Artificial Neural Network	Consumer gender prediction using facial action coding (Gurbuj and Toga) [28]	83.8%
	TV advertisement liking recognition using EEG signal (Soria Morillo et al.) [43]	80%
	TV advertisement liking recognition using EEG (Soria Morillo et al.) [40]	80%
	Like/dislike classification among e-commerce products (Yadava et al.) [18]	60%

Areas for Future Research

- More complex multisensory stimuli and immersive experiences
- Physical characteristics of the store and social interactions
- Market segmentations
- Use experience
- Analyze fake answer
- Neutral choice for the products
- Combine other modalities with eeg

Ethical Issue of Neuromarketing

- Control on consumer psychology
- Manipulation of buyer's brand preference
- Disruption of Privacy of thoughts
- Lack of Regulation
- Promoting Consumerism

7 useful scientific journals for neuromarketing research

- Frontiers in Neuroscience.
- PLOS ONE.
- Journal of Consumer Research.
- Journal of Experimental Psychology: General.
- Journal of Marketing Research.
- Journal of Consumer Psychology.
- Journal of Advertising Research.

THANK YOU

For more information,
Email to
salame.hoseini@gmail.com